Low-Global Warming Potential A2L Refrigerants

A Review National Model Codes, State Code Adoption, and Safety Standards

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Executive Summary

Background

Worldwide efforts to combat climate change have included a push to attempt to reduce the impact that refrigerants have on global warming. In an effort to shift away from widely used refrigerants that have a major global warming impact, the refrigeration industry has found that most alternative refrigerants are flammable. Some refrigeration end uses, such as small appliances with limited refrigerant charge have already transitioned to use flammable refrigerants. However, most flammable refrigerants are too flammable to be used in systems with larger capacities. One group of refrigerants that could act as a replacement is a newly classified A2L refrigerant group, which is described as "mildly flammable." While several countries have already transitioned to using these mildly flammable refrigerants, several major obstacles remain in place for the transition to happen in the U.S.

Direct air-conditioning and heat pump systems used in residential and commercial applications for human comfort are a major refrigerant end use. A 2017 CARB report indicates that residential air-conditioning and appliances make up 15% of refrigerant emissions while commercial air-conditioning makes up 17% of refrigerant emissions.[1] However, building codes across the country currently do not allow the use of these mildly flammable A2L refrigerants in these systems. Transitioning from current refrigerants which are classified as having no flame propagation, to refrigerants that are even mildly flammable, introduces a new risk that code development organizations have been hesitant to accept.

This paper is intended to describe the current state of codes and standards as they relate to A2L refrigerants, while identifying code gaps, and providing guidance to states and model code organizations for the allowance of A2L refrigerants.

Research

Significant study, spanning well over a decade and funded by industry, government, and advocacy organizations has been performed in support of updating refrigerant safety standards

[1] California Air Resources Board (CARB), 2017. *Potential Impact of the Kigali Amendment on California HFC Emissions*

to identify and include requirements for A2L refrigerants. This technical body of research is extensive, and has resulted in updates to safety standards, in addition to industry innovation.

National Model Codes

Relevant codes adopted around the country include the International Residential Code, the International Mechanical Code, the International Fire Code, the Uniform Mechanical Code, NFPA 101, NFPA 1, NFPA 90A and NFPA 90B. In their current form, the Uniform Mechanical Code and the NFPA Codes do not reference the most up to date refrigerant safety standards, nor do they allow the use of A2L refrigerants in high-probability systems for human comfort. The International Fire Code, the International Residential Code, and the International Mechanical Code do include some of the most up to date referenced standards, and allow A2L refrigerants for use in high-probability systems for human comfort. However, these codes to not contain all necessary standards updates and still contain some conflicting language that will hinder A2L use in high-probability systems for human comfort. While several codes include A2L provisions, these are primarily focused on A2L machinery rooms. In some cases, the code's internal treatment of A2L refrigerants is inconsistent – in sometimes treating them as their own safety group while other times treating them as a subgroup of A2 refrigerants. In addition to standard reference updates, significant amendments are needed in most codes to remove conflicts and allow more comprehensive use of A2L refrigerants.

Some updates have been slowed by safety concerns over any flammable refrigerant. Another aspect is the complicated nature of code development and adoption in the U.S., in which multiple organizations develop model codes, often with competing scopes. These codes are then adopted, and sometimes amended, by individual states, or even counties and municipalities. Codes often include requirements by referencing other codes and technical standards.

Referenced Refrigerant Standards

ASHRAE 34-2019 now classifies A2L refrigerants as a separate safety group. ASHRAE-15-2019 includes significant safety requirements for A2L refrigerants, while allowing them for use in high-probability systems for human comfort. 2019 UL 60335-2-40 includes extensive safety and testing requirements for equipment using A2L refrigerants, including air conditioning and heat pump systems. 2017 UL 60335-2-40 does not yet include any information about A2L refrigerants, but does reference ASHRAE 15 and ASHRAE 34. This standard will be relevant to

a variety of commercial refrigeration products, but also to heat pump water heaters. Either referencing these standards directly or updating code references to the most recent version of the standard will be an important step to allowing the use of A2L refrigerants.

State Adoption

Although several states have adopted legislation or regulation to require the transition to new refrigerants, only Washington State has enacted code changes that will allow the use of viable alternatives. Even Washington's adoption was not perfect. It missed several necessary standards updates and includes code language that conflicts with the updated standards. Other states that are considering adoption do not adopt some codes statewide, further complicating the transition.

The Path Forward

In order to support states with goals to transition to new refrigerant alternatives, as well as national and global initiatives working toward the same goals, building codes need to be updated to include A2L refrigerants. Because of the complicated nature of model code development and adoption in the U.S., extensive and careful model code changes are required, in addition to simple updates to referenced standards, in order to effectively allow the use of A2L refrigerants in a clear way that does not create codes and standards conflicts. States indenting to transition to A2L refrigerants will need to make these changes in their own code while awaiting model codes that have addressed the issue.

