State of Wisconsin \ Department of Commerce

RULES in FINAL DRAFT FORM

Rule No.: Chapter Comm 45

Relating to: Mechanical Refrigeration

Clearinghouse Rule No.: 03-012

The Department of Commerce proposes an order to repeal and recreate chapter Comm 45, relating to mechanical refrigeration.

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Analysis of Proposed Rules

Statutory Authority: Sections 101.02 (15)(h) to (j), 101.17 and 101.177, Stats.
Statutes Interpreted: Sections 101.02 (15)(h) to (j), 101.17 and 101.177, Stats.

The Division of Safety and Buildings within the Department of Commerce is responsible for protecting the health, safety and welfare of the public by establishing reasonable and effective safety standards for the construction, repair and maintenance of public buildings and places of employment. Chapter Comm 45 contains minimum safety standards for the design, construction, installation, operation, inspection, repair and maintenance of mechanical refrigeration systems.

The proposed rules consist of a complete update of chapter Comm 45 in order to bring the chapter up to date with current technology and nationally recognized standards. The current chapter Comm 45 is basically a rewritten version of a previous edition of the Safety Code for Mechanical Refrigeration, ASHRAE 15, published by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). The proposed rules require compliance with the 2000 edition of the International Mechanical Code (IMC), as incorporated by reference in the new Wisconsin Commercial Building Code. The proposed rules also include most of the requirements from the current edition of the ASHRAE 15 standard as well as the IIAR 2 standard published by the International Institute of Ammonia Refrigeration, as referenced in the IMC. The proposed new chapter Comm 45 contains basically the same administration and enforcement provisions as the current chapter.

The proposed rules have been developed with the assistance of the Mechanical Refrigeration Code Advisory Council. The members of that citizen advisory council are as follows:

Name	Representing
Jeffrey G. Boldt	Madison Chapter ASHRAE
John Brenton	Wisconsin Association of Meat Processors
Brady Farrell	Mechanical Contractors Association of Wisconsin
David Guckelberger	Air-Conditioning and Refrigeration Institute
Gary Hammen	Wisconsin State AFL-CIO
Al Mlakar	Sheet Metal & Air-Conditioning Contractors Assn
Randy S. Pucek	City of Milwaukee
Frederick Weidenfeller II	Vilter Manufacturing Corporation

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SECTION 1. Chapter Comm 45 is repealed and recreated to read:

Chapter Comm 45
MECHANICAL REFRIGERATION

Subchapter I - Purpose and Scope

Comm 45.01 Purpose. Pursuant to ss. 101.17 and 101.177, Stats., the purpose of this chapter is to establish minimum safety standards for the design, construction, installation, operation and inspection of mechanical refrigerating systems installed in public buildings and places of employment, and for preventing the release of ozone-depleting refrigerants to the atmosphere. The provisions of this chapter are not retroactive unless specifically stated in the administrative rule.

Note: Chapter Comm 5 contains requirements pertaining to the registration of persons engaged in the business of servicing refrigeration equipment or selling ozone-depleting refrigerant and persons installing and servicing refrigeration equipment which may release an ozone-depleting refrigerant.

Note: Chapters Comm 61 to 65 contain additional requirements pertaining to the installation of mechanical refrigerating systems in public buildings and places of employment.

Comm 45.02 Scope. **(1)** APPLICATION. This chapter applies to all of the following:

(a) The installation of mechanical refrigerating systems and heat pumps.

(b) A change to a refrigerant of a different number designation.

(c) Parts or components replaced only if they are not identical in function.

(d) Additions or alterations to any refrigerating system that exceeds the registration criteria in s. Comm 45.07.

(2) EXEMPTIONS. This chapter does not apply to the use of water or air as the primary refrigerant.

(3) LISTED EQUIPMENT. Equipment listed by an approved nationally recognized testing laboratory is deemed to meet the design, manufacture and factory test requirements of this chapter for the refrigerants for which the equipment was designed. Listed refrigerating systems are not required to be field tested.

(4) CONFLICTS. Where rules of the department specify conflicting requirements, the most restrictive rule shall govern.

Comm 45.03 Local regulations. This chapter does not limit the power of cities, villages and towns to make or enforce additional or more stringent regulations, provided the regulations do not conflict with this chapter, any other rule of the department, or law.

Subchapter II - Definitions

Comm 45.05 Definitions. In this chapter:

(1) "Approved" means acceptable to the department.

(2) "Approved nationally recognized testing laboratory" means a laboratory acceptable to the department, which provides uniform testing and examination procedures and standards for meeting design, manufacturing and factory test requirements of this chapter; is organized, equipped and qualified for testing; and has a follow-up inspection service of the current production of the listed products.

(3) "ASHRAE" means the American Society of Heating, Refrigerating and Air-Conditioning Engineers.

(4) "Department" means the department of commerce.

(5) "IIAR" means the International Institute of Ammonia Refrigeration.

(6) "IMC" means the International Mechanical Code.

(7) "Ozone-depleting refrigerant" has the meaning specified under s. 100.45 (1) (d), Stats.

Note: Under s. 100.45 (1) (d), Stats., "ozone-depleting refrigerant" means a substance used in refrigeration that is or contains a class I substance, as defined in 42 USC 7671 (3) or a Class II substance, as defined in 42 USC 7671 (4).

(8) "Place of employment" has the meaning specified under s. 101.01 (11), Stats.

