**BSR/ASHRAE Standard 15.2P**

# Public Review Draft

# Safety Standard for Refrigeration Systems in Residential Applications

**Second Public Review (October 2020)**
**(Draft Shows Complete Proposed Standard)**

This draft has been recommended for public review by the responsible project committee. To submit a comment on this proposed standard, go to the ASHRAE website at www.ashrae.org/standards-research--technology/public-review-drafts and access the online comment database. The draft is subject to modification until it is approved for publication by the Board of Directors and ANSI. Until this time, the current edition of the standard (as modified by any published addenda on the ASHRAE website) remains in effect. The current edition of any standard may be purchased from the ASHRAE Online Store at www.ashrae.org/bookstore or by calling 404-636-8400 or 1-800-727-4723 (for orders in the U.S. or Canada).

The appearance of any technical data or editorial material in this public review document does not constitute endorsement, warranty, or guaranty by ASHRAE of any product, service, process, procedure, or design, and ASHRAE expressly disclaims such.

© 2020 ASHRAE. This draft is covered under ASHRAE copyright. Permission to reproduce or redistribute all or any part of this document must be obtained from the ASHRAE Manager of Standards, 1791 Tullie Circle, NE, Atlanta, GA 30329. Phone: 404-636-8400, Ext. 1138. Fax: 404-321-5478. E-mail: standards.section@ashrae.org.

**ASHRAE, 1791 Tullie Circle, NE, Atlanta GA 30329-2305**

**(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)**

## FOREWORD

*This proposed standard is the "residential" companion to the existing ANSI/ASHRAE Standard 15, Safety Standard for Refrigeration Systems. As the title implies, this standard is focused for residential applications. SSPC 15 and the Standard 15.2 subcommittee notes the following aspects of the proposed standard. Historically, residential HVAC systems have not been subjected to as rigorous application safety requirements as commercial HVAC systems related to accidental refrigerant release primarily due to: a) only refrigerants classified as A1 by ASHRAE Standard 34 have been permitted by product safety standards such as UL 1995 and UL 60335-2-40 and b) acute toxicity exposure limit (ATEL) limits of the pertinent refrigerants in residential applications would typically not be exceeded in the event of a catastrophic leak. The current movement towards refrigerants having lower global warming potential (GWP) – many of which are classified as A2L by ANSI/ASHRAE Standard 34, Designation and Safety Classification of Refrigerants – has resulted in the need for an application safety standard on which building codes could rely. The primary objective of this proposed Standard 15.2 is to craft a stakeholder document that can be utilized to seek changes in the model building codes. It is the intention that this standard can be understood and applied by manufacturers, installers, contractors, service technicians, building code officials and any other stakeholder.*

*North American product safety standards for residential products have been modified to address flammable refrigerants. UL/CSA 60335-2-40 3rd edition was released in December of 2019. This proposed ASHRAE application safety standard was developed in parallel and is more conservative than the UL standard in several places and never less conservative.*

*The first public review draft for this standard received over 145 comments. For this second public review draft, more than one hundred of these comments have been incorporated to improve the standard, resulting in the revision of many of the standard sections. Significant changes are summarized below:*

*5. GENERAL REQUIREMENTS*

*Requirements for detection systems and mitigation actions were added.*

*6. REFRIGERANT CLASSIFICATION AND REQUIREMENTS*

*The information related to service and maintenance was moved to Informative Appendix B, "General Service and Maintenance."*

*8. PIPING REQUIREMENTS*

*This section was rewritten and reorganized for better clarity. Changes were made to allow the use of existing interconnecting piping when installing a new system.*

*9. MAXIMUM REFRIGERANT CHARGE*

*This section was reorganized and rewritten for clarity. A compliance flow chart was added to visually direct the user to the proper sections. The symbols and names were reduced for clarity. The method for determining the area and the height of the dispersal volume was clarified. Finally, the tables were changed from a generic refrigerant to R-32 with correction factors for the other currently available A2L refrigerants.*

*10. SYSTEM INSTALLATION*

*The piping strength and leak test was moved to this section as those tasks are part of the installation.*

*11. MECHANICAL VENTILATION*

*This section was reorganized and rewritten for clarity adding requirements on exhaust air from ventilation.*

*12. ADD-ON HEAT PUMPS*

*This section was reorganized and rewritten for clarity. The requirements of Section 14 were consolidated into this section. The equations were replaced with tables for the other currently available A2L refrigerants.*

*13. REFRIGERANT CHARGE CALCULATION METHOD FOR A2L REFRIGERANTS*

*This section was eliminated as it was no longer necessary.*

*14. MAXIMUM INDUCTIVE ELECTRICAL LOAD FOR ADD-ON HEAT PUMPS*

*This section's requirements were consolidated into Section 12, "Add-On Heat Pumps."*

## 1. PURPOSE

This standard specifies the minimum requirements for the safe design and installation of refrigeration systems used in residential applications.

## 2. *SCOPE

**2.1** This standard applies to listed direct refrigeration systems in the following residential applications that are limited to serving only a single dwelling unit or sleeping unit:

a. one- and two-family dwellings and townhouses;
b. detached outbuildings associated with a one- or two-family dwelling or townhouse and located on the same property included in a) above, and
c. individual dwelling units and sleeping units located in a multi-family occupancy.

## 3. ADMINISTRATIVE

**3.1 Precedence with Conflicting Requirements.** Where there is a conflict between this standard and local building, electrical, fire, mechanical, or other adopted codes, the provisions of the local or adopted code shall take precedence, unless otherwise stated in those codes.

**3.2 Alternative Materials, Methods, Equipment, and Appliances.** The provisions of this standard are not intended to prevent the installation of any material or to prohibit any method of construction not specifically prescribed by this standard, provided that any alternative is approved by the authority having jurisdiction.

**3.3 New Technologies.** Nothing in this standard shall be construed as a restriction on new technologies or alternative methods, provided that the level of safety as herein described is not reduced and is acceptable to the authority having jurisdiction.

## 4. DEFINITIONS

***access (to):*** that which enables a device, appliance, or equipment to be reached by ready access or by a means that first requires the removal or movement of a panel, door, or similar obstruction, or the use of a ladder.

***add-on heat pump:*** a refrigeration system for heating and cooling, cooling only, or heating only that normally consists of an outdoor section, one or more indoor sections (without a circulating fan), and related control devices.

***air conditioner:*** a refrigeration system used to transfer heat from a space or substance.

***appliance:*** equipment, generally other than industrial, that is normally built in standardized sizes or types and is installed or connected to perform one or more functions such as clothes washing, air-conditioning, food mixing, deep frying, and so forth.

***approved:*** acceptable to the authority having jurisdiction.

***authority having jurisdiction (AHJ):*** an organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

***attic:*** the unfinished space between the ceiling assembly and the roof assembly.

***brazed joint:*** a gas-tight joint obtained by the joining of metal parts with metallic mixtures or alloys that melt at temperatures above 842°F (450°C) but less than the melting temperatures of the joined parts.

***building code:*** the building code adopted by the jurisdiction.

***circulation:*** mechanically inducing airflow within a space or duct connected spaces.

***compressor:*** a machine used to compress refrigerant vapor.

***conditioned air:*** air that has been heated, cooled, humidified, or dehumidified.

***conditioned space:*** an area, room, or space that is enclosed within the building thermal envelope that is directly or indirectly heated or cooled. Spaces are indirectly heated or cooled where they communicate through openings with conditioned spaces, where they are separated from conditioned spaces by uninsulated walls, floors, or ceilings, or where they contain uninsulated ducts, tubing, or other sources of heating or cooling.

***crawl space:*** an uninhabitable space between the bottom of the floor joists and the earth under a dwelling to which service personnel have access.

***design pressure:*** the maximum gage pressure for which a specific part of a refrigeration system is designed.

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

***dispersal volume:*** the cubic measure of space into which refrigerant flows in the event of a refrigerant leak.

****duct:*** a tube or conduit used to convey or encase something.

***air duct:*** a tube or conduit used to convey air.

***ducted HVAC:*** an air conditioner, heat pump, whole house dehumidifier, or whole house dehumidifying ventilator in which conditioned air is distributed through any amount of ductwork.

***ductless HVAC:*** an air conditioner, heat pump in which conditioned air is distributed directly into the conditioned space from the equipment without the use of ductwork.

***ductwork:*** see duct.

***dwelling:*** any building that contains one or two dwelling units used, intended, or designed to be built, used, rented, leased, or otherwise occupied for living purposes.

***dwelling, multi-family:*** a building that contains three or more dwelling units.

***dwelling unit:*** a single unit providing complete independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking, and sanitation.

***equipment:*** all control devices, condensing sections, evaporator sections, combination appliances, and other components of fixed systems that are integrated to provide control of environmental conditions for buildings.

****field installed accessories:*** components added to comfort conditioning systems during or after installation, including items added directly to the equipment.

***fixed:*** a type of refrigeration system that is intended to be used while fastened to a support or while secured in a specific location.

***fusible plug:*** a plug containing an alloy that will melt at a specified temperature and relief pressure.

***header:*** a pipe or tube that is extruded, cast, or fabricated, to which other pipes or tubes are connected.

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

***heat pump water heater:*** a refrigeration system used to heat potable water.

****ignition source:*** a flame, spark, or hot surface capable of igniting flammable vapors or fumes.

***integral:*** mounted within or mounted directly to an equipment housing and treated as part of the equipment.

***line set:*** a set of two field installed refrigerant pipes that extends from the condenser to the evaporator in direct systems, consisting of a suction line and a liquid line.

***listed:*** equipment or materials included in a list published by an approved, nationally recognized testing laboratory, inspection agency, or other organization concerned with product evaluation that maintains periodic inspection of

production of listed equipment or materials and whose listing states either that the equipment or material meets nationally recognized standards or has been tested and found suitable for use in a specified manner.

***lower flammability limit (LFL):*** the minimum concentration of the refrigerant at which a flame is capable of propagating through a homogenous mixture of the refrigerant and air under specific test conditions, as defined by ANSI/ASHRAE Standard 34[1].

***manufacturer:*** the company or organization that evidences its responsibility by affixing its name, trademark, or trade name to refrigeration equipment.

***manufacturer's installation instructions:*** printed instructions included with equipment as part of the conditions of listing and labeling.

***mechanical code:*** the mechanical code adopted by the jurisdiction.

***mechanical joint:*** a gas-tight joint obtained by joining metal parts with a positive-holding mechanical construction such as flanged, screwed, or flared joints or compression fittings.

***micron:*** a unit of pressure equal to the height of column of mercury in μm of Hg which is used to denote absolute pressure on a scale where a perfect vacuum is 0 microns and atmospheric pressure at sea-level is 760,000 microns.

***mitigation actions:*** a series of actions taken by equipment that are initiated by detection of leaked refrigerant by the refrigerant detection system.

***multi-split system:*** a split system air conditioner or heat pump having three or more steps of capacity with two or more independently controlled indoor sections on a single refrigeration system.

***nationally recognized testing laboratory (NRTL):*** an organization which is recognized by OSHA and which tests for safety, and lists or labels or accepts, equipment or materials, as defined by 29 C.F.R. §1910.7.

***piping:*** see *tubing*.

***plenum:*** a compartment or chamber to which one or more air ducts are connected and that forms part of the air distribution system.

***pressure-limiting device:*** a pressure-responsive electronic or mechanical control designed to automatically stop the operation of the pressure-imposing element at a predetermined pressure.

****pressure-relief device:*** a pressure-, not temperature-, actuated valve or rupture member designed to automatically relieve pressure higher than its setting.

***pressure vessel:*** any refrigerant-containing receptacle in a refrigeration system, other than the following:

1. Evaporators, where each separate evaporator section does not exceed 0.5 $ft^3$ (0.014 $m^3$) of refrigerant-containing volume regardless of the maximum inside dimension, and
2. Evaporator coils, compressors, condenser coils, controls, headers, pumps, and piping.