Training

The A2L refrigerant concern consistently identified by refrigerant experts, manufacturers, and fire service personnel, is the need for training. Training for HVAC trade contractors, emergency responders, code enforcement officials, and maintenance personnel is needed to ensure understanding and safe installation, operation, and disposal of A2L refrigerant equipment. This need was also identified internationally by countries already using A2L refrigerants.

Introduction and Background

In 1987 the Montreal Protocol, a Global Agreement ratified by the U.S., set requirements for a phase out of Ozone Depleting Substances (ODS), which included commonly used refrigerants. Hydrofluorocarbons (HFC Refrigerants) were used in many cases as non-ODS replacements. While HFC Refrigerants don't contribute to ozone depletion, they do have the drawback of contributing to global warming. They have a high Global Warming Potential (GWP), which is the metric used to global warming effects of different gasses. In 2016, the Kigali amendment was passed to the Montreal Protocol in an effort to phase out high-GWP HFC refrigerants and replace them with low GWP alternatives. Although the U.S. has not ratified the Kigali amendment, many states are considering action to implement the concepts from the amendment locally.[2] Viable low-GWP alternative refrigerants mostly fall into the classification of flammable refrigerants, especially in the newly identified group A2L refrigerant group.[3] Refrigerants are classified based on the following safety groups:

	No Flame Propagation	Flammable	Higher Flammability
Lower Toxicity	A1	A2	A3
Higher Toxicity	B1	B2	B3

Until 2019, A2L refrigerants (Lower Flammability) were classified as a subgroup of A2 refrigerants, and were subject to most of the same restrictions. Although smaller appliances use refrigerants with higher flammability, they are not allowed by most codes and standards for direct air-conditioning and heat pump systems used for human comfort.

	No Flame Propagation	Lower Flammability	Flammable	Higher Flammability
Lower Toxicity	A1	A2L	A2	A3
Higher Toxicity	B1	B2L	B2	B3

In 2019, A2L refrigerants were introduced as a separate safety group with their own set of requirements in several standards including ASHRAE 15, ASHRAE 34, and UL 60335-2-40. These standards allowed the use of A2L refrigerants for human comfort systems and defined safety restrictions around their use. In the 2021 code cycle for the International Code Council

[2] https://www.state.gov/key-topics-office-of-environmental-quality-and-transboundary-issues/the-montreal-protocol-on-substances-that-deplete-the-ozone-layer/

[3] https://www.achrnews.com/articles/141733-understanding-a2l-refrigerants-for-air-conditioners

(ICC), several proposals were introduced to reference the updated safety group. Several changes to update safety standards did pass, opening the door for use of A2L refrigerants through updated safety standards. However, more text changes are still needed to include A2L in the code comprehensively, and to avoid conflicts and confusion. Several text changes were also made related to piping materials and connections. There was some resistance to the idea of including A2L refrigerants in the code. On top of some objection to allowing any A2 refrigerants to be used in this way at all, there was concern about adopting requirements that were being finalized in standards but not yet published.[4] Similarly, the International Association of Plumbing and Mechanical Officials (IAPMO) also rejected changes to the Uniform Mechanical Code (UMC) that would allow A2L refrigerants to be used in direct systems for human comfort. This is less clear than in the ICC codes because the 2018 UMC includes an introduction explaining the inclusion of A2L as its own safety group, but at some points still exempts A2L from A2 requirements as if it were still a subgroup. A2 refrigerants are not allowed in systems for human comfort by the 2018 UMC and no exemption is offered for A2L refrigerants.[5] The 2021 UMC did fix some, but not all of the inconsistencies regarding A2L classifications. However, the prohibition on using A2L refrigerants in human comfort systems remained in place.[6] Like the ICC, IAPMO still references ASHRAE and UL standards prior to the change designating A2L refrigerants as their own group.

Prominent Examples of Research

The introduction of A2L safety group refrigerants into refrigerant standards, and the interest in using them as a substitute for current refrigerants with higher GWP has led to the development of a significant body of research. While not an exhaustive literature review, this section discusses prominent examples of this research, much of which was used in developing updates to the refrigerant safety standards.

An Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Study published in 2015 performed a risk assessment of a variety of A2L refrigerants in commercial refrigeration applications and found that “the risk assessment indicates that the overall average risks associated with the use of these ASHRAE 2L refrigerants are significantly lower than the risks of common hazard events associated with other causes and also well below risks commonly

[5] IAPMO/ANSI UMC - 2018
[6] IAPMO/ANSI UMC - 2021

accepted by the public in general." The study compared flammable refrigerant ignition risks from a variety of leak scenarios to other typical risks such as slip and fall injuries, fatal occupational injuries, commercial cooking fires, commercial building fires, injuries due to fire or explosions, and injuries due to firework use.[7] An article in Engineering Systems discussing the risk of A2L refrigerants stated that "As of December 2018, more than 68 million air conditioners using A2L refrigerants have been installed around the world. The majority of these units are installed in Asia and Europe. Manufacturers have addressed the safety issues around using A2L refrigerants in air conditioning systems and managed to maintain or improve the energy efficiency versus existing systems. To date, no accidents or incidents with loss of life or limb have been reported."[8]

