BSR/ASHRAE Addendum l
to ANSI/ASHRAE Standard 15-2019

First Public Review Draft

Proposed Addendum l to Standard 15-2019, Safety Standard for Refrigeration Systems

First Public Review (November 2021)
(Draft shows Proposed Changes to Current Standard)

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FOREWORD

This proposed addendum l to ASHRAE Standard 15-2019 modifies portions of the document to incorporate requirements for commercial refrigeration applications with the use of A2L, A2 and A3 refrigerants. The text developed is in response to CMP0004-001 based on information and requirements in conjunction with proposed product safety standard UL/CSA 60335-2-89, as well as research performed in collaboration of AHRI, ASHRAE, the U.S. Department of Energy, California Energy Commission.

Many of the proposed requirements use of flammable refrigerants for commercial refrigeration applications, found mostly in new Section 7.7, are very similar to the existing requirements for A2L refrigerants for human comfort applications, found mostly in Section 7.6. Note the A2L requirements for human comfort were published in addendum d to Standard 15-2016. Notably, several of the Section 7.7 requirements refer back to Section 7.6.

Note: This addendum makes proposed changes to the current standard. These changes are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) except where the reviewer instructions specifically describe some other means of showing the changes. Only these changes to the current standard are open for review and comment at this time. Additional material is provided for context only and is not open for comment except as it relates to the proposed changes.

Addendum l to Standard 15-2019

Modify Section 7 as follows. The remainder of Section 7 remains unchanged.

7. RESTRICTIONS ON REFRIGERANT USE

[…]

7.4 Location in a *Machinery Room* or Outdoors. All components containing *refrigerant shall* be located either in a *machinery room* or outdoors, where the quantity of *refrigerant* needed exceeds the limits defined by Sections 7.2 and 7.3 or where direct-fired absorption equipment is used.

Exceptions to 7.4:

1. *Listed self-contained*~~*Self-contained*~~ *systems* are permitted outside of a *machinery room*, provided that such systems are not located in public hallways or *lobbies* and are limited to the following *occupancies* and *refrigerant* quantities:

[…]

7.5 Additional Restrictions

7.5.1 All Occupancies. Sections 7.5.1.1 through ~~7.5.1.8~~7.5.1.9 apply to all *occupancies*.

[…]

7.5.1.9 Addition of Doors to Open Refrigerated Display Cases Containing Flammable *Refrigerants*. It is acceptable for doors to be added to open display cases containing flammable *refrigerants* only when in accordance with all the following:

a. The owner or the owner's authorized agent *shall* be notified prior to addition of a door(s) and the addition of a door(s) *shall not* be made where the owner objects to the change.

b. Flammable *refrigerant* charge sizes *shall not* exceed the limits for closed refrigerated display cases, as defined by UL 60335-2-89[18] / CSA C22.2 No. 60335-2-89[19]. All construction, testing, and marking requirements for a new installation of closed cases, as defined in UL/CSA 60335-2-89,

shall also apply.

c. Validation of safety and suitability of the addition of doors through one of the following:

1. written instructions of the original equipment *manufacturer* and approval of the *AHJ*
2. evaluation of the system by a registered design professional and approval of the *AHJ*
3. evaluation by an *approved nationally recognized* testing *laboratory*.

[…]

7.5.2 Applications ~~for Human Comfort~~ Restrictions by *Refrigerant* Safety Group

7.5.2.1 Refrigeration Systems for Human Comfort. Group A2, A3, B1, B2L, B2, and B3 *refrigerants shall not* be used in high-probability systems for human comfort. Use of Group A2L *refrigerants shall* be in accordance with Section 7.6.

Exceptions to 7.5.2.1:

1. These restrictions do not apply to *unit systems* having *refrigerant* quantities less than
   a. 6.6 pounds (3 kg) of *refrigerant* where located in residential *occupancies* or
   b. 22 pounds (10 kg) of *refrigerant* where located in commercial *occupancies*
2. These restrictions do not apply to industrial *occupancies*.

7.5.2.2 Refrigeration Systems Other Than Human Comfort. *High-probability systems* for other than human comfort applications *shall not* use Class B *refrigerants*. Use of Group A2L *refrigerants shall* be in accordance with Section 7.7. Use of Group A2 *refrigerants shall* be in accordance with Section 7.8. Use of Group A3 *refrigerants shall* be in accordance with Section 7.5.3.