***ready access (to):*** that which enables a device, appliance, or equipment to be directly reached, without requiring the removal or movement of any panel, door, or similar obstruction, or the use of a ladder.

***reclaimed refrigerants:*** refrigerants reprocessed to the same specifications as new refrigerants by any means, including distillation. Such refrigerants have been chemically analyzed to verify that those specifications have been met.

***recycled refrigerants:*** previously used refrigerants for which contaminants have been reduced by oil separation, removal of non-condensable gases, and single or multiple passes through filter driers or other devices that reduce moisture, acidity, and particulate matter.

***refrigerant:*** the fluid used for heat transfer in a refrigeration system; the refrigerant absorbs heat and transfers it at a higher temperature and a higher pressure, usually with a change of state.

***refrigerant charge, system ($m_s$):*** the mass of refrigerant in a single refrigeration system after completion of field refrigerant charge adjustment.

***refrigerant charge, maximum ($m_{max}$):*** the largest permissible mass of refrigerant for a space.

***refrigerant charge, releasable ($m_{rel}$):*** the portion of the total refrigeration system charge that can be released into a space.

***refrigerant circuit:*** a complete series of refrigerant containing parts of the refrigeration system, including but not limited to, compressor(s), coil(s), tubing, piping, filter drier(s), accumulator(s), receiver(s), reversing valve(s), and service valve(s).

***refrigerant concentration limit (RCL):*** the concentration limit of a refrigerant in air, determined in accordance with ANSI/ASHRAE Standard 34, intended to reduce the risks of acute toxicity, asphyxiation, and flammability hazards in normally occupied, enclosed spaces.

***refrigerant designation:*** the unique identifying alphanumeric value or refrigerant number assigned to an individual refrigerant as published in ANSI/ASHRAE Standard 34.

***refrigerant detector:*** a device that is capable of sensing the presence of refrigerant vapor.

****refrigeration detection system:*** a system or portion of a combination system that utilizes one or more stationary devices to detect the presence of a specified refrigerant at a specified concentration and initiates one or more mitigation actions required by this standard. A self-contained refrigerant detector and alarm device is not classified as a refrigerant detection system.

***refrigeration system:*** a combination of interconnected equipment, connected by tubing, which forms a closed refrigerant circuit in which refrigerant is circulated to extract, then reject, heat.

***rupture member:*** a non-reclosing device that will rupture and release refrigerant to relieve pressure.

***safety shut-off valve:*** an automatically controlled refrigerant valve that is connected to a refrigerant detection system to limit the amount of refrigerant released into a space when a refrigerant leak is detected.

***self-contained system:*** a complete, factory-assembled, and factory-tested system that is shipped in one or more sections and has no refrigerant-containing parts that are joined in the field by other than companion or block valves.

***shall:*** used in this standard when a provision is mandatory.

***shall not:*** used in this standard when an action is prohibited.

****sleeping unit:*** a single unit that provides rooms or spaces for one or more persons, includes permanent provisions for sleeping and can include provisions for living, eating, and either sanitation or kitchen facilities but not both. Such rooms and spaces that are also part of a dwelling unit are not sleeping units.

***space:*** an enclosed volume within a residential building.

***split system:*** any air conditioner or heat pump that has one or more of the major assemblies separated from the others.

> ***indoor section:*** a component of a split system central air conditioner or heat pump that is designed to transfer heat between refrigerant and the conditioned space.
>
> ***outdoor section:*** a component of a split system central air conditioner or heat pump that is designed to transfer heat between refrigerant and heat sink outside the conditioned space.

***tubing:*** pipe or tube used to convey fluid from one part of a refrigeration system to another. Tubing includes tubes, flanges, bolting, gaskets, valves, fittings, tube-supporting fixtures, structural attachments, and the pressure-containing parts of other components, such as expansion joints, strainers, filters, and devices that serve such purposes as mixing, separating, muffling, snubbing, distributing, metering, or controlling flow.

***ventilation:*** providing a space with ventilation air.

***ventilation air:*** external air delivered to a space via mechanical methods that is intended to dilute released refrigerant.

***whole house dehumidifier:*** a refrigeration system used to remove water vapor from a dwelling.

***whole house dehumidifying ventilator:*** a refrigeration system used to remove water vapor from outdoor air supplied to a dwelling or a combination of outdoor air and recirculated air supplied to a dwelling.

## 5. GENERAL REQUIREMENTS

**5.1 Equipment Requirements.** All fixed refrigeration systems using A2L refrigerants shall be listed to UL 60335-2-40/CSA-C22.2 No. 60335-2-40-19. Refrigeration systems using A1 refrigerants shall be listed to either UL 60335-2-40/CSA-C22.2 No. 60335-2-40-19 or UL 1995/CSA C22.2 No. 236.

**5.2 Manufacturer's Installation Instructions.** All refrigeration systems shall be installed in accordance with the manufacturer's installation instructions. After installation, the manufacturer's installation instructions, owner's manuals, service manuals, and any other product literature provided with the equipment shall be left with the homeowner or building owner.

**5.3 *Refrigerant Detection System Requirements.** Refrigeration systems with more than m1 refrigerant charge, as determined in Section 9.4, shall have an integral refrigerant detection system. The refrigerant detection system shall comply with the following:

1. Utilize a non-adjustable set point to initiate mitigation actions.
2. Recalibration of the set point shall not be permitted.
3. Capable of detecting the refrigerant contained in the refrigeration system.
4. Have access for replacement of refrigerant detection system components.
5. Have self-diagnostics to determine operational status of the sensing element.
6. Energize air circulation fans of the equipment upon failure of a self-diagnostic check.
7. Tested under either of the two conditions to ensure an output signal is initiated in not more than:
   a. 15 seconds when sensing a refrigerant concentration of 25% LFL or less
   b. 10 seconds when sensing a refrigerant concentration of more than 25% of up to 100% LFL or less

**5.3.1 Mitigation Action Requirements.** When a refrigerant detection system provides an output signal, the following mitigation actions shall occur within 15 seconds:

1. Energize the air circulation fan(s) of the equipment.
2. Deenergize the compressor.
3. Open zoning dampers installed in the ductwork connected to the refrigeration system.
4. Activate required mechanical ventilation per Section 11, "Mechanical Ventilation."
5. Deenergize integral electric resistance heat or electric resistance heat installed in the ductwork connected to the refrigeration system.

**5.4 Field Installed Accessory Requirements.** All field installed accessories shall be listed to the component standards of UL 60335-2-40/CSA-C22.2 No. 60335-2-40-19 or UL 1995/CSA C22.2 No. 236 and installed in accordance with the manufacturer's installation instructions. Field installed accessories for A2L refrigeration systems that are ignition sources shall additionally be listed to UL 60079-15.

**5.5 Ductwork and Duct Systems.** All ductwork and duct systems shall comply with one of the following codes: the ICC International Residential Code (Mechanical Section); ICC International Mechanical Code; IAPMO Uniform Mechanical Code; NFPA 90A or NFPA 90B.

**5.6 Signs and Identification.** Each refrigeration system shall have the following information legibly and permanently indicated on a markable label provided by the equipment manufacturer:

a. contact information of the responsible company that installed the refrigeration system, and
b. the actual refrigerant charge

## 6. REFRIGERANT CLASSIFICATION AND REQUIREMENTS

**6.1 *Permissible Refrigerants.** Only refrigerants having an approved refrigerant designation of safety group A1 or A2L in ANSI/ASHRAE Standard 34 shall be used in conjunction with this standard.

### 6.2 Refrigerant Requirements

**6.2.1 Refrigerant Type and Purity.** Refrigerants used in a refrigeration system shall have a designation specified by the equipment manufacturer and the refrigerant designation shall be marked on the appliance. Refrigerants used to adjust the charge in new equipment shall conform to AHRI 700 in purity unless a more restrictive specification is specified by the equipment manufacturer.

**6.2.2 Used Refrigerants.** Only reclaimed refrigerants that have been reclaimed by an EPA-certified refrigerant reclaimer in accordance with AHRI 700 shall be permitted to be reused.

## 7. LOCATION OF REFRIGERATION SYSTEMS AND RESTRICTIONS

**7.1 General.** Refrigeration systems shall be located in accordance with the manufacturer's installation instructions.

**7.1.1 Indoor Equipment.** Equipment marked with an ingress protection code of less than IP54 on the nameplate per ANSI/IEC 60529 or CSA-C22.2 no. 60529:05 (R2016) shall not be installed outdoors.

**7.1.2 Outdoor Equipment.** Equipment marked "For outdoor use only" shall only be installed outdoors.

**7.1.3 Provision for Service**

**7.1.3.1** Access shall be provided to all serviceable components of refrigeration systems.

**7.1.3.2** Access shall be provided to outdoor sections or outdoor sections with enclosures.

## 8. PIPING REQUIREMENTS

**8.1 General.** Refrigerant piping, valves, and fittings shall comply with Sections 8.2 through 8.6.

**8.2 Materials.** Materials used in the construction and installation of refrigeration systems shall be suitable for conveying the refrigerant used. Materials that will deteriorate because of the refrigerant, the lubricant, or their combination in the presence of air or moisture shall not be used.

**8.2.1 Magnesium Alloy Restriction.** Magnesium alloys shall not be used in contact with any halogenated refrigerants.

**8.3 Refrigerant Piping, Valves, Fittings, and Related Parts.** Refrigerant piping, valves, fittings, and related parts, whether new or reused on an existing refrigeration system that is being renovated or modified, shall comply with Sections 8.3.1 through 8.3.5.

**8.3.1 General.** Refrigerant piping, valves, fittings, and related parts having a maximum internal or external design pressure greater than 15 psig (103.4 kPa gage) shall be listed either individually or as part of an assembly or a system by an approved, nationally recognized testing laboratory, or shall comply with ASME B31.5 where applicable.

**8.3.2 Piping.** Refrigerant pipe shall either be listed or demonstrate compliance with one or more of the standards in Table 8.3.2.

**Table 8.3.2 Refrigerant Pipe**

| Piping Material | Standard |
|---|---|
| Aluminum Tube | ASTM B210, ASTM B210M, ASTM B491/B491M |
| Copper Tube | ASTM B68, ASTM B75, ASTM B280, ASTM B819 |
| Copper Line Sets | ASTM B1003, ASTM B280 |

**8.3.2.1 Annealed Copper Tube.** Soft annealed copper tubing larger than 1 3/8 in. (35 mm) O.D. shall not be used for field assembled refrigerant piping, unless it is protected from mechanical damage.

**8.3.3 Pipe Fittings.** Refrigerant pipe fittings shall be suitable for installation with the piping materials to be installed and shall either comply with one or more of the standards listed in Table 8.3.3 or be listed to UL 207.

**Table 8.3.3 Refrigerant Pipe Fittings**

| Fitting Material | Standard |
|---|---|
| Aluminum | ASTM B361 |
| Brass (Copper Alloy) | ASME B16.15 |
| Copper | ASME B16.15, ASME B16.18, ASME B16.22, ASME B16.26, ASME B16.50 |
| Steel | ASTM A105, ASTM A181, ASTM A234, ASTM A420 |

**8.3.3.1 Copper Brazed Field Swaged Fittings.** The minimum and maximum cup depth of field fabricated copper brazed swaged fitting connections shall comply with Table 8.3.3.1.