Note: Under s. 101.01 (11), Stats., "place of employment" includes every place, whether indoors or out or underground and the premises appurtenant thereto where either temporarily or permanently any industry, trade or business is carried on, or where any process or operation, directly or indirectly related to any industry, trade or business, is carried on, and where any person is, directly or indirectly, employed by another for direct or indirect gain or profit, but does not include any place where persons are employed in private domestic service which does not involve the use of mechanical power or in farming. "Farming" includes those activities specified in s. 102.04 (3), and also includes the transportation of farm products, supplies or equipment directly to the farm by the operator of said farm or employes for use thereon, if such activities are directly or indirectly for the purpose of producing commodities for market, or as an accessory to such production. When used with relation to building codes, "place of employment" does not include an adult family home, as defined in s. 50.01 (1), or, except for the purposes of s. 101.11, a previously constructed building used as a community-based residential facility, as defined in s. 50.01 (1g), which serves 20 or fewer residents who are not related to the operator or administrator.

(9) "Public building" has the meaning specified under s. 101.01 (12), Stats.

Note: Under s. 101.01 (12), Stats., "public building" means any structure, including exterior parts of such building, such as a porch, exterior platform or steps providing means of ingress or egress, used in whole or in part as a place of resort, assemblage, lodging, trade, traffic, occupancy, or use by the public or by 3 or more tenants. When used in relation to building codes, "public building" does not include a previously constructed building used as a community-based residential facility as defined in s. 50.01 (1g) which serves 20 or fewer residents who are not related to the operator or administrator or an adult family home, as defined in s. 50.01 (1).

Subchapter III – Administration and Enforcement

Comm 45.07 Installation registration. (1) CLASSIFICATIONS. The installer shall register with the department the installation of new, used or additional mechanical refrigerating systems of the following classifications:

(a) Any system using a Group A1 or B1 refrigerant and having a capacity rated at or greater than 50 horsepower, 50 tons or 50,000 volt-amperes.

(b) Any system using a Group A2, B2, A3 or B3 refrigerant and having a capacity rated at or greater than 10 horsepower, 10 tons or 10,000 volt-amperes.

(2) FORMS. Registration information shall be submitted on form SBD-34 obtainable from the department.

Note: The department forms required in this chapter are available from the Division of Safety and Buildings, Material Orders, P.O. Box 2509, Madison, WI 53701-2509, telephone 608/266-3151 or 608/264-8777 (TTY), or at the Safety and Buildings web site at www.commerce.state.wi.us.

(3) SUBMITTAL. The registration form shall be submitted to the department before the system is placed in operation.

Note: The purpose of the registration is so that inspections can be made as specified in s. Comm 45.08 (2).

(4) REACTIVATION. The owner or user shall notify the department before reactivating a mechanical refrigerating system at any time after the expiration date on the permit to operate. The system shall be re-inspected by the department and a new permit to operate shall be obtained before the system may be reactivated.

Note: The department can be notified by writing to the Division of Safety and Buildings, Inspection Support Unit, P.O. Box 7302, Madison, WI 53707-7302, or by telephone at 608/266-3151 or 608/264-8777 (TTY).

Comm 45.08 Enforcement and inspections. (1) ENFORCEMENT. This chapter shall be enforced by the department and its deputies, and by all local officials or bodies having jurisdiction to approve plans or specifications or issue permits for construction, alterations or installations within the scope of this chapter or having authority to investigate and eliminate related fire hazards.

Note: Examples of deputies are third party inspection agencies having a contract with the department.

(2) INSTALLATION INSPECTIONS. (a) The department shall inspect a mechanical refrigerating system which requires registration under s. Comm 45.07 (1) before the system is placed in operation.

(b) The department shall inspect refrigerant steel piping using welded joints to be erected on the premises after the piping material is delivered to the job site and prior to the start of construction. The installer shall give the department a minimum of 5 business days notice to arrange for the inspection.

(c) The installer shall complete form SBD-5204 and retain it at the job site prior to the refrigerant piping inspection. The certified inspector shall indicate acceptance of the refrigerant piping system design by signing form SBD-5204.

(d) The owner of the refrigerant piping system may request piping inspections in addition to the minimum inspections required under this section.

(3) PERIODIC INSPECTIONS. (a) 1. Except as provided in subd. 2, any mechanical refrigerating system using a Group A1 or B1 refrigerant and having a capacity rated at or greater than 50 horsepower, 50 tons or 50,000 volt-amperes shall be subject to inspection by the department at least once every 36 months.

2. Groups A1 and B1 systems located outdoors with the discharge located at least 20 feet from any building opening and used only for air-conditioning for human comfort are exempt from periodic inspections.

(b) Any mechanical refrigerating system using a Group A2, B2, A3 or B3 refrigerant and having a capacity rated at or greater than 10 horsepower, 10 tons or 10,000 volt-amperes shall be subject to inspection by the department at least once every 12 months.

Comm 45.09 Permit to operate. (1) (a) The owner or user of a mechanical refrigerating system which requires periodic inspections under s. Comm 45.08 (3) shall be responsible for obtaining and maintaining a valid permit to operate.

(b) The permit to operate shall be posted in the machinery room or adjacent to the entrance to the machinery room.

(2) After the initial inspection or after each periodic inspection, a permit to operate shall be issued by the department upon determination that the system meets the applicable requirements of this chapter. The department shall make that determination and issue a permit to operate within 15 business days of the initial or periodic inspection.

(3) The permit to operate shall indicate the maximum allowable working pressure permitted under the requirements of this chapter.

(4) The permit to operate shall be valid until 20 days after the next periodic inspection.

Comm 45.10 Reporting of accidents. Whenever mechanical refrigeration equipment or system components fail and cause injury to any person, the owner or user shall report in writing the facts involved to the department within the following 24 hours. The owner or user may not remove or disturb mechanical refrigeration equipment or any of its parts nor permit any such removal or disturbance prior to receiving authorization from the department, except for the purpose of saving human life or preventing further property damage.

Note: Accidents are to be reported to the department at the Safety and Buildings Division, Inspection Support Unit, P.O. Box 7302, Madison, WI 53707-7302.