Air-Conditioning, Heating, and Refrigeration Technology Institute (AHRTI) has sponsored a significant body of safety testing that has been performed on A2L refrigerants. On behalf of AHRTI, UL conducted room-scale leak and ignition testing on a variety of systems including split air-conditioning systems. This study examined both commercial and residential refrigerant systems to evaluate the risk probabilities in various leak and ignition source scenarios.[9] E^{x}ponent, an engineering consulting firm, performed a study, on behalf of AHRTI, of the hot surface ignition properties of A2L refrigerants. During this testing, none of the A2L refrigerants reached ignition at hot surface temperatures up to 800◦C but the authors note that under different test conditions it may be possible for these same refrigerants to ignite at these temperatures.[10] ICF performed leak detection testing. This study found that sensors currently existed in the market that could perform this function and that other sensors needed to be updated to detect A2L refrigerants in all the parameters designated in safety standards. The study found that infrared sensors were the most likely technology to be used in commercial and industrial applications but that current technology was mainly capable of sensing A2L refrigerants at 10% of the Lower Flammability Limit rather than up to 20-25% which is the target of technical standards. Due to cost considerations Metal Oxide Sensors are a better solution for

[7] AHRI (2015). *Risk Assessment of Refrigeration Systems Using A2L Flammable Refrigerants*

[8] Ballanco, McCrudden, and Johnson (2019). Engineered Systems Magazine, *A2L Refrigerants: Safely Addressing Flammability Concern*. https://www.esmagazine.com/articles/99996-a2l-refrigerants-safely-addressing-refrigerant-flammability-concerns

[9] Ghandi, Hunter, Haseman and Rodgers (2017). AHRTI Project 9007-01, *Benchmarking Risk by Whole Room Scale Leaks and Ignitions Testing of A2L Refrigerants – Final Report*

[10] Cundy (2017). AHRTI Project 9008, *Hot Surface Ignition of A2L Refrigerants – Final Report*

residential applications but also need solutions to increase the sensing range.[11] Since the publication of this report, several sensor manufacturers have launched solutions intended to address this need.[12] [13] [14] A new AHRTI multi-phase study is currently performing in-depth testing of infrared sensors, Metal Oxide Sensors, and Micro Machined Membrane sensors.[15]

ASHRAE has also funded several projects on flammable refrigerants including a safety study on field made joints for flammable refrigerant systems[16] and a set of guidelines for safe handling (including installation, maintenance and dismantling) of flammable refrigerants. This research examined both residential and commercial systems for air-conditioning and refrigeration. The study covered all stages of A2L product interaction and identified installation, service, and removal of equipment as the highest risk situations, calling for the need for trade contractor training.[17]

The US Department of Energy and Oak Ridge National Lab developed a methodology for determining charge limits for flammable refrigerants in HVACR systems. The methodology used Computational Fluid Dynamics (CFD) to assess how a refrigerant leak would interact with a space based on variables such as refrigerant charge, leak rate, floor area, leak release height, molecular weight, and ventilation in order to examine outputs such as Flammable Volume Fraction (FVF) over time.[18] [19] ORNL is also working to develop modeling tools for refrigerant blend flammability.[20]

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[11] Wagner and Ferenchiak (2017). AHRTI Project 9009, *Leak Detection of A2L Refrigerants in HVACR Equipment – Final Report*

[12] https://senseair.com/updates/news/senseair-launches-a2l-refrigerants-gas-sensor-solution-at-ahr/

[13] https://www.envirotech-online.com/news/gas-detection/8/figaro-engineering-inc/new-a2l-refrigerant-gas-sensor-and-pre-calibrated-sensor-module/49077

[14] https://nevadanano.com/mps-a2l-refrigerant-gas-sensor/

[15] Zheng and Elbel (2020) AHRTI Project 9014. *Refrigerant Detector Characteristics for Use in HVACR Equipment-Phase I*

[16] Elbel, Lawrence, and Raj (2019). ASHRAE Research Project 1808, *Servicing and Installing Equipment Using Flammable Refrigerants: Assessment of Field-made Mechanical Joints*

[17] Goezler, Guernsey, and McClive (2019). ASHRAE Research Project 1807, *Guidelines for Flammable Refrigerant Handling, Transporting, Storing, and Equipment Servicing, Installation, and Dismantling*

[18] Baxter, et al (2018). *Methodology for Estimating Safe Charge Limits of Flammable Refrigerants in HVAC&R Applications – Part 1*

[19] Abdelaziz, et al (2019). *Methodology for Estimating Safe Charge Limits of Flammable Refrigerants in HVAC&R Applications – Part 2*

[20] https://www.energy.gov/eere/buildings/downloads/modeling-tools-flammability-ranking-low-gwp-refrigerant-blends