**Table 8.3.3.1 Copper Brazed Swaged Cup Depths**

| Fitting Size (Inch) | Minimum (Inch) | Maximum (Inch) |
|---|---|---|
| 1/8 | 0.15 | 0.23 |
| 3/16 | 0.16 | 0.24 |
| 1/4 | 0.17 | 0.26 |
| 3/8 | 0.20 | 0.30 |
| 1/2 | 0.22 | 0.33 |
| 5/8 | 0.24 | 0.36 |
| 3/4 | 0.25 | 0.38 |
| 1 | 0.28 | 0.42 |
| 1-1/4 | 0.31 | 0.47 |
| 1-1/2 | 0.34 | 0.51 |
| 2 | 0.40 | 0.60 |
| 2-1/2 | 0.47 | 0.71 |
| 3 | 0.53 | 0.80 |
| 3-1/2 | 0.59 | 0.89 |
| 4 | 0.64 | 0.96 |

**8.3.4 Valves, Flexible Connectors, Expansion, and Vibration Compensators.** Valve, flexible connectors, and expansion and vibration control devices, and other similar components shall be listed to UL 207 for the refrigerant systems and shall meet the design pressure for the systems in which they are installed.

## 8.4 Joints and Connections

**8.4.1 General.** Joints and connections shall be either a listed or an approved type. Joints and connections shall be tight for the pressure of the refrigerant system when tested in accordance with Section 8.6.

**8.4.2 Joints Between Different Piping Materials.** Joints between different piping materials shall be made with either listed or approved adapter fittings. Joints between dissimilar metallic piping materials shall be designed to prevent galvanic corrosion which includes but is not limited to the use of a dielectric fitting or a dielectric union conforming to dielectric tests of ASSE 1079. Adapter fittings with threaded ends between different materials shall be joined with proper thread lubricant in accordance with Section 8.4.5.5.

**8.4.3 Allowable Joints.** The allowable joints for a specific piping material shall be in accordance with Table 8.4.3.

**Table 8.4.3 Allowable Joints**

| Material | Brazed (Section 8.4.5.1) | Mechanical (Section 8.4.5.2) | Flared (Section 8.4.5.3) | Press-Connect (Section 8.4.5.4) |
|---|---|---|---|---|
| **Aluminum Tube** | X | X | | X |

| | | | | |
|---|---|---|---|---|
| **Copper Tube** | X | X | X | X |

**8.4.4 Preparation of Pipe Ends.** Pipes shall be cut square, reamed, and chamfered, and shall be free of burrs and obstructions. Pipe ends shall not be undercut to reduce pipe wall below the minimum thickness as required for the application.

**8.4.5 Joint Preparation and Installation.** The preparation and installation of brazed, mechanical, flared, press-connect, soldered, and threaded joints shall comply with Sections 8.4.5.1 through 8.4.5.5.

**8.4.5.1 Brazed Joints.** Joint surfaces shall be cleaned. A flux approved for the application shall be applied where required by the braze filler metal manufacturer. The piping being brazed shall be purged of air to remove the oxygen and filled with one of the following inert gases: oxygen-free nitrogen, helium, or argon. The piping system shall be pre-purged with an inert gas for a minimum time corresponding to five volume changes through the piping system prior to brazing. The pre-purge rate shall be at a minimum velocity of 100 feet per minute. The inert gas shall be directly connected to the tube system being brazed to prevent the entrainment of ambient air. After the pre-purge, the inert gas supply shall be maintained through the piping during the brazing operation at a minimum pressure of 1.0 psi and a maximum pressure of 3.0 psi. The joint shall be brazed with a filler metal conforming to AWS A5.8.

**8.4.5.2 Mechanical Joints.** Mechanical joints shall be installed in accordance with the manufacturer's installation instructions.

**8.4.5.3 Flared Joints.** Flared fittings shall be installed in accordance with the manufacturer's installation instructions. The flared fittings shall be used with the tube materials specified by the fitting manufacturer. The flared tube end shall be made by a tool designed for that operation.

**8.4.5.4 Press-Connect Joints.** Press-connect joints shall be installed in accordance with the manufacturer's installation instructions.

**8.4.5.5 Threaded Joints.** Threads shall conform to ASME B1.20.1, ASME B1.20.3, ASME B1.13M, or ASME B1.1. Thread lubricant, pipe-joint compound, or tape shall be applied on the external threads only and shall be approved for application on the piping material.

## 8.5 Refrigerant Pipe Installation

**8.5.1 Piping Location.** Refrigerant piping shall be located in accordance with Sections 8.5.1.1 through 8.5.1.6.

**8.5.1.1 Minimum Height.** Exposed refrigerant piping installed in open spaces that are accessible to occupants shall be not less than 7 feet 3 inches (2210 mm) above a walking surface.

**8.5.1.2 Pipe Protection.** The exterior of the pipe shall be protected from corrosion and degradation. Pipe shall not be in direct contact with metal that can cause galvanic corrosion. Refrigerant pipe shall not be in contact with building materials that can abrade the pipe. Refrigerant pipe shall be restricted to any of the following locations.

1. In a wall or floor space or a protective enclosure protected as follows: in concealed locations where aluminum tube or copper tube is installed through holes or notches in studs, joists, or similar members less than 1-1/2 inches (38 mm) from the nearest edge of the member, the tube shall be protected by steel shield plates having a minimum thickness of 0.0575 inch (1.463 mm) (No. 16 gage). Protective steel shield plates shall cover the area of the tube where the member is notched or bored, and shall extend not less than 2 inches (51 mm) above sole plates and below top plates.
2. Exposed inside of a building at an elevation that is more than 7 feet 3 inches (2.2 m) above the finished floor.
3. Exposed inside of a building at an elevation that is less than 7 feet 3 inches (2.2 m) above the finished floor, provided that the piping is placed within 72 inches (1830 mm) of the appliance to which it connects.
4. In an attic or crawl space, provided that aluminum tube or copper tube shall be protected in accordance with Item 1 when located within 1-1/2 inches (38 mm) from the nearest edge of a framing member.
5. In concrete floors, provided that refrigerant piping shall be encased in pipe, conduit, or ducts. The refrigerant piping shall be protected to prevent damage from vibration, stress, and corrosion.

6. Outside the building in accordance with any of the following:
   a. Protected from damage from the weather, including but not limited to hail, ice, and snow loads
   b. Protected from damage where located in an expected foot or traffic path
   c. Where buried, piping shall be located below the frost line, but not less than 8 inches below finished grade, and shall be protected against corrosion.

**8.5.1.3 Prohibited Locations.** Refrigerant piping shall not be installed in any of the following locations:

1. Exposed within a fire-resistance-rated exit access corridor
2. Exposed within an interior exit stairway
3. Exposed within an interior exit ramp enclosure
4. Exit passageway
5. Elevator, dumbwaiter, or other shaft containing a moving object
6. Inside an air duct or return air plenum

**8.5.1.4 *Refrigerant Pipe Shafts.** Refrigerant piping that penetrates two or more floor/ceiling assemblies shall be enclosed in a fire-resistance-rated shaft enclosure where such enclosure is required by the building code.

**8.5.1.5 Exposed Piping Surface Temperature.** Exposed piping with ready access having temperatures greater than 120°F (49°C) or less than 5°F (–15°C) shall be protected from contact or have thermal insulation which limits the exposed insulation surface temperature to a range of 5°F (–15°C) to 120°F (49°C).

**8.5.1.6 Pipe Support.** Piping shall be supported at intervals specified in Table 8.5.1.6 or in accordance with ANSI/MSS SP-58.

**Table 8.5.1.6 Pipe Hanger Spacing**

| Piping Material | Maximum Horizontal Spacing (ft) | Maximum Vertical Spacing (ft) |
|---|---|---|
| Aluminum Tube | | |
| 1/4 inch to 1-1/4 inch | 10 | 15 |
| Copper Tube | | |
| 1/4 inch | 5 | 10 |
| 3/8 to 1/2 inch | 6 | 10 |
| 3/4 inch | 7 | 10 |
| 1 inch | 8 | 10 |
| 1-1/4 inch | 9 | 10 |

**8.5.2 Installation Requirements for A2L Refrigerants.** In addition to other requirements of this section, piping systems using Group A2L refrigerant shall comply with Sections 8.5.2.1 through 8.5.2.3.

**8.5.2.1 Field Applied Joints.** Where a refrigeration system is installed with field applied joints indoors, the joints shall be either:

a. listed and installed in compliance with UL 207; or
b. enclosed in a manner that will direct a leak in the joint to the appliance with a refrigerant detection system

**8.5.2.2 Shaft Ventilation.** Where shafts are required in accordance with Section 8.5.1.4, refrigerant pipe shafts for systems using Group A2L refrigerants shall comply with one of the following:

a. Naturally ventilated shafts shall have a minimum of a 4-inch diameter pipe, duct, or conduit that connects at the lowest point of the shaft and connects to the outdoors. The pipe, duct, or conduit shall be level or pitched to the outdoors. A makeup air opening shall be provided at the top of the

shaft. Required ventilation openings shall open directly to the outside air and shall be protected to prevent the entry of birds, rodents, snakes, and other similar creatures.

b. Mechanically ventilated shafts shall have a minimum air velocity in accordance with Table 8.5.2.3. The mechanical ventilation shall either be continuously operated or activated by a refrigerant detector. Systems utilizing a refrigerant detector shall activate the mechanical ventilation at a detection threshold not exceeding the RCL of the refrigerant. 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. Make up air shall be provided at the inlet to the shaft.

c. The shaft shall not be required to be ventilated for double wall refrigerant pipe where the interstitial space of the double wall pipe is vented to the outdoors.

**Table 8.5.3.2 Shaft Ventilation Velocity**

| Cross-Sectional Area of Shaft (Sq. In.) | Minimum Ventilation Velocity (feet per minute) |
|---|---|
| ≤20 | 100 |
| >20 to ≤250 | 200 |
| >250 to ≤1250 | 300 |
| >1250 | 400 |

**8.5.3 Refrigerant Pipe Penetrations.** The annular space between the outside of a refrigerant pipe and the inside of a pipe sleeve or opening in a building envelope wall, floor, or ceiling assembly penetrated by a refrigerant pipe shall be sealed in an approved manner with caulking material, foam sealant, or closed with a gasketing system. The caulking material, foam sealant, or gasketing system shall be designed for the conditions at the penetration location and shall be compatible with the pipe, sleeve, and building materials in contact with the sealing materials. Refrigerant pipes penetrating fire-resistance-rated assemblies or membranes of fire-resistance-rated assemblies shall be protected in accordance with the building code.

## 9. REFRIGERANT CHARGE LIMITS

**9.1 General Requirements.** All refrigeration systems shall have refrigerant charge added or adjusted complying with the equipment manufacturer's installation instructions.

**9.2 Charge Limit Compliance.** Charge limits for residential refrigeration systems shall follow a compliance path as shown in Figure 9-1.

