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A2L Refrigerants and ASHRAE® Standard 15

The HVAC&R industry is in the midst of another refrigerant transition. Some of the newer refrigerants under consideration are designated as having "lower flammability" (Class 2L), indicating that they can ignite under certain conditions. Building codes and industry standards (such as ASHRAE Standard 15) have been updated to include safety requirements that reflect the less-flammable nature of Class 2L refrigerants.

This Engineers Newsletter presents an overview of Standard 15's requirements for the safe design, installation, and operation of systems that use this class of refrigerants.

Phase Down of Higher-GWP Refrigerants

After the success of implementing the Montreal Protocol, an international treaty to reduce the presence of ozone-depleting substances in the atmosphere, the Kigali Amendment addressed the issue of global warming by phasing down the supply of HFC refrigerants.

The U.S. American Innovation and Manufacturing Act mandated that the U.S. Environmental Protection Agency (EPA) phase down the supply of HFC refrigerants on the same schedule as the Kigali Amendment. This legislation also authorizes the EPA to require "technology transitions" that limit the global warming potential (GWP) of refrigerants used in various types of equipment.

Refer to Trane's "Refrigerant Update" for the latest information on regulations to limit the GWP of refrigerants used in HVAC equipment.[1]

This global scrutiny of the environmental impact of refrigerants has resulted in the development of newer refrigerants that have a lower GWP. Some of the newer refrigerants under consideration are designated as having "lower flammability" (Class 2L), indicating that they can ignite under certain conditions.

Refrigerant Safety Groups

ANSI/ASHRAE® Standard 34, *Designation and Safety Classification of Refrigerants*, establishes a uniform system for assigning reference numbers, safety classifications, and refrigerant concentration limits to refrigerants.[2] This standard classifies each refrigerant into a "safety group" according to its toxicity (Class A or B) and its flammability (Class 1, 2L, 2, or 3).

Toxicity classification. Section 6.1.2 of Standard 34 defines two toxicity classes based on allowable exposure:

- Class A refrigerants are of a lower degree of toxicity, as indicated by an OEL >= 400 ppm.
- Class B refrigerants are of a higher degree of toxicity, as indicated by an OEL < 400 ppm.

Standard 34 defines this occupational exposure limit (OEL) as "the time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek to which nearly all workers can be repeatedly exposed without adverse effect."

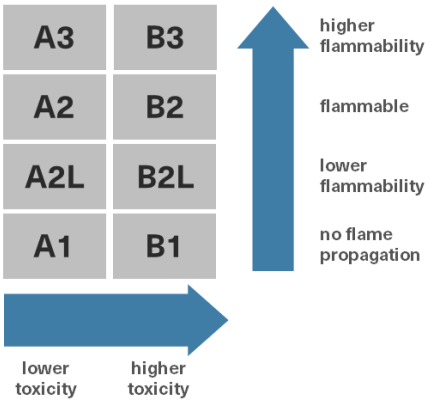
Flammability classification. The letter designation for toxicity is followed by a number that indicates how readily the refrigerant may ignite. Section 6.1.3 of Standard 34 defines four flammability classes:

- Class 3 refrigerants have a very low lower flammability limit (LFL), indicating that they ignite easily and the flame propagates easily.
- Class 2 refrigerants have lesser flammability characteristics than Class 3; they have a higher LFL, but are still easy to ignite and propagate flames well.
- Class 2L refrigerants have an even higher LFL and are more difficult to ignite.
- Class 1 refrigerants do not exhibit flame propagation, and are commonly referred to as "non-flammable."

The Class 2L definition was first added to Standard 34 in its 2010 published version. A flame propagation test is used to indicate that a refrigerant is flammable and to determine its LFL. Then a burning velocity test is used to determine how difficult it is to ignite. Refrigerants that are more difficult to ignite, and have a high LFL, are assigned the 2L classification.

Safety groups. Together, the toxicity and flammability classifications define eight safety groups—A1, B1, A2L, B2L, A2, B2, A3, and B3—which are represented by the matrix in Figure 1. These safety group designations are used by building codes and industry standards (such as ASHRAE Standard 15) to prescribe safety requirements for refrigeration systems.

Figure 1. Refrigerant safety groups from ASHRAE® Standard 34



ASHRAE® Standard 15

The purpose of ANSI/ASHRAE Standard 15, *Safety Standard for Refrigeration Systems*, is to specify safe practices for the design, construction, installation, and operation of refrigeration systems.[3] It applies to a broad range of systems, from a small window air conditioner to a large water chiller. Its requirements are intended for not only newly-installed systems, but also for replacements or alterations that change the function or capacity of the system, as well as conversions to a different type of refrigerant.