AHRI produced an FAQ sheet based on this research which answers questions about common concerns such as toxic gases released during wildfire incidents, large concentrations of flammable refrigerants in dwellings, the ability to detect refrigerant leaks, and the dangers of open flame vs. sparks and the lack of need for spark-proof tools. This fact sheet identifies a set of conditions that would be necessary for ignition of A2L refrigerant including a significant leak which builds up in a space to reach the Lower Flammability Limit for the refrigerant, in addition to the presence of an open flame (not a spark) or high energy ignition source. The fact sheet also addresses the concern of chemical release when burning. [21]

The Fire Protection Research Foundation (FPRF) has also performed fire safety research, risk assessment, and testing on flammable refrigerants, including A2L refrigerants. An example is a 2019 project which included demonstrative testing. A major finding of this research was that training was needed so that industry and fire protection services better understand the risks, new procedures, and best practices for their various fields in interacting with A2L refrigerants. Suggested training topics for fire service included hazard identification, emergency response, and post-incident considerations.[22]

National Model Codes

International Code Council (ICC)

The ICC publishes a group of building codes that are adopted by states and local jurisdictions across the country. Of those ICC codes, the International Residential Code, International Mechanical Code, and International Fire Code contain the relevant regulations related to refrigerants. Many of these codes further reference other standards that provide safety requirements for refrigerants and refrigeration systems.[23] This section provides:

- An overview of the way each of these codes currently treats A2L refrigerants, especially as they relate to systems for human comfort.
- Description of how the codes reference relevant refrigerant standards,
- Description of code sections that currently mention or provide requirements for A2L refrigerants,

[21] AHRI (2019). *Lower Global Warming Potential Refrigerants: Frequently Asked Questions*

[22] Ryder, Jordan, and Sutherland (2019). Fire Protection Research Foundation. F*lammable refrigerants firefighter training: Hazard assessment and demonstrative testing*

[23] Because publication of the 2021 ICC codes are still in progress at the time of this writing, code section references are based on the 2018 version unless otherwise noted.

- Description of prohibitions that prevent the use of A2L refrigerants.

This section does not provide an exhaustive review of all refrigerant requirements found in the various codes. In fact, there are many codes and standards requirements that apply to all refrigerants, which are not discussed here.

International Residential Code (IRC)

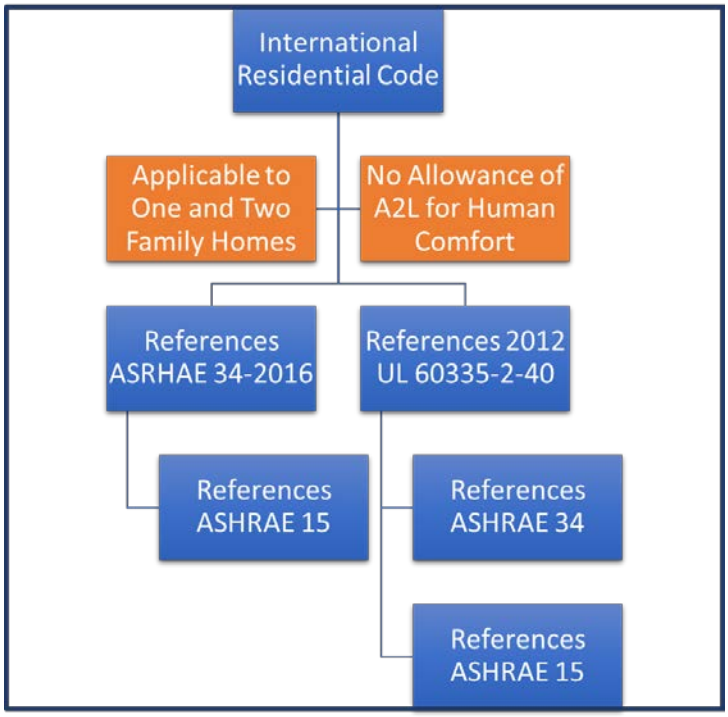
Most Recent Published Version: 2018 (2021 is complete and will be published soon)
Code Update Schedule: Updated and published on a 3-year cycle
Coverage of A2L Refrigerants:

- Directly – none
- Indirectly – by standard reference only

Allowance of A2L Refrigerants for Use in Direct Systems for Human Comfort: No
Relevant Referenced Standards: ASHRAE 34-2019; 2012 UL 60335-2-40