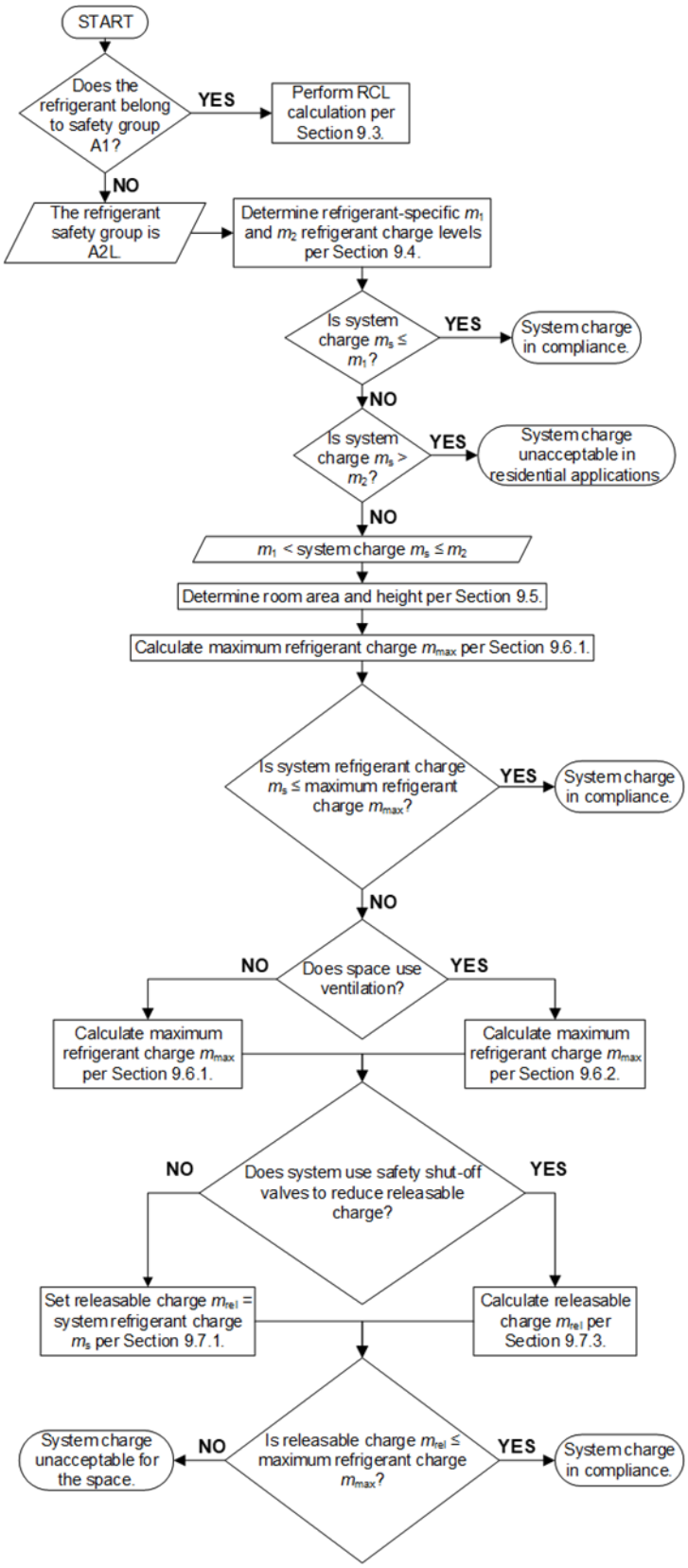


**Figure 9-1 Charge Limit Compliance Flow Path**

**9.3 Maximum Allowable Refrigerant Charge for A1 Refrigerants.** The maximum refrigerant charge ($m_{max}$) of A1 refrigerants permissible in a space shall be limited such that the RCL in ANSI/ASHRAE Standard 34, Table 4-1 or Table 4-2 shall not be exceeded in the event of a complete discharge of a single refrigeration system into the space.

**9.4 Flammable A2L Refrigerant Charge Levels for Mitigation.** Charge levels used to determine mitigation requirements for A2L refrigerants are shown in Table 9.4.1.

**Table 9.4.1 Flammable A2L Refrigerant Charge Levels for Mitigation**

| | $m_1$ Charge Level | | $m_2$ Charge Level | |
|---|---|---|---|---|
| | kg | $lb_m$ | kg | $lb_m$ |
| R-32 | 1.8 | 4.1 | 15.9 | 35.1 |
| R-452B | 1.9 | 4.1 | 16.1 | 35.6 |
| R-454A | 1.7 | 3.7 | 14.6 | 32.3 |
| R-454B | 1.8 | 3.9 | 15.4 | 34.0 |
| R-454C | 1.8 | 3.9 | 15.2 | 33.4 |
| R-457A | 1.3 | 2.9 | 11.2 | 24.8 |

**9.5 Dispersal Volume Determinations.** The dispersal volume used to determine the maximum refrigerant charge ($m_{max}$) shall be determined by multiplying the dispersal floor area and dispersal height as determined per the requirements of Sections 9.5.2 and 9.5.3, respectively.

**9.5.1 HVAC Systems with More Than One Indoor Unit.** The dispersal volume for each indoor unit of a HVAC system shall be calculated. The smallest shall be the dispersal volume used to calculate maximum refrigerant charge per the requirements of Section 9.6.

**9.5.2 Dispersal Floor Area Determination.** The dispersal floor area is the aggregated floor of space(s) served by an indoor unit. If more than one space is served by an indoor unit, only the floor area of the spaces connected by one or both methods in Sections 9.5.2.1 and 9.5.2.2 shall be included in the dispersal floor area.

**9.5.2.1 Spaces Connected by Ducted HVAC Systems.** The aggregate floor area of spaces connected to the same supply air distribution ductwork shall be used as the dispersal floor area.

**9.5.2.2 Spaces Connected by Open Passageways.** The aggregate floor area of spaces on the same floor that are connected by an open passageway shall be used in determination of dispersal floor area. An open passageway is a permanent opening that extends to the floor, is intended for people to walk through, and does not have a door. The use of doors with transfer grilles or undercuts shall not be considered sufficient to make an open passageway.

**9.5.3 Dispersal Height Determination.** All of the applicable requirements in this section shall be used to calculate dispersal height.

**9.5.3.1 *Systems Serving More than One Floor.** Where different stories and floor levels connect through an opening, the dispersal height for each higher space shall be reduced by the difference in height between the higher space and the lower space. If the difference in height between the floor of the higher space and lower space is 7.2 ft (2.2 m) or more, the dispersal height for the higher space shall be zero.

**9.5.3.2** The space above a suspended ceiling shall not be included in calculating the dispersal height.

**9.5.3.3 Ducted HVAC.** The dispersal height for ducted HVAC shall be the mean of the actual ceiling heights in the space(s), with no height greater than 7.2 ft (2.2 m) used for the calculation.

**9.5.3.4 Ductless HVAC Systems.** The dispersal height for ductless HVAC systems shall be the height of the highest point of the equipment opening delivering conditioned air, but not less than 2.0 ft (0.6 m), nor more than 7.2 ft (2.2 m).

**9.5.3.5 Heat Pump Water Heater.** The dispersal height shall be the floor area of the space containing the heat pump water heater multiplied by the height of the appliance, but not less than 2.0 ft (0.6 m), nor more

than 7.2 ft (2.2 m).

**9.6 Maximum Allowable Refrigerant Charge.** The maximum refrigerant charge ($m_{max}$) allowed for the space identified using Section 9.6 shall be determined as follows:

**9.6.1** For A2L refrigeration systems without ventilation:

$$m_{max} = C \times M$$

where:

C = LFL Conversion Factor, as given in Table 9.6.1

M = Refrigerant allowed in a dispersal volume based on 25% LFL, as given in Table 9.6.2 in kg ($lb_m$)

**9.6.2** For A2L refrigeration systems without ventilation:

$$m_{max} = C \times (M + MD)$$

where:

C = LFL Conversion Factor, as given in Table 9.6.1

M = Refrigerant allowed in a dispersal volume based on 25% LFL, as given in Table 9.6.2 in kg ($lb_m$)

MD = Additional refrigerant mass allowed in a dispersal volume based on dilution using ventilation, as given in Table 9.6.3 in kg ($lb_m$)

**Table 9.6.1 LFL Conversion Factor**

| Refrigerant | C |
|---|---|
| R-32 | 1.00 |
| R-452B | 1.02 |
| R-454A | 0.92 |
| R-454B | 0.97 |
| R-454C | 0.95 |
| R-457A | 0.71 |

**Table 9.6.2 M for A2L Systems Based on 7.2 ft (2.2 m) Space Height***

| Area** | | M*** | |
|---|---|---|---|
| $ft^2$ | $m^2$ | $lb_m$ | kg |
| 100 | 9.3 | 3.4 | 1.6 |
| 125 | 11.6 | 4.3 | 2.0 |
| 150 | 13.9 | 5.2 | 2.3 |
| 175 | 16.3 | 6.0 | 2.7 |
| 200 | 18.6 | 6.9 | 3.1 |
| 225 | 20.9 | 7.8 | 3.5 |
| 250 | 23.2 | 8.6 | 3.9 |
| 275 | 25.5 | 9.5 | 4.3 |
| 300 | 27.9 | 10.3 | 4.7 |
| 325 | 30.2 | 11.2 | 5.1 |

**Table 9.6.2 M for A2L Systems Based on 7.2 ft (2.2 m) Space Height***

| Area** | | M*** | |
|---|---|---|---|
| $ft^2$ | $m^2$ | $lb_m$ | kg |
| 350 | 32.5 | 12.1 | 5.5 |
| 375 | 34.8 | 12.9 | 5.9 |
| 400 | 37.2 | 13.8 | 6.3 |
| 425 | 39.5 | 14.6 | 6.6 |
| 450 | 41.8 | 15.5 | 7.0 |
| 475 | 44.1 | 16.4 | 7.4 |
| 500 | 46.5 | 17.2 | 7.8 |
| 525 | 48.8 | 18.1 | 8.2 |
| 550 | 51.1 | 19.0 | 8.6 |
| 575 | 53.4 | 19.8 | 9.0 |
| 600 | 55.7 | 20.7 | 9.4 |
| 625 | 58.1 | 21.5 | 9.8 |
| 650 | 60.4 | 22.4 | 10.2 |
| 675 | 62.7 | 23.3 | 10.6 |
| 700 | 65.0 | 24.1 | 10.9 |
| 725 | 67.4 | 25.0 | 11.3 |
| 750 | 69.7 | 25.9 | 11.7 |
| 775 | 72.0 | 26.7 | 12.1 |
| 800 | 74.3 | 27.6 | 12.5 |
| 825 | 76.6 | 28.4 | 12.9 |
| 850 | 79.0 | 29.3 | 13.3 |
| 875 | 81.3 | 30.2 | 13.7 |
| 900 | 83.6 | 31.0 | 14.1 |
| 925 | 85.9 | 31.9 | 14.5 |
| 950 | 88.3 | 32.7 | 14.9 |
| 975 | 90.6 | 33.6 | 15.2 |
| 1000 | 92.9 | 34.5 | 15.6 |
| 1025 | 95.2 | 35.1 | 15.9 |

* For space heights (h) less than 7.2 ft (2.2 m), multiply the charge quantities in this table by a correction factor of $h_c$, where $h_c$ = h/7.2 ft (2.2 m). For space heights greater than 7.2 ft (2.2 m), use the quantities shown in this table.

** Dispersal areas shall comply with Section 9.5.

*** For area sizes falling in between the values listed in this table, interpolation shall be permitted to determine precise charges. Otherwise, the closest lower area value shall be used.

**Table 9.6.3 Additional Charge Permitted for A2L Systems Using *Ventilation***

| Ventilation Rate | | MV* | |
|---|---|---|---|
| cfm | $m^3/hr$ | $lb_m$ | kg |
| 20 | 34 | 0.4 | 0.2 |
| 40 | 68 | 0.7 | 0.3 |
| 60 | 102 | 1.1 | 0.5 |
| 80 | 136 | 1.4 | 0.6 |
| 100 | 170 | 1.8 | 0.8 |

**Table 9.6.3 Additional Charge Permitted for A2L Systems Using *Ventilation***

| Ventilation Rate | | MV* | |
|---|---|---|---|
| **cfm** | **$m^3/hr$** | **$lb_m$** | **kg** |
| 120 | 204 | 2.1 | 1.0 |
| 140 | 238 | 2.5 | 1.1 |
| 160 | 272 | 2.8 | 1.3 |
| 180 | 306 | 3.2 | 1.4 |
| 200 | 340 | 3.5 | 1.6 |
| 220 | 374 | 4.2 | 1.9 |
| 240 | 408 | 4.6 | 2.1 |
| 260 | 442 | 5.0 | 2.3 |
| 280 | 476 | 5.4 | 2.4 |
| 300 | 510 | 5.8 | 2.6 |
| 320 | 544 | 6.2 | 2.8 |
| 340 | 578 | 6.5 | 3.0 |
| 360 | 612 | 6.9 | 3.1 |
| 380 | 646 | 7.3 | 3.3 |
| ≥400 | ≥680 | 7.3 | 3.5 |

* For ventilation rates falling between the values listed in this table, interpolation shall be permitted to determine the precise increase in charge. Otherwise, the closest lower area value shall be used.