Some of the requirements in Standard 15 are general and apply to all system types, while other requirements are specific to the type and use of the refrigeration system. Which safety requirements apply depends on:

1. The **safety group classification** of the refrigerant, as defined by Standard 34,
2. The **occupancy classification** of the room served by the refrigeration system, and
3. The **refrigeration system classification**, which is based on the likelihood (probability) of refrigerant leaking from a refrigeration system into an occupancy-classified area of the building.

Refrigeration system classification. Section 5.2 of Standard 15 classifies a refrigeration system as either:

- **High-probability systems** are those in which the basic design or location of components is such that leaked refrigerant from a failed connection, seal, or component has a high probability of entering an occupied space. Some common examples include a direct-expansion (DX) split system, a packaged DX rooftop unit, a water-source heat pump, a variable refrigerant flow (VRF) system, or a PTAC.
- **Low-probability systems** are those in which the basic design or location of components is such that leaked refrigerant from a failed connection, seal, or component has a low probability of entering an occupied space. A typical example is a water chiller, located either outdoors or in a "machinery room," that delivers chilled water to one or more remote air-handling units or terminal units.

Standard 15 requirements for Group A2L refrigerants used in high-probability systems. Safety requirements for Class 2L (lower flammability) refrigerants were first added to Standard 15 in its 2019 published version. For high-probability systems, these requirements underwent major revisions for the 2022 version, in an attempt to better harmonize with the requirements in UL 60335-2-40/CSA C22.2 No. 60335-2-40.[4]

Section 7.5.2.1 of Standard 15 prohibits the use A2, A3, B1, B2L, B2, and B3 refrigerants in a high-probability system that is used to provide human comfort—although industrial occupancies and some smaller "unit systems" are exempt. In general, this leaves only Group A1 or A2L refrigerants that may be used for this application.

Due to the flammability characteristics of Group A2L refrigerants, however, Section 7.6 of Standard 15 includes the following special requirements when they are used in a high-probability system for human comfort:

- **"Listed" equipment.** For this application, the refrigeration system must be "listed" in accordance with either the UL 60335-2-40/CSA C22.2 No. 60335-2-40, *Standard for Household and Similar Electrical Appliances–Safety–Part 2-40: Particular Requirements for Electrical Heat Pumps, Air-Conditioners and Dehumidifiers* (see inset on the right), or UL 484, *Standard for Room Air Conditioners*.
- **Refrigerant quantity limit.** The releasable refrigerant charge cannot exceed the effective dispersal volume charge (EDVC) limit defined in Section 7.6.1 of Standard 15. The EDVC is based on the lower flammability limit (LFL) of the refrigerant—as tabulated in ASHRAE Standard 34—and depends on whether or not the refrigeration system has "air circulation," either continuously operating or that is initiated by a refrigerant detector.
- **Refrigerant detection system.** For some refrigeration systems, the standard requires it to be equipped with an integral refrigerant detection system. However, even if not explicitly required by the standard, many systems will still likely be equipped with a refrigerant detector to lower the EDVC limit (for systems with air circulation) and to provide an added level of safety. Having the refrigerant detector installed in the factory by the manufacturer reduces the risk of improper installation in the field.
- **Required mitigation actions.** If the refrigerant detection system measures a refrigerant concentration that exceeds the setpoint, the standard requires the following mitigation actions to occur within 15 seconds: energize the air circulation fan of the equipment (if equipped), open any zone dampers installed in the ductwork connected to the refrigeration system, de-energize any electric resistance heaters installed in the ductwork connected to the refrigeration system, de-energize any other potential ignition sources, activate safety shutoff valves (if equipped) that are used to limit refrigerant release, and activate mechanical ventilation (if it's required by Section 7.6.4 of the standard). These actions must continue for at least five minutes after the detector has sensed a drop in refrigerant concentration below the setpoint.
- **Ignition sources cannot be installed in the ductwork.** If a ducted system experiences a refrigerant leak, it is critical to prevent ignition in the ductwork. Therefore, open-flame-producing devices and unclassified electrical devices cannot be installed in ductwork that serves the space. Hot surfaces > 1290°F (700°C) are permitted in the ductwork if an average air velocity ≥ 200 ft/min (1.0 m/s) can be maintained across the heating device, and a proof-of-airflow device ensures airflow before the heating device is energized.
- **Mechanical ventilation.** If the largest refrigerant charge from an independent refrigeration circuit exceeds the EDVC, then a mechanical ventilation system is required to remove this excess leaked refrigerant from the space. This requires the use of a separate fan to exhaust air from the space—or to transfer air to a separate indoor space—and provision to replace this exhaust air with makeup air from outdoors, or from other indoor spaces. In the context of Standard 15, the term "mechanical ventilation" refers to the process of removing air (along with leaked refrigerant) from a space to reduce the concentration of refrigerant in that space. This is different than ASHRAE Standard 62.1, in which ventilation refers to the process of introducing fresh outdoor air to a space for the purpose of controlling indoor air quality.