Comm 45.11 Petition for variance. The department shall consider and may grant a variance to a provision of this chapter in accordance with ch. Comm 3. The petition for variance shall include a position statement from the fire department having jurisdiction over the affected property.

Note: Chapter Comm 3 requires the submittal of a petition for variance form (SBD-9890) and a fee, and that an equivalency is established in the petition for variance that meets the intent of the rule being petitioned. Chapter Comm 3 also requires the department to process regular petitions within 30 business days and priority petitions within 10 business days.

Comm 45.12 Appeals. (1) APPEAL OF DEPARTMENT ORDER. Pursuant to s. 101.02 (6)(e), Stats., any person who owns or occupies a property that is affected by an order of the department may petition the department for a hearing on the reasonableness of the order.

(2) APPEAL OF LOCAL ORDER. Pursuant to s. 101.02 (7)(b), Stats., any person affected by a local order that is in conflict with an order of the department may petition the department for a hearing on the local order.

(3) PETITION FOR ADMINISTRATIVE RULE. Pursuant to s. 227.12, Stats., any municipality, corporation or any 5 or more persons having an interest in an administrative rule may petition the department requesting the adoption, amendment or repeal of the rule.

Comm 45.13 Penalties. Penalties for violations of this chapter shall be assessed in accordance with s. 101.02 (12) and (13) (a) or 101.177 (5), Stats.

Note: Section 101.02 (12), Stats., indicates that every day during which any person, persons, corporation or any officer, agent or employee thereof, fails to observe and comply with an order of the department will constitute a separate and distinct violation of such order.

Note: Section 101.02 (13) (a), Stats., indicates penalties will be assessed against any employer, employee, owner or other person who fails or refuses to perform any duty lawfully enjoined, within the time prescribed by the department, for which no penalty has been specifically provided, or who fails, neglects or refuses to comply with any lawful order made by the department, or any judgment or decree made by any court in connection with ss. 101.01 to 101.25, Stats. For each such violation, failure or refusal, such employee, owner or other person must forfeit and pay into the state treasury a sum not less than $10 nor more than $100 for each violation.

Note: Section 101.177 (5), Stats., indicates that any person who violates the installation, servicing or sale requirements relating to ozone-depleting refrigerants will be required to forfeit not less than $50 nor more than $1,000. Each act of installation, servicing or sale in violation of the rule constitutes a separate violation.

Comm 45.14 Fees. Fees for permits to operate, inspections and petitions for variance shall be submitted as specified in ch. Comm 2.

Subchapter IV - Standards

Comm 45.20 Construction and operation. (1) GENERAL. All mechanical refrigerating systems shall be designed, installed, maintained and operated in accordance with chapter 11 of the International Mechanical Code - 2000 incorporated by reference in s. Comm 61.05, subject to the changes, additions and omissions specified in subch. V.

(2) ADDITIONAL STANDARD. In addition to the requirements in IMC chapter 11, the following standard is hereby incorporated by reference into this chapter: Refrigeration Piping and Heat Transfer Components, ASME B31.5 - 2001. Refrigeration piping shall comply with ASME B31.5 - 2001.

Note: American Society of Mechanical Engineers (ASME) standards may be purchased from the ASME Order Department, 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300, telephone 800 THE ASME.

Note: Copies of adopted standards are on file in the offices of the department, the secretary of state, and the revisor of statutes.

Comm 45.21 Ozone-depleting refrigerants. (1) REQUIRED CERTIFICATION. Pursuant to s. 101.177 (2), Stats., no person may install or service a piece of refrigeration equipment that contains ozone-depleting refrigerant unless the person has been certified as a refrigerant handling technician in accordance with ch. Comm 5.

(2) CLEANING OF EQUIPMENT. Ozone-depleting refrigerant shall not be used for cleaning purposes, including the cleaning of interior or exterior surfaces of refrigeration equipment.

(3) TRANSFERRING REFRIGERANT. Whenever ozone-depleting refrigerant is removed from refrigeration equipment, the ozone-depleting refrigerant shall be transferred to storage containers using equipment that is approved by the department. The department shall approve any transfer equipment if an approved nationally recognized testing laboratory has certified the equipment.

Note: The department will accept equipment that has been tested and certified in accordance with the Air-Conditioning and Refrigeration Institute (ARI) standard ARI 740.

(4) RELEASING REFRIGERANT. Ozone-depleting refrigerant shall not be knowingly or negligently released to the environment, except for minimal releases that occur as a result of efforts to recover, reclaim or recycle ozone-depleting refrigerant removed from refrigeration equipment.

(5) ADDING REFRIGERANT. Before putting additional ozone-depleting refrigerant into refrigeration equipment, the refrigeration equipment shall be inspected and repaired if a leak is found or suspected. A yearly leak rate identified by the federal environmental protection agency shall be used to determine whether repairs are necessary.

Subchapter V – Changes, Additions or Omissions to Adopted Standards

Comm 45.30 Changes, additions or omissions to the International Mechanical Code. Changes or additions to or omissions from the IMC are specified in this subchapter and are rules of the department and are not requirements of the IMC.

Comm 45.31 [IMC 1101] General. (1) SCOPE. The requirements in IMC section 1101.1 are not included as part of this chapter.

(2) WATER CONNECTION. Substitute the following wording for the requirements in IMC section 1101.4: Water supply and discharge connections associated with refrigeration systems shall be made in accordance with this code and chs. Comm 81 to 87.

(3) FUEL GAS CONNECTION. Substitute the following wording for the requirements in IMC section 1101.5: Fuel gas devices, equipment and appliances used with refrigeration systems shall be installed in accordance with ch. Comm 65.