Exceptions to 7.5.2.2:

1. These restrictions do not apply to industrial *occupancies*.

7.5.3 Higher-Flammability *Refrigerants*. Group A3 and B3 *refrigerants shall not* be used except where *approved* by the *AHJ*.

Exceptions to 7.5.3:

1. This restriction does not apply to laboratories with more than 100 ft^2 (9.3 m^2) of space per person.
2. This restriction does not apply to industrial *occupancies*.
3. This restriction does not apply to *listed self-contained systems* containing no more than 0.331 lb (150 g) of Group A3 *refrigerant*, provided that the equipment is installed in accordance with the listing and the *manufacturer's* installation instructions.
4. This restriction does not apply to equipment *listed* to UL 60335-2-89[18] / CSA C22.2 No. 60335-2-89[19] containing no more than 0.459 × *LFL* (lb), where *LFL* is in pounds per 1000 ft^3 (13 × *LFL* [kg], where *LFL* is in kg/m^3) of Group A3 *refrigerant*, provided that the equipment is installed in accordance with the listing and the *manufacturer's* installation instructions. Refrigeration systems containing more than 0.141 × *LFL* (lb) (4 × *LFL* [kg]) in an independent circuit *shall not* be installed within 20 ft of an open flame.
5. This restriction does not apply to equipment *listed* to UL 60335-2-40/CSA C22.2 No. 60335-2-40 containing no more than 0.106 × *LFL* (lb) (3 × *LFL* [kg]) of Group A3 *refrigerant*, provided that the equipment is installed in accordance with the listing and the *manufacturer's* installation instructions.

[…]

7.7 Group A2L *Refrigerants* for Refrigeration Systems Other than Human Comfort. *High-probability systems* using Group A2L *refrigerants* for other than human comfort applications *shall* comply with Sections 7.7.1 through 7.7.6.

7.7.1 *Refrigerant* Charge Limits. *Refrigerant* charge *shall* be limited as follows:

1. Refrigeration systems containing more than 0.141 × *LFL* (lb) (4 × *LFL* [kg]) in an independent circuit

shall not be installed within 20 ft of an open flame.

2. Refrigeration systems *shall* contain no more than 9.2 × *LFL* (lb), where *LFL* is in pounds per 1000 ft^3 (260 × *LFL* [kg], where *LFL* is in kg/m^3) of Group A2L *refrigerant* per independent circuit.

Exceptions to 7.7.1:

1. This restriction does not apply to laboratories with more than 100 ft^2 (9.3 m^2) of space per person.
2. This restriction does not apply to industrial *occupancies*.
3. This restriction does not apply to systems located in *machinery rooms* or outdoors.

7.7.2 *Refrigerant Concentration Limits*

7.7.2.1 *Occupied spaces shall* comply with Section 7.2.

7.7.2.2 Unoccupied *spaces* with *refrigerant* containing equipment, including but not limited to *piping* or tubing, *shall* comply with Section 7.2 except as permitted by Section 7.7.5.

7.7.3 Listing and Installation Requirements. Refrigeration systems *shall* be *listed* to UL 60335-2-89[18] /CSA C22.2 No. 60335-2-89[19] and *shall* be installed in accordance with listing, the *manufacturer's* instructions, and any markings on the equipment restricting the installation.

Exception to 7.7.3:

1. These requirements do not apply to industrial *occupancies*.

7.7.3.1 The nameplate required by Section 9.15 *shall* include a symbol indicating that a flammable *refrigerant* is used, as *specified* by the product listing.

7.7.3.2 A label indicating a flammable *refrigerant* is used *shall* be placed adjacent to service ports and other locations where service involving components containing *refrigerant* is performed, as *specified* by the product listing.

7.7.3.3 A *refrigerant detector shall* be provided in accordance with Section 7.7.6, except where the following apply:

a. When the *refrigerant* charge of any independent circuit is less than or equal to 0.459 × *LFL* (lb), where *LFL* is in pounds per 1000 ft^3 (13 × *LFL* [kg], where *LFL* is in kg/m^3); or

b. When the complete discharge of *refrigerant* from any independent circuit will not exceed 50% of the *RCL* of the space and the lowest point from which leak *refrigerant* will disperse into the space is greater than or equal to 14.5 ft (4.4 m).

7.7.3.4 When a *refrigerant detector* required by Section 7.7.3.3 senses a rise in *refrigerant* concentration above the value *specified* in Section 7.7.6(b), the actions of Section 7.6.2.4 *shall* be taken.