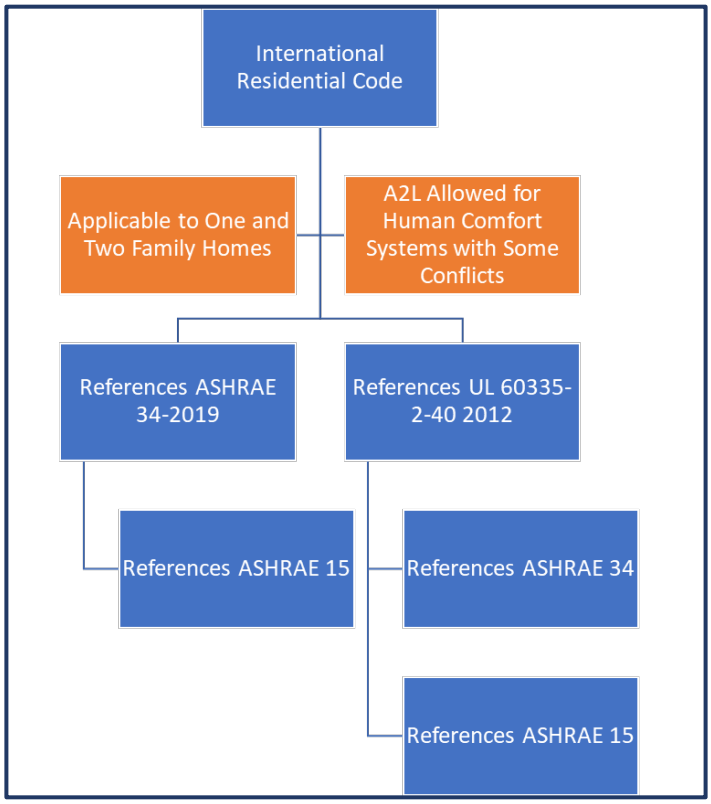
The IRC applies to all one- and two-family buildings. Residential refrigeration systems, apart from those used in multifamily construction or other residential structures that fall under the International Building Code, are regulated by this code in states that have adopted it. Requirements for refrigerants represent a relatively small portion of this code which has broad requirements for structural, fire, ventilation, plumbing, etc. This report only discusses how the IRC includes A2L refrigerants through reference.

2018 IRC



The IRC does not directly include requirements for A2L refrigerants. Instead, it references several standards which set requirements for refrigerants. As published by the ICC, the 2018 IRC still referenced ASHRAE 34-2016 and UL 60335-2-40-2012. Neither of the standards referenced by the published IRC included provisions for A2L refrigerants as their own safety group, which is currently a barrier to the A2L transition. Although not published at the time of this writing, the 2021 IRC does not appear to have updated the reference to the 2019 version of either of these standards, based on the listed changes that passed during the code development process.

The IRC references ASHRAE 34 and UL 60335-2-40 several times in Chapter 14 (Heating and Cooling Equipment and Appliances). Section 1403.1 requires heat pumps to be listed and labeled through UL 1995 or UL60335-2-40. This reference introduces listing/labeling requirements for the appliances related to refrigerants and includes safety requirements for flammable refrigerants. The 2012 standard does not include separate requirements for A2L refrigerants. Two revisions (2017 and 2019) to the standard since the 2012 version add significant stringency in testing requirements and add the A2L safety group. The 2019 version of the UL standard includes entire appendices added specifically covering A2L safety requirements. These standards are also referenced in Section 1412 and 1413 related to other types of heating/cooling equipment (Absorption Cooling and Evaporative Cooling). Section 1411 (Heating and Cooling Equipment) references ASHRAE 34 requiring that refrigerants in direct refrigerating systems conform to ASHRAE 34. This standard does not include references that will adequately identify A2L refrigerants. At a minimum this code needs referenced standards updates.



2021 IRC

Changes to the 2021 IRC were accepted to updated the ASHRAE 34 standard reference to the 2019 version of the standard. This gives users of the IRC access to A2L refrigerant classifications that were not available in the 2016 version of ASHRAE 34.

The code still needs an update to the 2019 version of UL 60335-2-40 in order to reference appliance safety standards with A2L provisions. Likewise, a reference to UL 60335-2-40 would be appropriate in M1404.1 (Refrigeration Cooling Equipment) to be consistent with M1403.1 (Heat Pump Equipment). A code change to add this reference and to update the UL 60335-2-40 reference to the 2019 standard has been submitted to the 2024 IRC.

International Mechanical Code (IMC)

Most Recent Published Version: 2021 (released March 2020)

Code Update Schedule: Updated and published on a 3-year cycle

Coverage of A2L Refrigerants:

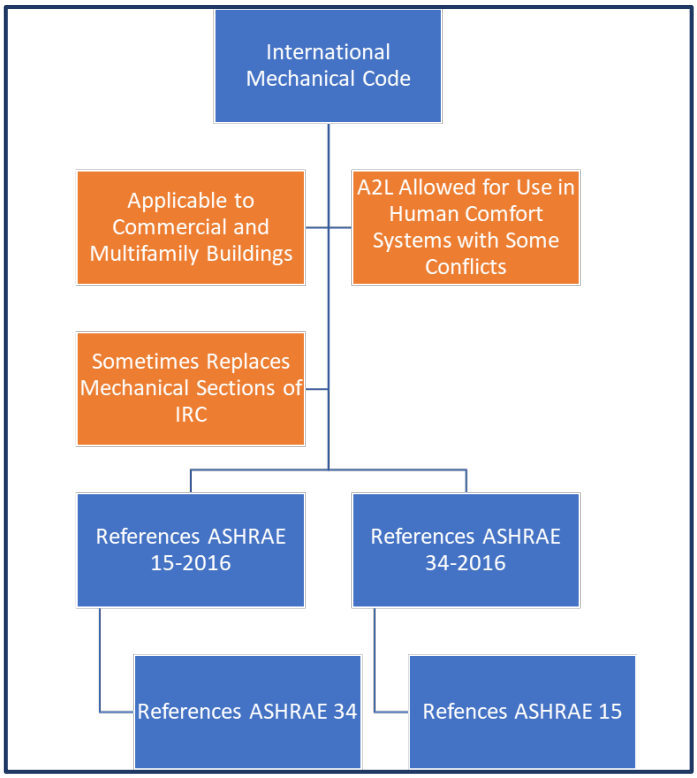
- Directly – A2L refrigerant machinery room requirements; piping requirements
- Indirectly – by standard reference