(4) GENERAL. Substitute the following wording for the requirements in IMC section 1101.6:

(a) The sections of the ASHRAE 15-1994 standard, as referenced in IMC section 1101.6, that apply under this chapter are sections 8.1, 8.2, 8.6, 8.12.1, 8.12.2, 8.12.4, 8.15, 8.16, 9.1 to 9.7.4, 9.7.6 to 9.7.8.4, 9.8, 9.9, 9.10.1, 9.11, 9.12.4, 9.14, 11.1 to 11.5, 11.7.1, and 11.7.2.

(b) The sections of the IIAR 2-1999 standard, as referenced in IMC section 1101.6, that apply under this chapter are sections 5.0 to 5.14, 5.15 (intro.), 5.15.3, 5.16 to 5.18, 6.1.1.2, 6.1.1.3, 6.3.1.4, 6.3.1.8, 6.3.1.9, 6.3.2.1, 6.3.2.2, 6.3.2.3, 6.3.2.4, 6.3.3.1, 6.3.3.2, 7.1.1, 7.1.2, 7.2, 7.3.1, 7.3.2, 7.3.3, 7.3.5, 7.3.6, 7.4, 7.5.2, 7.5.3, 7.5.4, 7.5.6.4, 7.5.7, 7.5.8, and 7.6.

(5) CHANGE IN REFRIGERANT TYPE. Substitute the following wording for the requirements in IMC section 1101.8: The type of refrigerant in refrigeration systems required to be registered under s. Comm 45.07 shall not be changed without prior notification to the department and compliance with the applicable code provisions for the new refrigerant type.

(6) REFRIGERANT DISCHARGE. Substitute the following wording for the requirements in IMC section 1101.9:

(a) Except as provided in par. (b), the fire department shall be notified immediately upon the automatic or manual discharge of refrigerant from systems having a refrigerant circuit containing more than 220 pounds of Group A1 or 30 pounds of any other refrigerant. Refrigerant shall not be discharged except in an emergency.

(b) Notification is not required for any of the following conditions:

1. Refrigeration systems operating at pressures below atmospheric and incorporating automatic purge systems.

2. Incidental operation of automatic pressure relief valves resulting in minor release of the refrigerant charge.

3. Incidental minor releases associated with service operations after system pump-down has been accomplished.

Comm 45.32 [IMC 1102] System requirements. This is a department informational note to be used under IMC section 1102.2:

Note: The department will approve the use of refrigerants assigned group classifications by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) under ASHRAE standard 34, Number Designation and Safety Classification of Refrigerants. In granting the approval, the department may require compliance with additional limitations.

Comm 45.33 [IMC 1104] System application requirements. Substitute the following wording for the requirements and exception in IMC section 1104.4.2:

(1) Except as provided in sub. (2), when an evaporator or condenser is located in an air duct system, the volume of the smallest occupied space, or in the case of an unpartitioned multi-story building the volume of the smallest occupied story, served by the duct shall determine the permissible quantity of refrigerant in the system.

(2) When the air duct system serves several enclosed spaces, the permissible quantity of refrigerant in the system shall not exceed the amount determined by using the total volume of those spaces in which the airflow cannot be reduced to less than one quarter of its maximum when the fan is operating.

Comm 45.34 Installation restrictions. This is a department rule in addition to the requirements in IMC chapter 11 and a substitution for the requirements in ASHRAE 15 section 8.12.3:

(1) Refrigerant piping shall not penetrate floors, ceilings or roofs, except as follows:

(a) Penetrations connecting the basement and the first floor.

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

(c) Penetrations connecting adjacent floors served by the refrigerating system.

(d) Penetrations of a direct system where the refrigerant quantity does not exceed IMC Table 1103.1 quantity for the smallest occupied space through which the refrigerant piping passes.

(e) In other than industrial occupancies and where the refrigerant quantity exceeds IMC Table 1103.1 quantity for the smallest occupied space, penetrations that connect separate pieces of equipment that are:

1. Enclosed by an approved gas-tight, fire-resistive duct or shaft with openings to those floors served by the refrigerating system; or

2. Located on the exterior wall of a building when vented to the outside or to the space served by the system and not used as an air shaft, closed court or similar space.

Comm 45.35 [IMC 1105] Machinery room, general requirements. (1) REFRIGERANT DETECTOR. Substitute the following wording for the requirements in IMC section 1105.3:

(a) Except as provided in par. (b), 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 specified in IMC section 1103 for the refrigerant classification. The alarm shall annunciate visual and audible alarms inside the refrigerating machinery room and outside each entrance to the refrigerating machinery room.

(b) Detectors are not required for ammonia systems where the machinery room complies with IMC section 1106.3.

(2) TERMINATION OF RELIEF DEVICES. The requirements in IMC section 1105.7 are not included as part of this chapter.

(3) AMMONIA DISCHARGE. This is a department rule in addition to the requirements in IMC section 1105.8: Pressure relief valves for ammonia systems shall be replaced in accordance with manufacturer's recommendations but not to exceed 5 years from the date of installation. In lieu of

the expiration date, a relief valve may be used for a total of 5 years if a record is maintained of when it was installed and it was not over 2 years old at the time of installation.

Comm 45.36 [IMC 1106] Machinery room, special requirements. (1) AMMONIA ROOM VENTILATION. Substitute the following wording for the requirements, but not the exceptions, in IMC section 1106.3: Ventilation systems in ammonia machinery rooms shall be operated continuously at the normal ventilation rate. Failure of the mechanical ventilation system shall actuate an alarm.

(2) REMOTE CONTROLS. Substitute the following wording for the requirements in IMC section 1106.5 (intro.): 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 principal entrance.

(3) EMERGENCY SIGNS AND LABELS. Substitute the following wording for the requirements in IMC section 1106.6: Refrigeration units or systems having a refrigerant circuit containing more than 220 pounds of Group A1 or 30 pounds of any other group refrigerant shall be provided with approved emergency signs, charts and labels. Hazard signs shall be in accordance with IMC section 1103 for the refrigerant classification.