7.7.4 Ignition Sources Located in Ductwork. Any ductwork serving the space *shall* comply with Section 7.6.3.

7.7.5 *Compressors* and *Pressure Vessels* Located Indoors. For refrigeration *compressors* and *pressure vessels* located in an indoor space that is accessible only during service and maintenance, it *shall* be permissible to use larger *refrigerant* amounts than those given in Section 7.2, provided a mechanical ventilation system is used to prevent exceeding the *RCL* and all of the following provisions are met:

a. The releasable *refrigerant charge* of the largest independent refrigerating circuit *shall not* exceed 9.2 × *LFL* (lb) (260 × *LFL* [kg]). Releasable charges greater than 9.2 × *LFL* (lb) (260 × *LFL* [kg]) *shall* comply with the *machinery room* requirements of Section 8.13.

b. A mechanical ventilation system *shall* be provided that will mix air with leaked *refrigerant* and remove it from the space where the equipment is located. The space *shall* be provided with an exhaust fan. The exhaust fan *shall* remove air from the space where the equipment is located in accordance with Section 8.13.11.4.

c. The space and mechanical ventilation system is in compliance with Sections 7.6.4(b) and 7.6.4(d) through 7.6.4(f).

d. Electric motors driving fans *shall not* be placed inside the exhaust *ducts*; fan rotating elements *shall* be nonferrous or non-sparking, or the casing *shall* consist of or be lined with such material.

7.7.6 *Refrigerant Detectors* and Mitigation Activation. *Refrigerant detectors* required by Section 7.7.3 *shall* meet the requirements of Section 7.6.5.

7.8 Group A2 *Refrigerants* for *Refrigeration Systems* Other than Human Comfort. High probability systems using Group A2 *refrigerants* for other than human comfort applications *shall* comply with this section. *Refrigeration systems* using Group A2 *refrigerants shall* be limited to *listed self-contained systems* containing no more than 0.459 × *LFL* (lb), where *LFL* is in pounds per 1000 ft^3 (13 × *LFL* [kg], where *LFL* is in kg/m^3), provided that the system is installed in accordance with the listing and the *manufacturer's* installation instructions. Refrigeration systems containing more than 0.141 × *LFL* (lb), (4 × *LFL*[kg]) in an independent circuit *shall not* be installed within 20 ft of an open flame.

Exceptions to 7.8:

1. This restriction does not apply to laboratories with more than 100 ft^2 (9.3 m^2) of space per person.
2. This restriction does not apply industrial *occupancies*.
3. This restriction does not apply to systems located in *machinery rooms* or outdoors.

[…]

Modify Section 14 as follows. The remainder of Section 14 remains unchanged. Normative Appendix B—Normative References was redesignated as Section 14 by Addendum f to Standard 15-2019.

14. NORMATIVE REFERENCES

[…]

18. UL. 2021. ANSI/UL 60335-2-89-2021, Edition 2. *Household and Similar Electrical Appliances – Safety – Part 2-89: Particular Requirements for Commercial Refrigerating Appliances and Ice-Makers with an Incorporated or Remote Refrigerant Unit or Motor-compressor*. Northbrook, IL: UL LLC.
19. CSA. 2021. CAN/CSA-C22.2-21 No. 60335-2-89, Edition 2. *Household and Similar Electrical Appliances – Safety – Part 2-89: Particular Requirements for Commercial Refrigerating Appliances and Ice-Makers with an Incorporated or Remote Refrigerant Unit or Motor-compressor*. Toronto, ON, Canada, CSA Group.

Modify Informative Appendix B as follows. The remainder of Informative Appendix B remains unchanged. Informative Appendix A—Informative References was redesignated as Informative Appendix B—Informative References by Addendum f to Standard 15-2019.

INFORMATIVE APPENDIX B—INFORMATIVE REFERENCES

[…]

18. See Section 14, "Normative References."
19. See Section 14, "Normative References."

(The following additional information is not part of this addendum. It is presented for reference only and includes supporting information for the text developed in this addendum; it is not part of any changes proposed to ANSI/ASHRAE Standard 15, *Safety Standards for Refrigeration Systems*.)