Allowance of A2L Refrigerants for Use in Direct Systems for Human Comfort: Partial allowance with some limits/conflicts.

Relevant Referenced Standards: ASHRAE 15-2019; ASHRAE 34-2019; 2017 UL 60335-2-40; 2017 UL 60335-2-89

The IMC typically applies to all structures that are not one- and two-family homes, including multifamily construction and commercial buildings. Occasionally, jurisdictions will adopt the IMC for one-and two-family homes instead of the mechanical sections of the IRC. Refrigeration

systems for commercial buildings as well as multifamily buildings are regulated by this code in states that have adopted it. This report is not a comprehensive description of everything in the IMC or even in the refrigerant section. Rather it focuses on how A2L refrigerants are currently included, prohibited, or referenced via reference standard.



2018 IMC

The IMC's treatment of A2L refrigerants is internally consistent in that it consistently treats A2L refrigerants as a subgroup of A2 refrigerants as they were classified in the 2016 versions of ASRHAE 34 and 15. Referenced standards would need to be updated to include A2L refrigerants in a comprehensive way and to allow their use in systems for human comfort.

The IMC does provide specific requirements that are only applicable to A2L refrigerants, and occasional provides exceptions for A2L refrigerants from the broader A2 refrigerant requirements. This inclusion seems to set a precedent for the inclusion of A2L refrigerants in the code, but contradicts the continued reference to older ASHRAE standards that do not provide a separate A2L safety group classification. The IMC only directly addresses A2L refrigerants in special requirements for machinery rooms, in addition to the newly added piping installation requirements. The primary way that IMC regulates A2L refrigerants is through reference to standards. As published the 2018 referenced ASHRAE 15-2016 and ASHRAE 34-2016.

The IMC references ASHRAE 15 multiple times in Chapter 11 (Refrigeration). Section 1101.6 requires refrigeration systems to comply with ASHRAE 15, except when modified by IMC Chapter 11. The modifications included in chapter 11 make inclusion of A2L refrigerants more complicated than a simple update of the ASHRAE standard reference.

IMC 1102.2.1 prohibits mixing of refrigerants with different designations in ASHRAE 34-2016. This does not apply to refrigerant blends already identified in ASRHAE 34-2016.This is not an obstacle to the A2L transition, but an example of how the standard reference is included in the text.

ASHRAE 34 is referenced in Section 1103.1 which includes the refrigerant classification table directly from the standard. However, the IMC references the table in the 2016 standard and reprints it in the code. Even with an update to the standard reference, this table would also need to be updated.

2021 IMC Section 1104.3.2 does not allow high probability systems with more than 6.6 pounds of A2 refrigerants for non-industrial occupancies. Because the 2018 IMC did not include A2L refrigerants as their own safety group, this paragraph includes A2 and A2L. This will eliminate most air-conditioning and heat pump systems for either residential or commercial occupancies from being able to use A2L refrigerants.

IMC 1105.3 references refrigerant detector requirements for machinery rooms in the IFC 605.8 and IFC 605.17. IFC 605.8 includes general refrigerant machinery room requirements and applies broadly to all machinery rooms, while IFC 605.17 establishes additional requirements for machinery rooms containing A2L refrigerants specifically. While these safety requirements are good ideas, the codes would be less confusing if the sections were harmonized or simply referenced the most current ASHRAE 15 standard.