**9.7 Releasable Charge ($m_{rel}$).** Releasable charge ($m_{rel}$) shall be determined as follows:

**9.7.1** For systems without safety shut-off values, the releasable charge ($m_{rel}$) shall be the system refrigerant charge ($m_s$).

**9.7.2** For systems utilizing safety shut-off valves, the releasable charge ($m_{rel}$) shall be determined according to Section 9.8.3.

**9.7.3 Releasable Charge for Systems Using Safety Shut-Off Valves with A2L Refrigerants.** The releasable charge ($m_{rel}$) shall be the refrigerant contained in the interconnecting tubing and indoor section located downstream of the safety shut-off valves, and shall be the largest value determined by Sections 9.7.3.1 and 9.7.3.2. The releasable charge ($m_{rel}$) shall not exceed the maximum refrigerant charge ($m_{max}$), as determined by Section 9.6.

**9.7.3.1 Releasable Refrigerant Charge in Heating Mode.** The releasable charge in heating mode shall be calculated using the appropriate equation from Table 9.7.1 as follows:

**Table 9.7.1 $m_{rel}$ Equations for Systems Using Safety Shut-Off Valves in Heating Mode**

| Refrigerant | Releasable Refrigerant Charge in Heating Mode |
|---|---|
| R-32 | $m_{rel} = ML_H + MG_H + MU_H$ |
| R-452B | $m_{rel} = (1.03 \times ML_H) + (1.11 \times MG_H) + (1.04 \times MU_H)$ |
| R-454A | $m_{rel} = (1.07 \times ML_H) + (1.05 \times MG_H) + (1.07 \times MU_H)$ |
| R-454B | $m_{rel} = (1.02 \times ML_H) + (1.08 \times MG_H) + (1.03 \times MU_H)$ |
| R-454C | $m_{rel} = (1.09 \times ML_H) + (0.99 \times MG_H) + (1.09 \times MU_H)$ |
| R-457A | $m_{rel} = (1.08 \times ML_H) + (0.87 \times MG_H) + (1.08 \times MU_H)$ |

where:

$ML_H$ = refrigerant liquid contained in liquid interconnecting tubing in heating mode in kg ($lb_m$), per Table 9.7.3-1

$MG_H$ = refrigerant vapor contained in vapor interconnecting tubing in heating mode in kg ($lb_m$), per Table 9.7.3-2

$MU_H$ = refrigerant contained in the indoor section in heating mode in kg ($lb_m$), per Table 9.7.3-3

**9.7.3.2 Releasable Refrigerant Charge in Cooling Mode.** The releasable charge in cooling mode shall be calculated using the appropriate equation from Table 9.7.2 as follows:

**Table 9.7.1 $m_{rel}$ Equations for Systems Using Safety Shut-Off Valves in Cooling Mode**

| Refrigerant | Releasable Refrigerant Charge in Heating Mode |
|---|---|
| R-32 | $m_{rel} = ML_C + MG_C + MU_C$ |
| R-452B | $m_{rel} = (1.02 \times ML_C) + (1.11 \times MG_C) + (1.03 \times MU_C)$ |
| R-454A | $m_{rel} = (1.07 \times ML_C) + (1.01 \times MG_C) + (1.07 \times MU_C)$ |
| R-454B | $m_{rel} = (1.02 \times ML_C) + (1.07 \times MG_C) + (1.02 \times MU_C)$ |
| R-454C | $m_{rel} = (1.10 \times ML_C) + (0.94 \times MG_C) + (1.09 \times MU_C)$ |
| R-457A | $m_{rel} = (1.09 \times ML_C) + (0.82 \times MG_C) + (1.09 \times MU_C)$ |

where:

$ML_C$ = refrigerant liquid contained in liquid interconnecting tubing in cooling mode in kg ($lb_m$), per Table 9.7.3-4

$MG_C$ = refrigerant vapor contained in vapor interconnecting tubing in cooling mode in kg ($lb_m$), per Table 9.7.3-5

$MU_C$ = refrigerant contained in the indoor section in cooling mode in kg ($lb_m$), per Table 9.7.3-6

**Table 9.7.3-1 $ML_H$: Refrigerant Liquid Contained in Liquid Interconnecting Tubing from Safety Shut-Off Valves to Each Indoor Section in Heating Mode**

*SI Units*

| | Tube Length (m) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1.0** | **2.0** | **3.0** | **4.0** | **5.0** | **6.0** | **7.0** | **8.0** | **9.0** | **10.0** | **11.0** | **12.0** |
| **Tube OD (mm)** | **$ML_H$ (kg)** | | | | | | | | | | | |
| 6.35 | 0.02 | 0.04 | 0.06 | 0.08 | 0.10 | 0.12 | 0.14 | 0.16 | 0.18 | 0.20 | 0.23 | 0.25 |
| 7.94 | 0.04 | 0.07 | 0.11 | 0.14 | 0.18 | 0.22 | 0.25 | 0.29 | 0.32 | 0.36 | 0.39 | 0.43 |
| 9.53 | 0.06 | 0.11 | 0.17 | 0.22 | 0.28 | 0.33 | 0.39 | 0.44 | 0.50 | 0.56 | 0.61 | 0.67 |
| 12.70 | 0.11 | 0.22 | 0.32 | 0.43 | 0.54 | 0.65 | 0.75 | 0.86 | 0.97 | 1.08 | 1.18 | 1.29 |
| 15.90 | 0.17 | 0.34 | 0.52 | 0.69 | 0.86 | 1.03 | 1.21 | 1.38 | 1.55 | 1.72 | 1.90 | 2.07 |
| 19.10 | 0.25 | 0.50 | 0.74 | 0.99 | 1.24 | 1.49 | 1.73 | 1.98 | 2.23 | 2.48 | 2.72 | 2.97 |
| 22.20 | 0.34 | 0.69 | 1.03 | 1.37 | 1.71 | 2.06 | 2.40 | 2.74 | 3.08 | 3.43 | 3.77 | 4.11 |
| 25.40 | 0.45 | 0.90 | 1.35 | 1.80 | 2.25 | 2.70 | 3.15 | 3.60 | 4.05 | 4.50 | 4.95 | 5.40 |
| 28.60 | 0.58 | 1.16 | 1.75 | 2.33 | 2.91 | 3.49 | 4.08 | 4.66 | 5.24 | 5.82 | 6.40 | 6.99 |
| 31.80 | 0.72 | 1.44 | 2.16 | 2.88 | 3.61 | 4.33 | 5.05 | 5.77 | 6.49 | 7.21 | 7.93 | 8.65 |
| 38.10 | 1.05 | 2.11 | 3.16 | 4.21 | 5.27 | 6.32 | 7.37 | 8.43 | 9.48 | 10.53 | 11.59 | 12.64 |

*IP Units (Values for Reference)*

| | Tube Length (ft) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **3.0** | **6.0** | **9.0** | **12.0** | **15.0** | **18.0** | **21.0** | **24.0** | **27.0** | **30.0** | **33.0** | **36.0** |
| **Tube OD (inch)** | **$ML_H$ ($lb_m$)** | | | | | | | | | | | |
| 0.250 (1/4) | 0.05 | 0.10 | 0.15 | 0.19 | 0.24 | 0.29 | 0.34 | 0.39 | 0.44 | 0.49 | 0.53 | 0.58 |
| 0.313 (5/16) | 0.09 | 0.17 | 0.26 | 0.34 | 0.43 | 0.51 | 0.60 | 0.68 | 0.77 | 0.85 | 0.94 | 1.02 |
| 0.375 (3/8) | 0.13 | 0.26 | 0.39 | 0.53 | 0.66 | 0.79 | 0.92 | 1.05 | 1.18 | 1.32 | 1.45 | 1.58 |
| 0.500 (1/2) | 0.26 | 0.51 | 0.77 | 1.02 | 1.28 | 1.54 | 1.79 | 2.05 | 2.30 | 2.56 | 2.81 | 3.07 |
| 0.625 (5/8) | 0.41 | 0.82 | 1.23 | 1.64 | 2.05 | 2.46 | 2.87 | 3.28 | 3.69 | 4.10 | 4.51 | 4.92 |
| 0.750 (3/4) | 0.59 | 1.18 | 1.76 | 2.35 | 2.94 | 3.53 | 4.11 | 4.70 | 5.29 | 5.88 | 6.46 | 7.05 |
| 0.875 (7/8) | 0.81 | 1.63 | 2.44 | 3.25 | 4.06 | 4.88 | 5.69 | 6.50 | 7.31 | 8.13 | 8.94 | 9.75 |
| 1.000 | 1.07 | 2.13 | 3.20 | 4.26 | 5.33 | 6.40 | 7.46 | 8.53 | 9.60 | 10.66 | 11.73 | 12.79 |
| 1.125 (1–1/8) | 1.38 | 2.76 | 4.14 | 5.52 | 6.89 | 8.27 | 9.65 | 11.03 | 12.41 | 13.79 | 15.17 | 16.55 |
| 1.250 (1–1/4) | 1.71 | 3.42 | 5.13 | 6.83 | 8.54 | 10.25 | 11.96 | 13.67 | 15.38 | 17.08 | 18.79 | 20.50 |
| 1.500 (1–1/2) | 2.49 | 4.98 | 7.46 | 9.95 | 12.44 | 14.93 | 17.42 | 19.90 | 22.39 | 24.88 | 27.37 | 29.85 |

***Note:*** $ML_H$ shall be determined by interpolation of the values in the table or by selecting the next highest value.

**Table 9.7.3-2 $MG_H$: Refrigerant Vapor Contained in Vapor Interconnecting Tubing from Safety Shut-Off Valves to Each Indoor Section in Heating Mode**

*SI Units*

| | Tube Length (m) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1.0** | **2.0** | **3.0** | **4.0** | **5.0** | **6.0** | **7.0** | **8.0** | **9.0** | **10.0** | **11.0** | **12.0** |
| **Tube OD (mm)** | **$MG_H$ (kg)** | | | | | | | | | | | |
| 6.35 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 7.94 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 |
| 9.53 | 0.00 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 | 0.04 |
| 12.70 | 0.01 | 0.01 | 0.02 | 0.03 | 0.03 | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 | 0.07 | 0.08 |
| 15.90 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.07 | 0.08 | 0.09 | 0.10 | 0.11 | 0.12 | 0.13 |
| 19.10 | 0.02 | 0.03 | 0.05 | 0.06 | 0.08 | 0.09 | 0.11 | 0.13 | 0.14 | 0.16 | 0.17 | 0.19 |
| 22.20 | 0.02 | 0.04 | 0.07 | 0.09 | 0.11 | 0.13 | 0.15 | 0.17 | 0.20 | 0.22 | 0.24 | 0.26 |
| 25.40 | 0.03 | 0.06 | 0.09 | 0.11 | 0.14 | 0.17 | 0.20 | 0.23 | 0.26 | 0.29 | 0.31 | 0.34 |
| 28.60 | 0.04 | 0.07 | 0.11 | 0.15 | 0.18 | 0.22 | 0.26 | 0.30 | 0.33 | 0.37 | 0.41 | 0.44 |
| 31.80 | 0.05 | 0.09 | 0.14 | 0.18 | 0.23 | 0.27 | 0.32 | 0.37 | 0.41 | 0.46 | 0.50 | 0.55 |
| 38.10 | 0.07 | 0.13 | 0.20 | 0.27 | 0.33 | 0.40 | 0.47 | 0.53 | 0.60 | 0.67 | 0.73 | 0.80 |