Note: See NFPA 704 for information regarding emergency signs, charts and labels.

(4) SEALING OF MACHINERY ROOMS. This is a department rule in addition to the requirements in IMC section 1106: The machinery room doors shall be tight-fitting, self-closing and swing in the direction of egress travel. Walls, floors and ceilings shall be air-tight, and pipes shall be tightly sealed to the walls, floor or ceiling through which they pass.

Comm 45.37 Design and construction of equipment and systems. These are department rules in addition to the requirements in IMC chapter 11:

(1) HYDROSTATIC PRESSURE RELIEF. This is a department exception to the requirements in ASHRAE 15 section 9.4.3: For systems containing refrigerant quantities in excess of 10,000 pounds, the use of trained technicians to isolate liquid-containing parts of the system is allowed in lieu of piped hydrostatic relief devices.

(2) DISCHARGE CAPACITY. Substitute the following wording for the requirements in ASHRAE 15 section 9.7.5:

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

$$C = fDL$$

where C = minimum required discharge capacity of the relief device in pounds of air per minute,
D = outside diameter of vessel in feet,
L = length of vessel in feet, and
f = factor dependent upon type of refrigerant from Table 45.37-1

(b) When combustible materials are used within 20 feet of a pressure vessel, the value of f shall be multiplied by 2.5. The formula is based on fire conditions; other heat sources shall be calculated separately.

Table 45.37-1
Values of f

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

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

(3) DISCHARGE PIPING LENGTH. Substitute the following wording for the requirements in ASHRAE 15 section 9.7.8.5: The maximum length of the discharge piping installed on the outlet of pressure-relief devices and fusible plugs discharging to the atmosphere shall be determined by the following:

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

where L = equivalent length of discharging piping, ft;
C_r = rated capacity as stamped on the relief device in lb/min, or in SCFM multiplied by 0.0764, or as calculated in ASHRAE 15 section 9.7.7 for a rupture member or fusible plug, or as adjusted for reduced capacity due to piping as specified by the manufacturer of the device, or as adjusted for reduced capacity due to piping as estimated by an approved method;
f = Moody friction factor in fully turbulent flow from Table 45.37-2;
d = inside diameter of pipe or tube, in;
ln = natural logarithm;
P_2 = absolute pressure at outlet of discharge piping, psi; and
P_0 = absolute allowed back pressure at the outlet of pressure relief device, psi.

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

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

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

Note: See appendix for a table of the flow capacity of various equivalent lengths of discharge piping for conventional relief valves using the above formula.

Table 45.37-2
Moody Friction Factors

Tubing OD (in.)	ID (in.)	Value of f
3/8	0.315	0.0136
1/2	0.430	0.0128
5/8	0.545	0.0122
3/4	0.666	0.0117
7/8	0.785	0.0114
1 1/8	1.025	0.0108
1 3/8	1.265	0.0104
1 5/8	1.505	0.0101

Piping NPS	ID (in.)	Value of f
1/2	0.622	0.0259
3/4	0.824	0.0240
1	1.049	0.0225
1 1/4	1.380	0.0209
1 1/2	1.610	0.0202
2	2.067	0.0190
2 1/2	2.469	0.0182
3	3.068	0.0173
4	4.026	0.0163
5	5.047	0.0155
6	6.065	0.0149

Comm 45.38 [IMC 1107] Refrigerant piping. Substitute the following wording for the requirements in IMC section 1107.4.1: 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 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 and smaller, Group A2, A3, B2 or B3 refrigerant liquid lines sizes 2 inches through 6 inches, and all refrigerant suction and discharge lines 6 inches and smaller. Type F steel pipe shall not be used for refrigerant lines.

Comm 45.39 [IMC 1108] Field test. (1) TEST GASES. Substitute the following wording for the requirements and exception in IMC section 1108.2:

(a) *Non-ammonia systems.* For non-ammonia systems, tests shall be performed with an inert dried gas such as nitrogen or carbon dioxide. Oxygen, air, combustible gases and mixtures containing such gases shall not be used.

(b) *Ammonia systems.* For ammonia systems, tests shall be performed with a dried gas such as nitrogen or air. Oxygen, carbon dioxide, halocarbon refrigerants, water or water solutions, combustible gases and mixtures containing such gases shall not be used.

(2) DECLARATION. Substitute the following wording for the requirements in IMC section 1108.4: A certificate of test shall be provided for all systems containing 55 pounds 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 certificate of test shall be signed by the installer and shall be furnished to the department upon request.

Comm 45.40 [IMC 1109] Periodic testing. This is a department rule in addition to the requirements in IMC section 1109.1: The testing of the emergency devices and systems shall be performed at least annually and documentation of the testing shall be available onsite for the inspector.

Comm 45.41 General requirements. These are department rules in addition to the requirements in IMC chapter 11:

(1) SIGNS AND IDENTIFICATION. This is a department rule in addition to the requirements in ASHRAE 15 section 11.2: Each entrance to a refrigerating machinery room shall be provided with a legible permanent sign, securely attached and easily accessible, reading "Machinery Room - Authorized Personnel Only". The sign shall further communicate that entry is forbidden except by those personnel trained in the emergency procedures required by sub. (2) when the refrigerant alarm, required by s. Comm 45.35, has been activated.

(2) RESPONSIBILITY FOR OPERATION AND EMERGENCY SHUTDOWN. Substitute the following wording for the requirements in ASHRAE 15 section 11.8:

(a) The person in charge of the premises on which a refrigerating system containing more than 55 pounds of refrigerant is installed shall provide a schematic drawing or panel giving directions for the operation of the system at a location that is convenient to the operators of the equipment.