UL 60335-2-40/CSA C22.2 No. 60335-2-40

Prepared by Underwriters Laboratories Inc. (UL) and CSA Group, UL 60335-2-40/CSA C22.2 No. 60335-2-40 is a product safety standard for HVAC equipment in the United States and Canada.[4]

While the ASHRAE committee attempted to harmonize the requirements in Standard 15 with those in this UL/CSA standard, there are some instances where the standards may differ.

Manufacturers of HVAC equipment are likely to follow the requirements of this UL/CSA standard strictly, to ensure their products are "listed"—this listing is a requirement of Section 7.6.2 in Standard 15 if a Group A2L refrigerant is used in a "high-probability" system for human comfort.

Depending on the application, it's possible that a specific requirement of Standard 15 may be more stringent than what is required by this UL/CSA standard. Following are some examples of these differences, not an exhaustive comparison of the standards:

- Both standards prescribe a maximum refrigerant charge. Based on this charge, the UL/CSA standard requires the manufacturer to calculate the minimum floor area of the room served by the equipment using a determined minimum installation height, and then indicate both of these values on the product nameplate. For systems with air circulation, Section 7.6.1.1 of Standard 15 bases its EDVC calculation on the effective dispersal volume.
- The UL/CSA standard does not include an occupant adjustment factor when determining the EDVC limit. Therefore, for an occupancy classified as "institutional," the Standard 15 calculation of EDVC will likely be more stringent.
- There are some applications where Standard 15 might require a refrigerant detection system, while the UL/CSA standard does not.
- The UL/CSA standard prescribes several methods for the manufacturer to measure or calculate the releasable refrigerant charge. This might result in a value higher or lower than the releasable charge calculated per Section 7.3.4 in Standard 15.

Standard 15 requirements for Group A2L refrigerants used in low-probability systems. As mentioned previously, safety requirements for Class 2L (lower flammability) refrigerants were first added to Standard 15 in its 2019 published version. For low-probability systems, these requirements are largely unchanged (other than section renumbering) for the 2022 version, with one exception (see more information below).

For a large refrigeration system, such as a water chiller, Section 7.4 of Standard 15 often requires that all components containing refrigerant must be located in a "machinery room" or outdoors. The term "machinery room" has a special meaning in Standard 15; it is defined as a designated space that complies with the requirements listed in Sections 8.9, 8.10, and 8.11. Which of these requirements apply depends on the safety group classification of the refrigerant(s) being used (summarized in Table 1):

7.4.2 Class 1 Refrigerants. *Machinery rooms required by Section 7.4 and containing only Group A1 or B1 refrigerants shall be constructed and maintained in accordance with Section 8.9.*

7.4.3 Class 2L, Class 2, and Class 3 Refrigerants. *Machinery rooms required by Section 7.4 and containing any Group A2, A3, B2, or B3 flammable refrigerants shall be constructed and maintained in accordance with Sections 8.9 and 8.10. Machinery rooms required by Section 7.4, containing any Group A2L or B2L flammable refrigerants and containing no Group A2, A3, B2, or B3 flammable refrigerants, shall be constructed and maintained in accordance with Sections 8.9.1 through 8.9.4 and Section 8.11.*

As mentioned, the requirements for machinery rooms were largely unchanged between the 2019 and 2022 versions of Standard 15. The one exception is a reduction in the "Level 2" ventilation rate when a Class 2L refrigerant is used.

"Level 2" ventilation is the rate at which air must be removed from the machinery room (and discharged outside) if the measured refrigerant concentration in the room exceeds the "emergency alarm" setpoint—which can be any concentration no higher than the refrigerant concentration limit (RCL) of the refrigerant.

For a machinery room that contains a Class 2L refrigerant (but no Class 2 or 3 refrigerants), this "Level 2" ventilation rate is calculated based on the design pressure (DP) of the refrigeration system and the mass of refrigerant (G) in the largest independent refrigeration circuit. For systems with a DP > 200 psig (1.4 MPa), the required "Level 2" ventilation rate was reduced in the 2022 of the standard, as compared to the 2019 version.