*IP Units (Values for Reference)*

| | Tube Length (ft) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **3.0** | **6.0** | **9.0** | **12.0** | **15.0** | **18.0** | **21.0** | **24.0** | **27.0** | **30.0** | **33.0** | **36.0** |
| **Tube OD (inch)** | **$MG_H$ ($lb_m$)** | | | | | | | | | | | |
| 0.250 (1/4) | 0.00 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 |
| 0.313 (5/16) | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 |
| 0.375 (3/8) | 0.01 | 0.02 | 0.03 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.08 | 0.09 | 0.10 |
| 0.500 (1/2) | 0.02 | 0.03 | 0.05 | 0.07 | 0.08 | 0.10 | 0.12 | 0.13 | 0.15 | 0.16 | 0.18 | 0.20 |
| 0.625 (5/8) | 0.03 | 0.05 | 0.08 | 0.11 | 0.13 | 0.16 | 0.18 | 0.21 | 0.24 | 0.26 | 0.29 | 0.32 |
| 0.750 (3/4) | 0.04 | 0.08 | 0.11 | 0.15 | 0.19 | 0.23 | 0.26 | 0.30 | 0.34 | 0.38 | 0.42 | 0.45 |
| 0.875 (7/8) | 0.05 | 0.10 | 0.16 | 0.21 | 0.26 | 0.31 | 0.37 | 0.42 | 0.47 | 0.52 | 0.58 | 0.63 |
| 1.000 | 0.07 | 0.14 | 0.21 | 0.27 | 0.34 | 0.41 | 0.48 | 0.55 | 0.62 | 0.69 | 0.76 | 0.82 |
| 1.125 (1–1/8) | 0.09 | 0.18 | 0.27 | 0.36 | 0.44 | 0.53 | 0.62 | 0.71 | 0.80 | 0.89 | 0.98 | 1.07 |
| 1.250 (1–1/4) | 0.11 | 0.22 | 0.33 | 0.44 | 0.55 | 0.66 | 0.77 | 0.88 | 0.99 | 1.10 | 1.21 | 1.32 |
| 1.500 (1–1/2) | 0.16 | 0.32 | 0.48 | 0.64 | 0.80 | 0.96 | 1.12 | 1.28 | 1.44 | 1.60 | 1.76 | 1.92 |

***Note:*** $MG_H$ shall be determined by interpolation of the values in the table or by selecting the next highest value.

**Table 9.7.3-3 $MU_H$: Refrigerant Contained in Indoor Section in Heating Mode**

| Internal Volume of Indoor Section | | $MU_H$ | |
|---|---|---|---|
| $m^3$ | $ft^3$ | kg | $lb_m$ |
| 0.001 | 0.04 | 3.38 | 7.81 |
| 0.002 | 0.08 | 4.10 | 9.78 |
| 0.003 | 0.12 | 4.82 | 11.75 |
| 0.004 | 0.16 | 5.55 | 13.72 |
| 0.005 | 0.20 | 6.27 | 15.69 |
| 0.006 | 0.24 | 6.99 | 17.65 |
| 0.007 | 0.28 | 7.72 | 19.62 |
| 0.008 | 0.32 | 8.44 | 21.59 |
| 0.009 | 0.36 | 9.17 | 23.56 |
| 0.010 | 0.40 | 9.89 | 25.52 |
| 0.011 | 0.44 | 10.61 | 27.49 |
| 0.012 | 0.48 | 11.34 | 29.46 |
| 0.013 | 0.52 | 12.06 | 31.43 |
| 0.014 | 0.56 | 12.78 | 33.40 |
| 0.015 | 0.60 | 13.51 | 35.36 |
| 0.016 | 0.64 | 14.23 | 37.33 |
| 0.017 | 0.68 | 14.96 | 39.30 |
| 0.018 | 0.72 | 15.68 | 41.27 |

***Note:*** $MU_H$ shall be determined by interpolation of the values in the table or by selecting the next highest value.

**Table 9.7.3-4 $ML_C$: Refrigerant Liquid Contained in Liquid Interconnecting Tubing from Safety Shut-Off Valves to Each Indoor Section in Cooling Mode**

*SI Units*

| | Tube Length (m) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1.0** | **2.0** | **3.0** | **4.0** | **5.0** | **6.0** | **7.0** | **8.0** | **9.0** | **10.0** | **11.0** | **12.0** |
| **Tube OD (mm)** | **$ML_C$ (kg)** | | | | | | | | | | | |
| 6.35 | 0.02 | 0.04 | 0.06 | 0.08 | 0.10 | 0.12 | 0.14 | 0.16 | 0.18 | 0.20 | 0.22 | 0.24 |
| 7.94 | 0.04 | 0.07 | 0.11 | 0.14 | 0.18 | 0.21 | 0.25 | 0.28 | 0.32 | 0.35 | 0.39 | 0.42 |
| 9.53 | 0.05 | 0.11 | 0.16 | 0.22 | 0.27 | 0.33 | 0.38 | 0.44 | 0.49 | 0.55 | 0.60 | 0.66 |
| 12.70 | 0.11 | 0.21 | 0.32 | 0.42 | 0.53 | 0.63 | 0.74 | 0.85 | 0.95 | 1.06 | 1.16 | 1.27 |
| 15.90 | 0.17 | 0.34 | 0.51 | 0.68 | 0.85 | 1.02 | 1.19 | 1.36 | 1.53 | 1.70 | 1.87 | 2.04 |
| 19.10 | 0.24 | 0.49 | 0.73 | 0.97 | 1.22 | 1.46 | 1.71 | 1.95 | 2.19 | 2.44 | 2.68 | 2.92 |
| 22.20 | 0.34 | 0.67 | 1.01 | 1.35 | 1.69 | 2.02 | 2.36 | 2.70 | 3.03 | 3.37 | 3.71 | 4.05 |
| 25.40 | 0.44 | 0.89 | 1.33 | 1.77 | 2.22 | 2.66 | 3.10 | 3.54 | 3.99 | 4.43 | 4.87 | 5.32 |
| 28.60 | 0.57 | 1.15 | 1.72 | 2.29 | 2.86 | 3.44 | 4.01 | 4.58 | 5.16 | 5.73 | 6.30 | 6.87 |
| 31.80 | 0.71 | 1.42 | 2.13 | 2.84 | 3.55 | 4.26 | 4.97 | 5.68 | 6.39 | 7.10 | 7.80 | 8.51 |
| 38.10 | 1.04 | 2.07 | 3.11 | 415 | 5.18 | 6.22 | 7.25 | 8.29 | 9.33 | 10.36 | 11.40 | 12.44 |

*IP Units (Values for Reference)*

| | Tube Length (ft) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **3.0** | **6.0** | **9.0** | **12.0** | **15.0** | **18.0** | **21.0** | **24.0** | **27.0** | **30.0** | **33.0** | **36.0** |
| **Tube OD (inch)** | **$ML_C$ ($lb_m$)** | | | | | | | | | | | |
| 0.250 (1/4) | 0.05 | 0.10 | 0.14 | 0.19 | 0.24 | 0.29 | 0.34 | 0.38 | 0.43 | 0.48 | 0.53 | 0.57 |
| 0.313 (5/16) | 0.08 | 0.17 | 0.25 | 0.34 | 0.42 | 0.50 | 0.59 | 0.67 | 0.75 | 0.84 | 0.92 | 1.01 |
| 0.375 (3/8) | 0.13 | 0.26 | 0.39 | 0.52 | 0.65 | 0.78 | 0.91 | 1.04 | 1.17 | 1.30 | 1.43 | 1.56 |
| 0.500 (1/2) | 0.25 | 0.50 | 0.76 | 1.01 | 1.26 | 1.51 | 1.77 | 2.02 | 2.27 | 2.52 | 2.78 | 3.03 |
| 0.625 (5/8) | 0.40 | 0.81 | 1.21 | 1.62 | 2.02 | 2.42 | 2.83 | 3.23 | 3.64 | 4.04 | 4.45 | 4.85 |
| 0.750 (3/4) | 0.58 | 1.16 | 1.74 | 2.32 | 2.90 | 3.48 | 4.06 | 4.63 | 5.21 | 5.79 | 6.37 | 6.95 |
| 0.875 (7/8) | 0.80 | 1.60 | 2.40 | 3.21 | 4.01 | 4.81 | 5.61 | 6.41 | 7.21 | 8.01 | 8.81 | 9.62 |
| 1.000 | 1.05 | 2.10 | 3.15 | 4.20 | 5.26 | 6.31 | 7.36 | 8.41 | 9.46 | 10.51 | 11.56 | 12.61 |
| 1.125 (1–1/8) | 1.36 | 2.72 | 4.08 | 5.44 | 6.80 | 8.16 | 9.52 | 10.88 | 12.24 | 13.60 | 14.96 | 16.32 |
| 1.250 (1–1/4) | 1.68 | 3.37 | 5.05 | 6.74 | 8.42 | 10.11 | 11.79 | 13.47 | 15.16 | 16.84 | 18.53 | 20.21 |
| 1.500 (1–1/2) | 2.45 | 4.91 | 7.36 | 9.81 | 12.26 | 14.72 | 17.17 | 19.62 | 22.08 | 24.53 | 26.98 | 29.43 |

***Note:*** $ML_C$ shall be determined by interpolation of the values in the table or by selecting the next highest value.

**Table 9.7.3-5 $MG_C$: Refrigerant Vapor Contained in Vapor Interconnecting Tubing from Safety Shut-Off Valves to Each Indoor Section in Cooling Mode**

*SI Units*

| | Tube Length (m) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1.0** | **2.0** | **3.0** | **4.0** | **5.0** | **6.0** | **7.0** | **8.0** | **9.0** | **10.0** | **11.0** | **12.0** |
| **Tube OD (mm)** | **$MG_C$ (kg)** | | | | | | | | | | | |
| 6.35 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 7.94 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 9.53 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 12.70 | 0.00 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.04 |
| 15.90 | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 | 0.06 | 0.07 |
| 19.10 | 0.01 | 0.02 | 0.03 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.08 | 0.09 | 0.10 |
| 22.20 | 0.01 | 0.02 | 0.03 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 | 0.10 | 0.12 | 0.13 | 0.14 |
| 25.40 | 0.02 | 0.03 | 0.05 | 0.06 | 0.08 | 0.09 | 0.11 | 0.12 | 0.14 | 0.15 | 0.17 | 0.18 |
| 28.60 | 0.02 | 0.04 | 0.06 | 0.08 | 0.10 | 0.12 | 0.14 | 0.16 | 0.18 | 0.20 | 0.22 | 0.24 |
| 31.80 | 0.02 | 0.05 | 0.07 | 0.10 | 0.12 | 0.15 | 0.17 | 0.20 | 0.22 | 0.24 | 0.27 | 0.29 |
| 38.10 | 0.04 | 0.07 | 0.11 | 0.14 | 0.18 | 0.21 | 0.25 | 0.29 | 0.32 | 0.36 | 0.39 | 0.43 |

*IP Units (Values for Reference)*

| | Tube Length (ft) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **3.0** | **6.0** | **9.0** | **12.0** | **15.0** | **18.0** | **21.0** | **24.0** | **27.0** | **30.0** | **33.0** | **36.0** |
| **Tube OD (inch)** | **$MG_C$ ($lb_m$)** | | | | | | | | | | | |
| 0.250 (1/4) | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 |
| 0.313 (5/16) | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.04 |
| 0.375 (3/8) | 0.00 | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 |
| 0.500 (1/2) | 0.01 | 0.02 | 0.03 | 0.04 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 | 0.10 | 0.11 |
| 0.625 (5/8) | 0.01 | 0.03 | 0.04 | 0.06 | 0.07 | 0.08 | 0.10 | 0.11 | 0.13 | 0.14 | 0.16 | 0.17 |
| 0.750 (3/4) | 0.02 | 0.04 | 0.06 | 0.08 | 0.10 | 0.12 | 0.14 | 0.16 | 0.18 | 0.20 | 0.22 | 0.24 |
| 0.875 (7/8) | 0.03 | 0.06 | 0.08 | 0.11 | 0.14 | 0.17 | 0.20 | 0.22 | 0.25 | 0.28 | 0.31 | 0.34 |
| 1.000 | 0.04 | 0.07 | 0.11 | 0.15 | 0.18 | 0.22 | 0.26 | 0.29 | 0.33 | 0.37 | 0.40 | 0.44 |
| 1.125 (1–1/8) | 0.05 | 0.09 | 0.14 | 0.19 | 0.24 | 0.28 | 0.33 | 0.38 | 0.43 | 0.47 | 0.52 | 0.57 |
| 1.250 (1–1/4) | 0.06 | 0.12 | 0.18 | 0.24 | 0.29 | 0.35 | 0.41 | 0.47 | 0.53 | 0.59 | 0.65 | 0.71 |
| 1.500 (1–1/2) | 0.09 | 0.17 | 0.26 | 0.34 | 0.43 | 0.51 | 0.60 | 0.68 | 0.77 | 0.86 | 0.94 | 1.03 |

***Note:*** $MG_C$ shall be determined by interpolation of the values in the table or by selecting the next highest value.