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

1. Instructions for shutting down the system in case of emergency.

2. The name, address, and day and night telephone numbers for obtaining service.

3. The names, addresses and telephone numbers of all corporate, local, state and federal agencies to be contacted as required in the event of a reportable incident.

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

(d) The emergency procedures shall forbid entry into the refrigerating machinery room when the refrigerant alarm required by s. Comm 45.35 has been activated, except by persons provided with the appropriate respiratory and other protective equipment and trained in accordance with jurisdictional requirements.

(END)

* *

EFFECTIVE DATE

Pursuant to s. 227.22 (2)(intro.), Stats., these rules shall take effect on the first day of the month following publication in the Wisconsin Administrative Register.

* *

APPENDIX

The following table provides the flow capacity of various equivalent lengths of discharge piping for conventional relief valves using the formula in s. Comm 45.37 (3).

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

Set (PSIG)	Length (feet)	Nominal Pipe Size, NPS/DN										
		0.5	0.75	1	1.25	1.5	2	2.5	3	4	5	6
		15	20	25	32	40	50	65	80	100	125	150
5	2	2.8	5.8	10.7	21.3	31.4	57.8	88.8	148.0	278.9	469	704
5	3	2.3	4.8	9.0	18.1	26.8	49.9	77.3	130.4	249.8	426	647
5	4	2.0	4.2	7.9	16.0	23.7	44.5	69.4	117.8	228.2	393	601
5	5	1.8	3.8	7.1	14.4	21.5	40.6	63.5	108.3	211.4	367	564
5	6	1.7	3.5	6.6	13.3	19.8	37.5	58.9	100.8	197.8	346	533
5	8	1.5	3.0	5.7	11.6	17.4	33.1	52.0	89.5	177.0	312	484
5	10	1.3	2.7	5.1	10.5	15.7	29.9	47.1	81.3	161.7	286	446
5	15	1.1	2.2	4.2	8.6	12.9	24.7	39.2	67.9	135.9	243	380
5	20	0.9	1.9	3.7	7.5	11.3	21.6	34.2	59.4	119.5	214	337
5	25	0.8	1.7	3.3	6.7	10.1	19.4	30.8	53.5	107.9	194	306
5	30	0.8	1.6	3.0	6.2	9.3	17.8	28.2	49.1	99.1	179	282
5	40	0.7	1.4	2.6	5.3	8.0	15.4	24.5	42.8	86.5	156	247
5	60	0.5	1.1	2.1	4.4	6.6	12.6	20.1	35.1	71.2	129	205
5	100	0.4	0.9	1.7	3.4	5.1	9.8	15.6	27.3	55.6	101	160
5	160	0.3	0.7	1.3	2.7	4.0	7.8	12.4	21.7	44.1	80	127
5	250	0.3	0.6	1.0	2.1	3.2	6.2	9.9	17.4	35.3	64	102
15	2	4.6	9.3	16.7	32.0	46.0	81.6	121.8	196.5	355.2	577	849
15	3	3.9	8.0	15.5	28.3	41.0	74.0	111.6	182.3	334.5	550	815
15	4	3.5	7.1	13.0	25.6	37.4	68.1	103.6	170.8	317.1	526	784
15	5	3.1	6.5	11.9	23.6	34.6	63.5	97.1	161.2	302.2	506	757
15	6	2.9	6.0	11.0	22.0	32.3	59.7	91.7	153.1	289.2	487	732
15	8	2.5	5.2	9.7	19.5	28.9	53.8	83.2	140.0	267.5	455	689
15	10	2.3	4.7	8.8	17.8	26.3	49.3	76.7	129.7	250.1	429	683
15	15	1.9	3.9	7.3	14.8	22.1	41.7	65.3	111.6	218.0	379	583

Set (PSIG)	Length (feet)	Nominal Pipe Size, NPS/DN										
		0.5	0.75	1	1.25	1.5	2	2.5	3	4	5	6
		15	20	25	32	40	50	65	80	100	125	150
50	2	7.6	14.7	25.4	46.5	65.3	111.7	162.8	256	451	718	1045
50	3	6.8	13.2	23.2	43.4	61.4	106.3	156.1	248	439	704	1027
50	4	6.1	12.2	21.6	40.8	58.1	101.6	150.2	240	429	691	1011
50	5	5.7	11.3	20.2	38.6	55.2	97.4	144.9	233	419	678	996
50	6	5.3	10.6	19.1	36.7	52.8	93.8	140.1	226	410	666	981
50	8	4.7	9.5	17.3	33.6	48.7	87.5	131.8	215	393	644	953
50	10	4.3	8.7	15.9	31.2	45.5	82.4	124.8	205	378	624	927
50	15	3.6	7.4	13.6	26.9	39.6	72.7	113.3	185	347	582	872
50	20	3.1	6.5	12.0	24.0	35.5	65.8	101.4	170	323	547	825
50	25	2.8	5.9	10.9	21.9	32.4	60.5	93.8	158	303	517	785
50	30	2.6	5.4	10.0	20.3	30.1	56.3	87.6	148	286	492	750
50	40	2.3	4.7	8.8	17.8	26.6	50.1	78.3	133	260	451	692
50	60	1.9	3.9	7.3	14.8	22.1	42.0	66.0	113	224	393	608
50	100	1.4	3.0	5.7	11.6	17.4	33.3	52.6	91	182	323	504
50	160	1.1	2.4	4.5	9.3	13.9	26.7	42.3	73	148	265	416
50	250	0.9	1.9	3.6	7.5	11.2	21.5	34.2	59	120	217	342
75	2	9.1	17.2	29.4	53.3	74.3	126.0	182.7	286	501	795	1154
75	3	8.2	15.8	27.3	50.4	70.7	121.2	176.9	279	491	783	1140
75	4	7.5	14.6	25.7	47.8	67.6	116.9	171.6	272	482	772	1127
75	5	7.0	13.7	24.3	45.7	64.8	113.1	166.8	266	474	762	1114
75	6	6.5	13.0	23.1	43.7	62.4	109.6	162.3	260	466	751	1101
75	8	5.9	11.8	21.1	40.6	58.3	103.4	154.4	249	450	732	1077
75	10	5.4	10.8	19.6	38.0	54.9	98.2	147.5	240	437	714	1054
75	15	4.5	9.2	16.9	33.2	48.4	88.0	133.7	220	407	675	1004