Introduction: The use of flammable refrigerants in ACR applications is growing throughout the world. Data collected from equipment manufacturers indicates that there are millions of plug-in refrigerated display cases/cabinets using hydrocarbons in supermarkets worldwide. Over a billion domestic refrigerators use hydrocarbon refrigerants as well. Lower flammability A2L refrigerants are also in use in tens of millions of air conditioning systems in cars, window units, mini-splits, PTACs, or portable systems. While these are typically smaller charge systems, regulations requiring lower GWP refrigerant options are leading to the use of flammable refrigerants in other larger charge applications.

Recently, a draft of the proposed 2nd edition of UL 60335-2-89 (*Safety Standard for Commercial Refrigeration Appliances*) was approved with comments. This draft includes language that would increase the charge limits for flammable refrigerants from 150 g to 8 × LFL for self-contained appliances with doors/drawers and refrigerating units, or 13 × LFL for other self-contained equipment (e.g., open display cases). For commonly used higher flammability A3 refrigerants (e.g., propane and isobutane), this translates to charge limits of ≈ 300/500 g. For typical lower flammability A2L refrigerants, the corresponding charge limits would be ≈ 2,400/3,900 g. Larger charge sizes of A2L refrigerants only would also be permitted for field erected applications (e.g., split systems). Along with increases in flammable refrigerant charge limits come a host of new safety requirements, similar to those found in the 3rd edition of UL 60335-2-40 (hereafter "2-40"). Many of these are centered around refrigerant leak prevention and mitigation. That public review draft was approved, and additional changes are being proposed to address public review comments. A public review of those proposed changes is anticipated.

Proposed language to modify ANSI/ASHRAE Standard 15 to include requirements for flammable refrigerants in commercial refrigeration was developed in parallel to the draft 2nd edition of UL 60335-2-89, so that the two standards might be better harmonized.

IEC 60335-2-89, 3rd Edition Background: The 3rd edition of the international IEC 60335-2-89 standard was published in 2019 and included increased charge limits for flammable refrigerants. This standard also served as the starting point for the draft of the proposed 2nd edition of UL 60335-2-89. One of the sentiments expressed during the development of this standard was that increases in flammable refrigerant charge sizes should not lead to increased risk. Part of the approach to ensuring this is the Annex CC test procedure, required for appliances using flammable refrigerant charge sizes > 150 g.

Annex CC (entitled "Test method for determining gas concentration beyond the boundary of the appliance") requires the appliance to be tested in a room while it is surrounded with concentration measuring sensors, and refrigerant is leaked from a critical point. For external leaks (e.g., from the condensing unit), the concentration of refrigerant cannot exceed 50% of the LFL. Appliances with doors and drawers are also required to perform additional tests, where the refrigerant charge is leaked into the refrigerated compartment and a door/drawer is opened. During the door opening test, refrigerant concentrations cannot exceed 50% of the LFL for a period greater than five minutes.

The compliance requirements for the door opening test have been the subject of significant discussion and debate. From a practical standpoint, this test does not ensure that a flammable concentration won't be formed. As noted earlier, there is a significant installed base of equipment using hydrocarbon refrigerants. Most of these units contain charge sizes of ≤150 g and have historically not been required to pass the Annex CC test. Recent testing has shown that in a relative worst-case scenario with a large leak and a quiescent environment, appliances with 150 g of hydrocarbons could theoretically form flammable concentrations that persist, sometimes for over ten minutes. Testing has also shown that even with the use of circulation air from an onboard fan, it is difficult to completely prevent a flammable concentration from forming during the door opening test for an internal leak, although the time it persists can be significantly reduced. While the 3rd edition of IEC 60335-2-89 allows for higher charge sizes of flammable refrigerants, appliances passing the door opening test will likely require circulation air or other mitigation techniques to help minimize the potential time during which a flammable concentration might form.

NFPA Report Number FPRF-2017-15: This study conducted leak and ignition testing scenarios from a refrigerated display case with R-290 (propane). Several parameters were examined during this study, including condensing unit location, use of a circulation air from a fan, and effects of different charge sizes and leak rates. Some of the findings included lower frequency of ignition events when using top-mounted vs. bottom-mounted condensing units, and a

significant decrease in ignition event frequency when running the fan 100% of the time with bottom-mounted condensing units. Another aspect of this study was to look at the relative risk of increasing charge sizes of R-290 in different environments, compared to a baseline of 150 g in a small kitchen. While charge sizes could be scaled up in larger commercial areas and still maintain a fire frequency less than or equal to that of the baseline, this effect was limited in larger size kitchens, due to the high density of ignition sources.