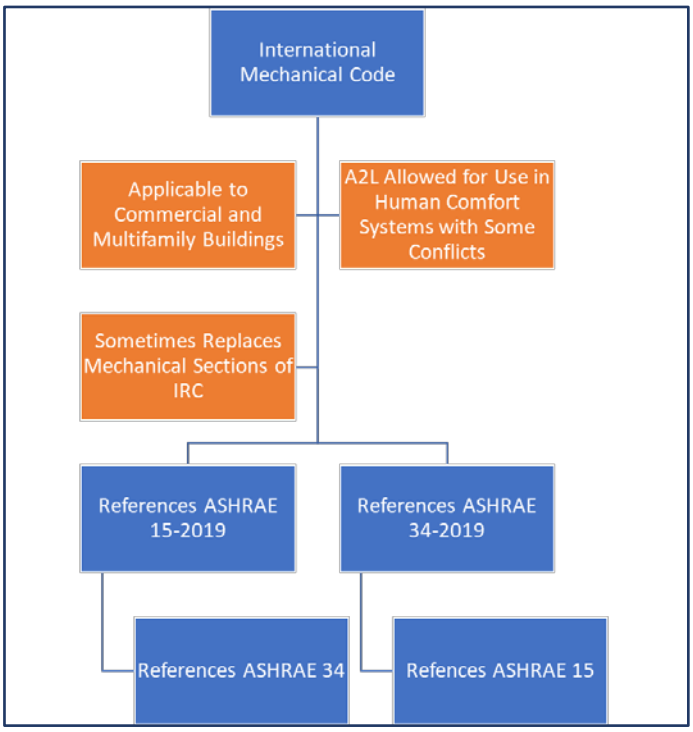
IMC 1106.4 points to requirements in NFPA 70 for machinery rooms with flammable refrigerants including A2, B2, A3, and B3. The section provides a specific exception for A2L refrigerants, treating them as a subgroup of A2, and points to special requirements for A2L refrigerant machinery rooms in 1106.5. Although this reference to A2L refrigerants is included in the 2018 IMC, requirements for machinery rooms are not applicable to direct air-conditioning or heat pump systems. IMC 1106.5.1 references IFC 605.8 requirements for refrigerant detection. 1106.5.2 sets emergency ventilation rate requirements for A2L refrigerants and references either ASHRAE 15-2016 ventilation rates or Table 1106.5.2. This table includes the identical rates listed for A2L refrigerants in IFC 605.17. These rates are similar too, but not identical to

the rates required in the UMC and are provided in a different format to those listed in ASHRAE 15-2016 or ASHRAE 15-2019.

There are also currently several references to ASHRAE 15-2016 in Section 1108 (Field Test).

This code needs text revisions to eliminate conflicts, additional referenced standards (UL 60335-2-40 and UL 60335-2-89), and updated standards references.

2021 IMC Updates



Two important changes that were added to the 2021 IMC during the code development process were an update to ASHRAE 15 and ASHRAE 34 references to the 2019 versions of those standards. With this change, the IMC took a major step toward allowing broader use of A2L refrigerants. In addition, references were added for appliance safety standards 2017 UL 60335-2-40 and UL 60335-2-89). While the 2017 version of UL 60335-2-40 does not include needed updates for A2L refrigerants, it does move the code one step closer to adequately providing safety standards for A2L inclusion. The 2024 IECC will need to update this standard to the latest version to include A2L content. A code change has been proposed to the 2024 IMC to update the reference to the 2019 standard. 2017 UL 60335-2-89 is currently the latest version of this standard, but updates to the standard will likely include A2L provisions. While this step takes the codes much closer to clearly allowing A2L refrigerants for use in human comfort systems, text changes are still needed to remove conflicts and eliminate confusion in the code.

Table 1103.1 still needs to be updated to include A2L refrigerant classifications. 1103 references ASHRAE 34-2019, but states that the ASHRAE 34 refrigerants are classified as

listed in Table 1103.1. Without A2L refrigerants listed, it will be unclear to IMC users what refrigerants should apply A2L provisions.

Section 1104.3 should be updated to reduce confusion in the code. Although the IMC references ASHRAE 15-2019, Section 1104.3 does not mention A2L refrigerants specifically. As mentioned in the 2018 IMC description, 1104.3.2 limits A2 refrigerants in human comfort systems to 6.6 pounds, eliminating significant numbers of human comfort systems. Although this provision does not address A2L specifically, clarifying that A2L and A1 refrigerants are specifically allowed for human comfort systems would remove any confusion. Clarifying language has been proposed to the 2024 IMC.

Another code change that passed through the development process and will be added to the 2021 IMC was a change to alter the current section on refrigerant piping (1107), as well as adding new sections 1108 and 1109. Section 1110 replaces the old field test section with a refrigerant piping system test section. The altered section 1107 still covers refrigerant piping while section 1108 covers refrigerant pipe connections, and 1109 covers refrigerant piping installation. No details were added for A2L refrigerants in the changes in 1107 and 1108. However, a reduced requirement specifically for A2L refrigerants is likely not justified for provisions such as piping material and connections. Currently A2L refrigerants would be included in the requirements for A2 refrigerants. If reference standards are updated in the future, these sections should be clarified that they include A2L refrigerants in addition to A2, section 1109.3 includes significant requirements and protections for A2L piping installation. These are a separate section from 1109.2 which covers other flammable refrigerants. This section provides needed guidance for when A2L refrigerants are recognized more broadly in the code.