Summary

Building codes and industry standards have been updated to include safety requirements that reflect the less-flammable nature of Class 2L refrigerants:

- UL 60335-2-40/CSA C22.2 No. 60335-2-40 first added these requirements in 2017; and has published several revised editions since then.
- ASHRAE Standard 15 first added these requirements in its 2019 published version. For "high-probability" systems, these requirements underwent major revisions for the 2022 version, in an attempt to better harmonize with the requirements in UL 60335-2-40/CSA C22.2 No. 60335-2-40. For "low-probability" systems (e.g., "machinery rooms"), these requirements are largely unchanged in the 2022 version.

Manufacturers of HVAC equipment are likely to follow the requirements of UL 60335-2-40/CSA C22.2 No. 60335-2-40 strictly, to ensure their products are "listed"—this listing is a requirement of Standard 15 if a Group A2L refrigerant is used in a "high-probability" system for human comfort. Depending on the application, it's possible that a specific requirement of Standard 15 may be more stringent than what is required by the UL/CSA standard.

A recently-revised Trane application manual (literature number: APP-APM001F-EN) explains how the requirements in the 2022 version of Standard 15 apply to various types of refrigeration systems—from packaged rooftop units to VRF systems to large water chillers—and all refrigerant safety groups, including Group A2L.[5] It also includes examples of how to calculate the releasable refrigerant charge and effective dispersal volume charge (EDVC) limit for several system types.

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Table 1. Summary of Standard 15 machinery room requirements for different refrigerant safety groups

Machinery room requirement	A1, B1	A2, B2, A3, B3	A2L, B2L
Equipment clearances with clear head room	Required (Section 8.9.1)	Required (Section 8.9.1)	Required (Section 8.9.1)
Tight-fitting, self-closing doors	Required (Section 8.9.2)	Required (Sections 8.9.2, 8.10.b)	Required (Sections 8.9.2, 8.11.2)
Exterior doors must not open under a fire escape or stairway	Not Required	Required (Section 8.10.d)	Required (Section 8.11.4)
No openings to building, tightly-sealed penetrations	Required (Section 8.9.2)	Required (Sections 8.9.2, 8.10.e)	Required (Sections 8.9.2, 8.11.5)
Gasketed ductwork/AHU panels and doors	Required (Section 8.9.3)	Required (Section 8.9.3)	Required (Section 8.9.3)
Restricted access, door signs	Required (Sections 8.9.4, 10.1.3)	Required (Sections 8.9.4, 10.1.3)	Required (Sections 8.9.4, 10.1.3)
Refrigerant detector	Required (Section 8.9.5)	Required (Section 8.9.5)	Required (Sections 8.11.8 - 8.11.10)
Mechanical ventilation to the outdoors	Required (Sections 8.9.6 – 8.9.8)	Required (Sections 8.9.6 – 8.9.8)	Required (Section 8.11.11)
No open flames or hot surfaces	Exceptions Allowed (Section 8.9.9)	No Exceptions (Section 8.10a)	Exceptions Allowed (Section 8.11.1))
Non-combustible construction (walls, floor, ceiling)	Not Required	Required (Section 8.10.c)	Required (Section 8.11.3)
Conform to NEC Class 1, Division 2	Not Required	Required (Section 8.10.f)	May Not Be Required (comply with Section 8.11.6)
Remote control for shutting down equipment	Not Required	Required (Section 8.10.g)	Required (Section 8.11.7)

To learn more about Trane's efforts to reduce greenhouse gases
visit the Trane Refrigerant Management information on Trane.com
Trane has made available several helpful resources on next generation refrigerants, the HVAC industry update on refrigerants, information on refrigerant management, and much more.

UPDATED AND NOW AVAILABLE!
Refrigeration Systems and Machinery Rooms:
Application Considerations for Compliance with ASHRAE® Standard 15-2022
(APP-APM001F-EN - July 2023)
Updated to help readers understand the changes recently made to ANSI/ASHRAE Standard 15-2022, *Safety Standard for Refrigeration Systems*. This manual explains how the standard's requirements apply to many types of refrigeration systems—from packaged rooftop units to VRF systems to large water chillers—and to all refrigerant safety groups, including A2L. It also includes examples of how to calculate the releasable refrigerant charge and effective dispersal volume charge (EDVC) limit for several common HVAC system types.

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