AHRI Project 8009: This project conducted a risk assessment on A2L refrigerants (R-32, R-1234yf, and R-1234ze(E)) in refrigeration systems. CFD modeling of refrigerant leaks with experimental testing for validation were performed to simulate both walk-in and reach-in coolers in small restaurant kitchen, lunch counter, and convenience store scenarios. A fault tree analysis was also conducted to quantify ignition risks. Based on the results gathered from this study, the average risks associated with the use of these A2L refrigerants were significantly lower than those of common hazard events, and "well below risks commonly accepted by the public in general".

AHRTI Project 9013: Leak and ignition testing were conducted to perform a direct comparison of the flammability behaviors of volume equivalent charge sizes of an A2L (R-454C) vs. an A3 refrigerant (R-290), using the same methodology as the previously mentioned NFPA study. Overall findings indicated that when using volume equivalent charges, fewer flammable concentrations were formed with R-454C than with R-290, in part due to R-454C's higher LFL. R-454C was also less likely to be ignited, due to its significantly higher minimum ignition energy. Ignition event severity was also noticeably lower for R-454C than with R-290, for both volume and LFL equivalent charge sizes. A large charge release, with both high humidity and turbulence was also required to produce a higher consequence ignition event with the A2L.

AHRTI 9015 Preliminary Results: Initial results from this ongoing study have been shared with ASHRAE SSPC 15 during previous meetings.

Differences Related to the Door Opening Test in the IEC 60335-2-89 Standard and UL Draft: As mentioned previously, the door opening test from Annex CC has been a topic of significant discussion and debate. In developing the draft of the UL 60335-2-89 proposal, two key differences from the IEC standard were implemented related to this test. First, the decision was made to limit the charge sizes of flammable refrigerants to 8 × LFL for appliances with doors and drawers, which would be subject to the door opening test. Second, the compliance criteria for the door opening test were also changed. In the IEC version, the concentration at sampling points around the appliance cannot exceed 50% LFL for a period exceeding five minutes. In the UL draft, this compliance criterion is only applied to sampling points in front of the door or drawer being opened. All other points are not permitted to exceed 50% LFL at any time. These differences are believed to be significant and are expected to make passing the Annex CC test in the UL draft more challenging and to reduce risk of ignition.

It is also worth noting that the IEC standard and UL draft are not prescriptive in requiring what mitigation measures are used to pass the Annex CC test, such as the use of a *condenser* fan for circulation airflow.

Other Learnings from the AHRTI 9015 Testing: The previously mentioned AHRI 8009 study examined leaks in a reach-in cooler, using 2,300 g of charge. This was very similar to the 8 × LFL charge size of R-454C used in the reach-in cooler during the AHRTI 9015 testing, and the proposed limit allowed for many A2Ls in reach-in coolers in the UL draft. As such, members of CANENA WG12 looked at the previous AHRI 8009 work for comparative purposes. It was determined that the bulk of the previous Fault Tree Analysis (FTA) was still applicable.

However, experimental measurements from the AHRI 8009 study found that the concentrations formed with the A2Ls from leaks with the reach-in cooler test scenarios were well below the LFL. During development of the AHRI 8009 FTA, crowded condition assumptions were made to allow for flammable concentrations forming, and probabilities were assigned to their presence. When using the actual time from the AHRTI 9015 testing where flammable concentrations were present, the resulting probabilities were found to be significantly lower than those in the AHRI 8009 report. This was also regardless of whether the condenser fan was used for mitigation purposes.

It should be noted that the criteria for acceptable use should not be one of zero risk. No existing applications in the standard can claim to have zero risk. Rather, the criteria should be requirements that provide for comparable or lower risk as compared with requirements for other existing applications within the standard. In the event of a refrigerant leak from any system, there will be a region immediately adjacent to that leak with refrigerant

concentrations that exceed the RCL or LFL. That is the inherent nature of leaks. From a risk standpoint, it is important that the extent of this leak, both in terms of time and distance, be minimized. The test requirements in Annex CC of the UL 60335-2-89 2nd edition draft are designed to accomplish this.

Reasoning for 20 ft from Open Flame Rule: Annex CC requires that no flammable concentrations form from external leaks. The potential to form flammable concentrations from the door opening test is limited to the area immediately in front of the appliance, where the likelihood of ignition sources occurring is small. The 20 ft restriction prevents the appliance from being installed next to open flames, which are competent ignition sources for all flammable refrigerants.