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

Set (PSIG)	Length (feet)	Nominal Pipe Size, NPS/DN											Set (PSIG)	Length (feet)	Nominal Pipe Size, NPS/DN									
		0.5	0.75	1	1.25	1.5	2	2.5	3	4	5	6			0.5	0.75	1	1.25	1.5	2	2.5	3	4	5	6
		15	20	25	32	40	50	65	80	100	125	150			15	20	25	32	40	50	65	80	100	125	150
15	20	1.6	3.4	6.4	13.0	19.4	36.8	57.9	99.4	195.8	344	532	75	20	4.0	8.2	15.1	29.9	43.8	80.5	123.1	204	383	641	960
15	25	1.5	3.1	5.7	11.7	17.5	33.3	52.5	90.5	179.3	316	492	75	25	3.6	7.4	13.7	27.4	40.3	74.6	114.8	192	363	612	921
15	30	1.3	2.8	5.3	10.7	16.1	30.7	48.4	83.6	166.3	295	460	75	30	3.3	6.8	12.7	25.4	37.6	69.8	107.9	181	345	587	887
15	40	1.2	2.4	4.6	9.4	14.0	26.8	42.4	73.5	147.1	262	411	75	40	2.9	6.0	11.2	22.5	33.4	62.5	97.2	164	317	544	828
15	60	1.0	2.0	3.8	7.7	11.6	22.1	35.1	61.0	122.7	220	347	75	60	2.4	5.0	9.3	16.8	28.0	52.9	82.8	141	276	481	739
15	100	0.7	1.5	2.9	6.0	9.0	17.3	27.5	47.9	96.8	175	276	75	100	1.9	3.9	7.3	14.8	22.2	42.2	66.5	115	227	401	623
15	160	0.6	1.2	2.3	4.7	7.1	13.7	21.8	38.1	77.3	140	222	75	160	1.5	3.1	5.8	11.9	17.8	34.0	53.8	93	186	332	520
15	250	0.5	1.0	1.9	3.8	5.7	11.0	17.5	30.6	62.3	113	179	75	250	1.2	2.5	4.7	9.6	14.4	27.5	43.6	76	153	274	432
25	2	5.7	11.3	20.0	37.6	53.5	93.2	137.5	219.2	398.5	628	918	100	2	10.3	19.4	32.9	59.3	82.2	138.8	200.8	314	547	868	1258
25	3	4.9	9.9	17.8	34.0	48.8	86.5	128.8	207.5	374.4	608	893	100	3	9.4	17.9	30.9	56.4	78.9	134.4	195.4	307	539	857	1246
25	4	4.4	8.9	16.2	31.3	45.3	81.0	121.6	197.6	360.1	589	869	100	4	8.7	16.8	29.2	54.0	75.9	130.3	190.4	301	531	847	1234
25	5	4.0	8.2	14.9	29.1	42.3	76.4	115.5	188.9	347.3	572	848	100	5	8.1	15.8	27.8	51.8	73.2	126.6	185.9	295	523	837	1222
25	6	3.7	7.6	13.9	27.4	39.9	72.6	110.2	181.3	335.8	556	828	100	6	7.6	15.0	26.5	49.9	70.8	123.2	181.7	289	515	828	1210
25	8	3.3	6.7	12.4	24.6	36.1	66.4	101.5	168.5	315.9	529	791	100	8	6.9	13.7	24.5	46.6	66.6	117.2	174.0	279	501	810	1188
25	10	3.0	6.1	11.3	22.6	33.3	61.5	94.6	158.1	299.1	505	759	100	10	6.3	12.7	22.8	43.9	63.1	112.0	167.2	270	488	793	1167
25	15	2.5	5.1	9.5	19.1	28.3	52.9	82.1	138.7	266.6	457	694	100	15	5.4	10.9	19.9	38.7	56.3	101.4	153.1	250	459	756	1120
25	20	2.1	4.5	8.3	16.8	25.0	47.1	73.5	125.0	242.9	420	643	100	20	4.7	9.7	17.8	35.1	51.3	93.4	142.1	234	435	723	1077
25	25	1.9	4.0	7.5	15.2	22.7	42.9	67.1	114.7	224.5	391	602	100	25	4.3	8.8	16.3	32.3	47.4	87.0	133.2	221	415	694	1039
25	30	1.8	3.7	6.9	14.0	20.9	39.6	62.2	106.6	209.8	367	568	100	30	4.0	8.2	15.1	30.1	44.3	81.8	125.8	210	397	668	1005
25	40	1.5	3.2	6.0	12.2	18.3	34.8	54.9	94.5	187.3	331	514	100	40	3.5	7.2	13.3	26.7	39.5	73.7	114.0	192	367	625	946
25	60	1.3	2.6	4.9	10.1	15.1	28.9	45.7	79.1	158.0	281	440	100	60	2.9	5.9	11.1	22.4	33.4	62.7	97.9	166	323	558	853
25	100	1.0	2.0	3.8	7.9	11.8	22.7	36.0	62.5	125.8	226	356	100	100	2.2	4.7	8.7	17.8	26.6	50.4	79.2	136	268	471	728
25	160	0.8	1.6	3.1	6.3	9.4	18.1	28.7	50.0	101.1	183	289	100	160	1.8	3.7	7.0	14.3	21.4	40.7	64.3	111	222	393	614
25	250	0.6	1.3	2.4	5.0	7.6	14.5	32.1	40.3	81.7	148	235	100	250	1.4	3.0	5.6	11.5	17.3	33.0	52.3	91	182	326	513