**Table 9.7.3-6 $MU_C$: Refrigerant Contained in Indoor Section in Cooling Mode**

| Internal Volume of Indoor Section | | $MU_C$ | |
|---|---|---|---|
| $m^3$ | $ft^3$ | kg | $lb_m$ |
| 0.001 | 0.04 | 3.57 | 8.36 |
| 0.002 | 0.08 | 4.49 | 10.87 |
| 0.003 | 0.12 | 5.41 | 13.38 |
| 0.004 | 0.16 | 6.33 | 15.89 |
| 0.005 | 0.20 | 7.25 | 18.40 |
| 0.006 | 0.24 | 8.17 | 20.91 |
| 0.007 | 0.28 | 9.08 | 23.42 |
| 0.008 | 0.32 | 10.00 | 25.93 |
| 0.009 | 0.36 | 10.92 | 28.44 |
| 0.010 | 0.40 | 11.84 | 30.95 |
| 0.011 | 0.44 | 12.76 | 33.46 |
| 0.012 | 0.48 | 13.68 | 35.97 |
| 0.013 | 0.52 | 14.60 | 38.48 |
| 0.014 | 0.56 | 15.52 | 40.99 |

***Note:*** $MU_C$ shall be determined by interpolation of the values in the table or by selecting the next highest value.

### 9.7.4 Safety Shut-Off Valves for Multi-Split Systems Using A2L Refrigerants

**9.7.4.1** Safety shut-off valves shall be specified for use in the manufacturer's installation instructions. When safety shut-off valves are activated by the refrigerant detection system, the valves shall close and remain closed until corrective action is taken. Safety shut-off valves shall be designed to close in the event of an electric power failure.

**9.7.4.2 Safety Shut-Off Valve Location.** Safety shut-off valves shall be located in either outside or in a space where the dispersal volume and total system charge complies with Section 9.6. Ready access shall be provided to safety shut-off valves.

## 10. SYSTEM INSTALLATION

### 10.1 General

**10.1.1** Installation of refrigerant systems shall be in accordance with this section. Refrigerant piping systems erected in the field shall be in accordance with Section 8 and tested in accordance with Section 10.5

**10.1.2 Safeguards.** Controls and other refrigeration equipment shall be safeguarded in a manner that minimizes the risk of accidental damage or rupture by mechanical impact.

**10.1.3 Access.** Per manufacturer's installation instructions, a clear and unobstructed approach and space shall be provided for inspection, service, and emergency shutdown of appliances.

**10.1.4 HVAC Appliances.** HVAC appliances shall be installed in accordance with the manufacturer's installations instructions.

**10.2 Security.** All refrigerant circuit service ports shall require a tool for access either directly on the service port or within a service panel, to use the service port.

**10.3 Provision for Service.** Access shall be provided to all serviceable components of refrigeration systems and to outdoor sections or outdoor sections with enclosures.

**10.4 Refrigerant Pressure-Measuring Instruments.** Pressure-measuring instruments shall be checked for accuracy and adjusted according to the pressure-measuring instrument manufacturer's instructions.

**10.5 Charging, Withdrawal, and Release of Refrigerants.** Service containers shall not be left connected to a

system, except while charging or withdrawing refrigerant. Refrigerants withdrawn from refrigeration systems shall be transferred into approved containers. Except for discharge from pressure-relief devices or fusible plugs, incidental releases due to leaks, purging of non-condensables, draining oil, and other routine operating or maintenance procedures in accordance with EPA §608 requirements, refrigerants shall not be released to the atmosphere.

**10.6 Refrigerant Piping System Test**

**10.6.1 General.** Refrigerant piping systems erected in the field shall be pressure-tested for strength and leak tested for tightness after installation and before being placed in operation or reused, in accordance with Sections 10.6.2 through 10.6.7.

**10.6.2** Tests shall include both the high- and low-pressure sides of each system.

**10.6.3** Listed equipment, including but not limited to, compressors, condensers, pre-charged line sets, pressure vessels, evaporators, safety devices, pressure gauges, and control mechanisms, shall not be required to be pressure tested for strength, but field installed connections to listed equipment shall be leak tested.

**10.6.4 Exposure of Refrigerant Piping System**

**10.6.4.1 New Piping.** Newly installed refrigerant pipe and joints installed in the field shall be exposed for visual inspection and testing prior to being covered or enclosed.

**10.6.4.2 Reused Piping.** Reused piping shall be in compliance with Section 10.6.4.1 unless in accordance with all of the following:

1. Piping shall be protected in accordance with Section 8.5.1.2. Verification of the presence of shield plates shall be accomplished by one of the following methods:
   a. Determine the piping was previously inspected for shield plates through building inspection records
   b. Use an approved tool or visual inspection to verify shield plates are installed.

**10.6.5 Test Gases.** The gas used for pressure testing the refrigerant system shall be one of the following inert gases: oxygen-free nitrogen, helium, argon, or pre-mixed nonflammable oxygen-free nitrogen with a tracer gas of hydrogen or helium. Oxygen, air, refrigerant, combustible gases, and mixtures containing such gases shall not be used for testing.

**10.6.6 Field Test Apparatus.** The means used to pressurize the refrigerant piping system shall have either a pressure-limiting device or a pressure-reducing device, and a test pressure measuring device on the outlet side. The test pressure measuring device for strength testing and leakage testing shall have an accuracy of not less than ±3% of the test pressure and shall have a resolution of not less than 3% of the test pressure.

**10.6.7 Piping System Strength Test and Leak Test.** The refrigerant piping system shall be tested in accordance with the manufacturer's installation instructions or this section, whichever is more stringent. Separate tests for low-side and high-side sections of the piping systems shall be permitted. The refrigerant piping system shall be tested in accordance with both of the following:

1. Pressurize for a minimum of sixty minutes to not less than the lower of the design pressures or the setting of pressure relief devices or pressure-relief valves. The design pressures for testing shall be the pressures listed on the label nameplate of the outdoor section, compressor, pressure vessel, or other system component of the refrigerant circuit with a nameplate. Additional test gas shall not be added to the system after the start of the pressure test. The system shall show no loss of pressure on the test pressure measuring device during the pressure test.
2. After completing the pressure test, a vacuum test shall be performed. Once the system reaches a vacuum of 500 microns, the system shall be isolated from the vacuum pump, and the system pressure shall not rise above 1500 microns within 10 minutes.

## 11. MECHANICAL VENTILATION

**11.1 Ventilation.** Where used as a basis for adjusting the maximum refrigerant charge ($m_{max}$) in Section 9.7, ventilation shall comply with Sections 11.1.1 and 11.1.2.

**11.1.1** Ventilation air shall be operated continuously in accordance with Section 11.1.1.1 or controlled by a

refrigerant detection system provided by the manufacturer that is integral to the appliance in accordance with Section 11.1.1.2.

**11.1.1.1 Continuous Operation.** Ventilation air shall be operated continuously except during maintenance of the ventilation system.

**11.1.1.2 Operation by Refrigerant Detection System.** Ventilation initiation by a refrigerant detection system shall operate continuously for a minimum of five minutes after the refrigerant detection system is automatically reset once refrigerant is no longer detected.

**11.1.2 Airflow Control Devices.** Airflow control devices, such as air valves or dampers, shall be driven fully opened when a refrigerant detection system detects refrigerant. Zone dampers, where present, shall fully open when a refrigerant detection system detects refrigerant.

**11.1.3 Discharge of Exhaust Air.** Mechanical ventilation shall discharge to the exterior of the building, or to an interior space that is larger than the minimum dispersal volume determined using Sections 9.5 and 9.6.

## 12. ADD-ON HEAT PUMPS

**12.1** Installation of add-on heat pumps containing A2L refrigerants shall comply with Sections 12.1.1 through 12.1.6.

**12.1.1** The sensor of the refrigerant detection system shall be an integral part of the indoor coil assembly.

**12.1.2** Wiring connecting the refrigerant detection system to a furnace assembly shall use wire with a minimum 18 AWG wire with a minimum insulation thickness of 0.0625 in./1.58 mm or the wire shall be protected from damage.

**12.1.3** Indoor sections using A2L refrigerants shall not be installed on furnaces or modular blowers with an inductive electrical load greater than 2.5 kVA. Where A2L refrigerants with burning velocities greater than 6.7 cm/sec (2.6 in./sec) are used, the maximum allowable inductive load shall comply with Section 12.1.6.

**12.1.4** *Upon detection of a leak, the refrigerant detection system shall activate the indoor fan to supply the airflow specified by the add-on heat pump manufacturer's installation instructions.

**12.1.5** The leak detection system shall be tested for proper operation after installation in accordance with the manufacturer's installation instructions.

**12.1.6** *The inductive load of the indoor blower used with an add-on heat pump shall not exceed the values in Table 12.1.6.

**Table 12.1.6 Maximum Inductive Loads (kVA)**

| Refrigerant | Breaking All Phases | Breaking 2 Legs (3Ph) or 1 Leg (1Ph) |
|---|---|---|
| R-32 | 5 | 2.5 |
| R-452B | 39.4 | 19.7 |
| R-454A | 1990.2 | 995.1 |
| R-454B | 13.8 | 6.9 |
| R-454C | 39.4 | 19.7 |
| R-457A | 6.4 | 3.2 |

## 13. NORMATIVE REFERENCES

1. ACCA. 2016. ANSI/ACCA 1 Manual D, *Residential Duct Systems*. Arlington, VA: Air Conditioning Contractors of America.

2. AHRI. 2019. AHRI Standard 700, *Specifications for Refrigerants*. Arlington, VA: Air-Conditioning, Heating, and Refrigeration Institute.

3. ASHRAE. 2019. ANSI/ASHRAE Standard 15, *Safety Standard for Refrigeration Systems*. Atlanta, GA: ASHRAE.

4. ASHRAE. 2019. ANSI/ASHRAE Standard 34, *Designation and Safety Classification of Refrigerants*. Atlanta,

GA: ASHRAE.