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

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

Set (PSIG)	Length (feet)	Nominal Pipe Size, NPS/DN											Set (PSIG)	Length (feet)	Nominal Pipe Size, NPS/DN									
		0.5	0.75	1	1.25	1.5	2	2.5	3	4	5	6			0.5	0.75	1	1.25	1.5	2	2.5	3	4	5	6
		15	20	25	32	40	50	65	80	100	125	150			15	20	25	32	40	50	65	80	100	125	150
150	2	12.5	23.3	39.2	70.1	96.8	162.7	234.5	366	636	1006	1457	300	2	18.4	33.7	56.1	99.4	136.7	228.3	328	510	884	1395	2019
150	3	11.6	21.8	37.2	67.4	93.7	158.5	229.6	360	628	996	1446	300	3	17.3	32.1	54.0	96.0	133.5	224.2	323	504	877	1386	2009
150	4	10.8	20.6	35.5	64.9	90.8	154.7	225.1	354	621	987	1435	300	4	16.4	30.8	52.2	94.1	130.6	220.4	319	498	869	1378	1998
150	5	10.2	19.6	34.0	62.8	88.1	151.2	220.7	348	613	979	1425	300	5	15.6	29.6	50.5	91.7	127.8	216.8	314	493	862	1369	1988
150	6	9.6	18.7	32.7	60.8	85.7	147.8	216.6	343	606	970	1414	300	6	14.9	28.5	49.0	89.6	125.2	213.4	310	488	856	1361	1978
150	8	8.8	17.3	30.5	57.3	81.4	141.8	209.1	333	593	954	1394	300	8	13.8	26.6	46.3	85.6	120.4	206.9	302	478	843	1345	1959
150	10	8.1	16.1	28.7	54.4	77.7	136.5	202.3	324	581	938	1375	300	10	12.8	25.1	44.1	82.2	116.2	201.0	295	468	830	1330	1940
150	15	6.9	14.0	25.2	48.7	70.3	125.4	187.8	304	553	902	1330	300	15	11.2	22.2	39.6	75.1	107.2	188.3	279	447	801	1293	1895
150	20	6.2	12.5	22.8	44.5	64.6	116.6	176.0	288	529	870	1289	300	20	10.0	20.1	36.2	69.6	100.1	177.7	265	428	775	1260	1853
150	25	5.6	11.4	21.0	41.2	60.2	109.4	166.2	274	507	841	1251	300	25	9.2	18.6	33.6	65.2	94.2	168.7	253	412	751	1229	1814
150	30	5.2	10.6	19.5	38.6	56.5	103.4	157.9	261	488	815	1217	300	30	8.5	17.3	31.5	61.5	89.2	160.9	243	397	729	1200	1777
150	40	4.5	9.4	17.3	34.5	50.8	93.9	144.5	241	456	769	1156	300	40	7.5	15.4	28.2	55.6	81.3	148.2	225	372	691	1148	1710
150	60	3.8	7.8	14.5	29.2	43.3	80.8	125.4	212	407	696	1058	300	60	6.3	12.9	23.9	47.7	70.2	129.7	199	333	639	1061	1595
150	100	2.9	6.1	11.5	23.3	34.7	65.6	102.7	175	343	597	918	300	100	4.9	10.3	19.1	38.5	57.2	107.1	167	282	544	934	1422
150	160	2.3	4.9	9.2	18.7	28.0	53.3	84.0	145	286	505	785	300	160	3.9	8.2	15.4	31.3	46.6	88.1	138	236	463	807	1243
150	250	1.9	3.9	7.4	15.2	22.7	43.4	68.6	119	238	423	662	300	250	3.2	6.6	12.5	25.4	38.0	72.3	114	196	389	687	1068
200	2	14.6	26.9	45.0	80.2	110.6	185.2	266.6	415	721	1139	1649	350	2	20.3	37.0	61.4	108.6	149	249	358	556	963	1519	2199
200	3	13.6	25.4	43.1	77.5	107.4	181.2	261.9	409	713	1130	1638	350	3	19.1	35.3	59.3	105.8	146	245	353	550	956	1510	2189
200	4	12.7	24.2	41.3	75.1	104.6	177.4	257.4	404	706	1121	1628	350	4	18.1	33.9	57.4	103.3	143	241	348	544	949	1502	2178
200	5	12.0	23.1	39.8	72.8	101.9	173.9	253.1	398	699	1113	1618	350	5	17.3	32.7	55.7	100.9	140	237	344	539	941	1493	2168
200	6	11.5	22.1	38.4	70.8	99.4	170.6	249.1	393	692	1105	1608	350	6	16.6	31.5	54.1	98.6	137	234	340	534	935	1484	2158
200	8	10.5	20.5	36.0	67.2	95.0	164.5	241.5	383	679	1089	1588	350	8	15.3	29.6	51.3	94.5	132	227	331	523	921	1468	2139
200	10	9.7	19.2	34.0	64.1	91.1	159.0	234.6	374	667	1073	1570	350	10	14.4	28.0	48.9	90.9	128	221	324	514	908	1452	2120
200	15	8.4	16.8	30.2	57.9	83.2	147.3	219.6	354	639	1038	1525	350	15	12.5	24.8	44.1	83.5	119	208	307	492	879	1414	2075
200	20	7.5	15.2	27.5	53.2	77.0	137.9	207.2	337	614	1005	1485	350	20	11.3	22.6	40.5	77.6	111	196	293	473	852	1379	2032

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

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

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