5. ASTM. 2011. ASTM B68/B68M, *Standard Specification for Seamless Copper Tube, Bright Annealed*. West Conshohocken, PA: American Society for Testing and Materials.
6. ASTM. 2011. ASTM B75/B75M, *Standard Specification for Seamless Copper Tube*. West Conshohocken, PA: American Society for Testing and Materials.
7. ASTM. 2016. ASTM B88, *Standard Specification for Seamless Copper Water Tube*. West Conshohocken, PA: American Society for Testing and Materials.
8. ASTM. 2016. ASTM B280, *Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.* West Conshohocken, PA: American Society for Testing and Materials.
9. ASTM. 2016. ASTM B1003, *Standard Specification for Seamless Copper Tube for Linesets.* West Conshohocken, PA: American Society for Testing and Materials.
10. IAPMO. 2018. IAPMO/ANSI UMC 1, *Uniform Mechanical Code*. Ontario, CA: The International Association of Plumbing and Mechanical Officials.
11. ICC. 2018. International Code Council, *International Mechanical Code*. Falls Church, VA: International Code Council.
12. ICC. 2018. International Code Council, *International Residential Code*, Mechanical Section. Falls Church, VA: International Code Council.
13. ISO. 2005. ISO Standard 17584, *Refrigerant Properties.* Geneva, Switzerland: International Standards Organization.
14. NIST. 2013. NIST Standard Reference Database 23: Reference Fluid Thermodynamic and Transport Properties–REFPROP, Version 9.1. Gaithersburg, MD: National Institute of Standards and Technology. Including patch update DLL version 9.1108 (July 29, 2014) and mixing parameter file HMX.BNC (November 9, 2015); http://www.nist.gov/srd/nist23.cfm, http://www.boulder.nist.gov/div838/theory/refprop/Frequently_asked_questions.htm.
    ***NOTE:*** The referenced software version or more recent version shall be acceptable.
15. NFPA. 2020. NFPA 70, *National Electric Code*. Quincy, MA: National Fire Protection Association.
16. NFPA. 2018. NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems.* Quincy, MA: National Fire Protection Association.
17. NFPA. 2018. NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems*. Quincy, MA: National Fire Protection Association.
18. UL. 2020. UL 207, *Standard for Refrigerant-Containing Components and Accessories, Nonelectrical*. St. Charles, IL: United Laboratories.
19. UL. 1995. UL 1995/CSA C22.2 No. 236, *Heating and Cooling Equipment.* St. Charles, IL: United Laboratories.
20. UL. 2016. UL 60335-1/CSA C22.2 No. 60335-1, *Safety of Household and Similar Appliances, Part 1: General Requirements.* St. Charles, IL: United Laboratories.
21. UL. 2019. UL 60335-2-40/CSA-C22.2 No. 60335-2-40, *Safety of Household and Similar Electrical Appliances, Part 2-40: Particular Requirements for Electrical Heat Pumps, Air-Conditioners, and Dehumidifiers*. St. Charles, IL: United Laboratories.

## 14. INFORMATIVE REFERENCES

1. ACCA. 2015. ANSI/ACCA Standard 5 QI, *HVAC Quality Installation Specification.* Arlington, VA: Air Conditioning Contractors of America.
2. IEC. 2004. ANSI/IEC 60529-2004 (R2011), *Degrees of Protection Provided by Enclosures (IP Code)*. Geneva, Switzerland: International Electrotechnical Commission

3. SMACNA. 2016. *Residential Comfort Systems Installation Standards Manual.* Chantilly, VA: Sheet Metal and Air Conditioning Contractors' National Association.

4. UL. 2013. UL Standard 181, *Standard for Factory-Made Air Ducts and Air Connectors*. St. Charles, IL: United Laboratories.

5. UL. 2013. UL Standard 181A, *Standard for Closure Systems for Use with Rigid Air Ducts*. St. Charles, IL: United Laboratories.

6. UL. 2013. UL Standard 181B, *Standard for Closure Systems for Use with Flexible Air Ducts and Air Connectors*. St. Charles, IL: United Laboratories.

7. UL. 2015. UL Standard 900, *Standard for Air Filter Units.* St. Charles, IL: United Laboratories.

**(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)**

## INFORMATIVE APPENDIX A—EXPLANATORY MATERIAL

This informative appendix is not part of the standard. It provides explanatory information related to provisions in the standard. Sections of the standard with associated explanatory information in this appendix are marked with an asterisk "*" after the section number, and the associated appendix information is located in a corresponding section number preceded by "A".

### A2. SCOPE

Although the scope of ASHRAE Standard 15.2 is broad enough to encompass all refrigerants and cord-connected appliances, regulations currently provided in this standard are limited to Group A1 and A2L refrigerants, and cord-connected appliances are not addressed. Refrigeration systems using refrigerants other than Group A1 and A2L are thereby covered by regulated by ANSI/ASHRAE Standard 15, *Safety Standard for Refrigeration Systems*, and regulation of cord-connected appliances is deferred to applicable UL standards. For ammonia refrigeration systems, refer to ANSI/IIAR Standard 2, *American National Standard for Safe Design of Closed-Circuit Ammonia Refrigeration Systems*.

### A4. DEFINITIONS

***access (to):*** the intent of "to be reached" is ensuring that close approach is not prevented by elevation or other barriers or obstructions, does not require climbing over or removing any obstacles, and does not require use of portable devices, other than a ladder, to get to the equipment and components. This differs from *ready access*, which intends to prohibit the need for a ladder to reach a device, appliance, or equipment; or to require removal of a panel, door, or similar obstruction to get to equipment or components.

***add-on heat pump:*** often referred to as a "furnace coil", which is a cooling coil that sits on top of (or under or beside) a furnace (which can be fossil-fuel-fired or electric).

***duct:*** air passages in self-contained systems are not considered to be air ducts.

***field installed accessories:*** such accessories include condensate pumps, UV lights, components having motors, items in the airstream such as supplemental electric heat, duct fans, zone dampers, humidifiers, dehumidifiers, and other items considered part of the system installation, such as circuit boards and controllers.

***ignition source:*** such sources include *appliance* burners, burner ignitions, and electrical switching devices.

***pressure-relief device:*** temperature regulated devices are excluded here because they are covered via the use of a ***fusible plug*.**

***refrigerant detection system*:** the term "devices" as used in the definition may include a sensing element, refrigerant sensor, or refrigerant detector, depending on the technology used by the manufacturer to detect the presence of refrigerant gas in compliance with the applicable requirements in a product safety standard.

***sleeping unit:*** an example of a sleeping unit is a hotel room.

**A5.3** A refrigeration system listed to UL 60335-2-40/CSA-C22.2 No. 60335-2-40-19 meets the requirements of this section.

**A6.1** For A2L refrigerants, this standard covers over the A2L refrigerants listed in the recently proposed SNAP 23 rule from the Environmental Protection Agency: R32, R452B, R454A, R454B, R457A. As other A2L's become available, those will be added.

**A8.5.1.4** Refrigerant piping is permitted by the building code to be in a shaft with other building utilities or piping systems.

**A9.5.3.1** In this section multi-level buildings are addressed. If floors are connected and the higher floor is a full flight higher than the lower floor, then the dispersal height for the higher floor is reduced to zero (7.2-8), and only

the first floor area and height are used. When there is a smaller elevation change between levels like three steps up, then upper level dispersal height is reduced by the difference in the levels of the two floor (7.2-1.94) assuming 7.75" per step.

**A12.1.4** Checking of the refrigerant detector set point is not required.

**A12.1.6** The maximum induction load is a function of the refrigerant burning velocity at the WCF condition. Currently, there is no value listed at WCF for R454C and R457C. For the table, the WCFF values were used. This will be updated when those burning velocities are available.

**(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)**

## INFORMATIVE APPENDIX B—GENERAL SERVICE AND MAINTENANCE

### B1 Service Instructions

**B1.1** Personnel performing service and maintenance of the refrigeration system should be trained and competent with respect to their tasks, meeting all applicable local, state, or national licensing requirements.

**B1.2** Personnel performing service and maintenance should follow manufacturer's instructions with respect to the addition and removal of refrigerants, oils, additives, controls, and accessories. Maintenance and service personnel should adhere to manufacturer specified service requirements.

### B2 Service and Maintenance Documentation

**B2.1** The service or maintenance technician should keep a service record of all service and maintenance performed on the refrigerant detection system or when the refrigeration circuit is repaired or replaced. This service record should be kept on site. The service record should be protected from weather and moisture.

**B1.2** In the service record, the following information should be recorded:

a. Date of service and initials of technician performing the work
b. Details of all maintenance and repair work performed on refrigerant detectors or refrigerant circuits and validation that maintenance and repair work has left the system in proper working order
c. Quantities and kind (new, reused, or recycled) of refrigerant which have been charged on each occasion, and the quantities of refrigerant which have been transferred from the system on each occasion (see also Sections 6.1 and 6.2)
d. Changes and replacements of all components of the system
e. Results of all periodic/routine inspections

### B3 Maintenance

**B3.1** Refrigeration systems should be maintained by the user in a clean condition, free from accumulations of oily dirt, waste, and other debris, and access to refrigeration systems should be provided at all times.

**B3.2** Maintenance, service, and replacement of refrigerant detection systems or refrigerant detection system components should be performed in accordance with the system manufacturer's instructions.

### B4 Repair

**B4.1** Repairs on refrigerant containing components should be performed by certified, licensed personnel and carried out in the following order, if appropriate:

a. Remove refrigerant
b. Purge the circuit with inert gas
c. Cut out the component to be repaired
d. Replacing the components to be repaired/replaced (e.g. filter drier, coil, compressor, power drive, pressure vessel, tubing)
e. Leak check per Section 8
f. Evacuating and recharging with refrigerant
g. Functional testing and checking of the repaired component

### B4.2 Refrigerant Leaks

**B4.2.1** For A2L systems, refrigerant leaks should be identified, repaired, and verified prior to adding additional refrigerant into the system. Patterns of adding refrigerant (once per three years or more often) should be considered proof of a leak. Any addition of refrigerant should be marked on the appliance, indicating the date and amount.

**B4.2.2** After any refrigerant system repair the following should be performed:

a. Leak check all joints internal to the building to which service personnel have access
b. Verify refrigerant detector is functioning per manufacturer's installation instructions
c. Verify mitigation ventilation/circulation system is functioning

**B4.3** After a pressure-relief valve has been actuated, it should be replaced.

**B4.4** When oil is drained from a refrigeration system, it should be removed safely in accordance with the system manufacturer's instruction manual.

## B5 Change of Refrigerant Type

**B5.1 Refrigerant Conversion.** Changes of refrigerant in an existing refrigeration system to a refrigerant with a different refrigerant designation, should only be allowed when in accordance with all requirements of Sections B5.1.1 through B5.1.4.

**B5.1.1** The replacement refrigerant should be in the same safety group as the original refrigerant.

**B5.1.2** The change of refrigerant should be approved by the owner and the manufacturer.

**B5.1.3** The product safety requirements and installation requirements that were applicable at the time of original product installation shall continue to be applicable after refrigerant conversion.

**B5.1.4** The ANSI/ASHRAE Standard 34 designation of the new refrigerant should be clearly marked on the appliance, and references to the replaced refrigerant removed or permanently covered.

## B6 Charging, Withdrawal, and Disposition of Refrigerants

**B6.1** No service containers should be left connected to a system except while charging or withdrawing refrigerant. Refrigerants withdrawn from refrigeration systems should be transferred to approved containers only. Except for discharge of pressure-relief devices and fusible plugs, incidental releases due to leaks, purging of non-condensables, draining oil, and other routine operating or maintenance procedures, no refrigerant should be intentionally vented to the atmosphere or to locations such as a sewer, river, stream, or lake.

**B6.2 Containers.** Containers used for refrigerants withdrawn from a refrigeration system should be as prescribed in the pertinent regulations of the U.S. Department of Transportation, or equivalent local enforcement agency, and should be weighed each time they are used for this purpose. Containers should not be filled in excess of the permissible filling weight.

**B6.3 Calibration of Pressure-Measuring Equipment.** Pressure-measuring equipment should be checked for accuracy and calibrated prior to test and immediately after every occasion of unusually high (full-scale) pressure, either by comparison with master gages or a dead-weight pressure gage tester, over the operating range of the equipment.

**B6.4 Periodic Tests.** Refrigerant detection systems, alarm(s), and mechanical ventilating systems should be tested in accordance with manufacturers' specifications.