International Fire Code (IFC)

Most Recent Published Version: 2021
Code Update Schedule: Updated and published on a 3-year cycle
Coverage of A2L Refrigerants:

- Directly – A2L refrigerant machinery room requirements
- Indirectly – by standard reference

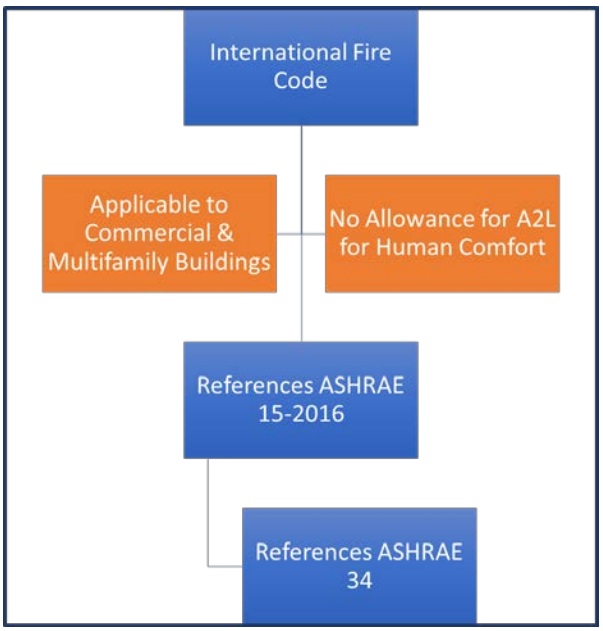
Allowance of A2L Refrigerants for Use in Direct Systems for Human Comfort: Yes

Relevant Referenced Standards: ASHRAE 15-2019

The IFC primarily governs buildings that fall within the scope of the International Building Code. There is applicability for one- and two-family homes that is limited to exterior requirements such as fire apparatus access, water supply, etc. This report is not a comprehensive description of everything in the IFC. Rather it focuses on how A2L refrigerants are currently included, prohibited, or referenced via reference standard.

2018 IFC

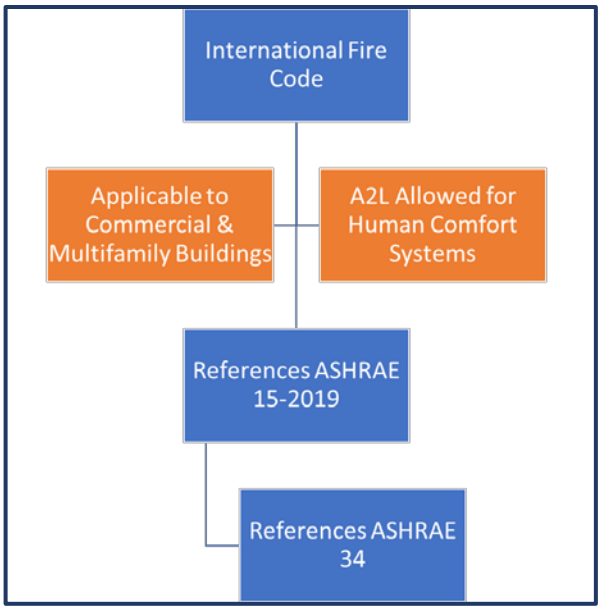
The IFC regulates refrigerants mainly by referencing ASHRAE 15 and the IMC. The IFC references ASRHAE 15-2016 in Section 605. The IFC only directly includes A2L refrigerants when setting requirements for A2L refrigerant machinery rooms. Section 605.17 includes the same machinery room ventilation rate requirements for A2L refrigerants found in IMC Section 1106.5. While these safety requirements are good ideas, the codes would be less confusing if the sections were harmonized or simply referenced the most current ASHRAE 15 standard.



This code mainly needs standards reference updates.

2021 IFC

The major relevant change to the 2021 IFC was the update the ASRHAE 15 reference to the 2019 standard. This code now references the appropriate version of refrigerant safety standards and would allow A2L refrigerants for use in human comfort systems if the IMC and IRC fully supported that allowance as well.



The International Association of Plumbing and Mechanical Officials (IAPMO)

IAPMO publishes a group of codes specifically focused on plumbing and mechanical issues that are adopted by states and local jurisdictions across the country. Of those IAPMO codes, the Uniform Mechanical Code contains the relevant regulations related to refrigerants. This code further references other standards that provide safety requirements for refrigerants and refrigeration systems.[24]

Uniform Mechanical Code (UMC)

Most Recent Published Version: 2021 (Released April 2020)

Code Update Schedule: Updated and published on a 3-year cycle

Coverage of A2L Refrigerants:

- Directly – multiple requirements
- Indirectly – by standard reference

Allowance of A2L Refrigerants for use in direct systems for human comfort: No. Unclear language in 2018 version was clarified in 2021 version.

Relevant Referenced Standards: ASHRAE 15-2016; ASHRAE 34-2016; 2012 UL 60335-2-40

The UMC is sometimes adopted as a standalone mechanical code, much like the IMC, in which case it is usually applied to buildings other than one- and two-family homes. In other cases, the UMC is adopted in place of the mechanical chapters of the residential building code. In these

[24] Because publication of the 2021 IAPMO codes are still in progress at the time of this writing, code section references are based on the 2018 version unless otherwise noted.

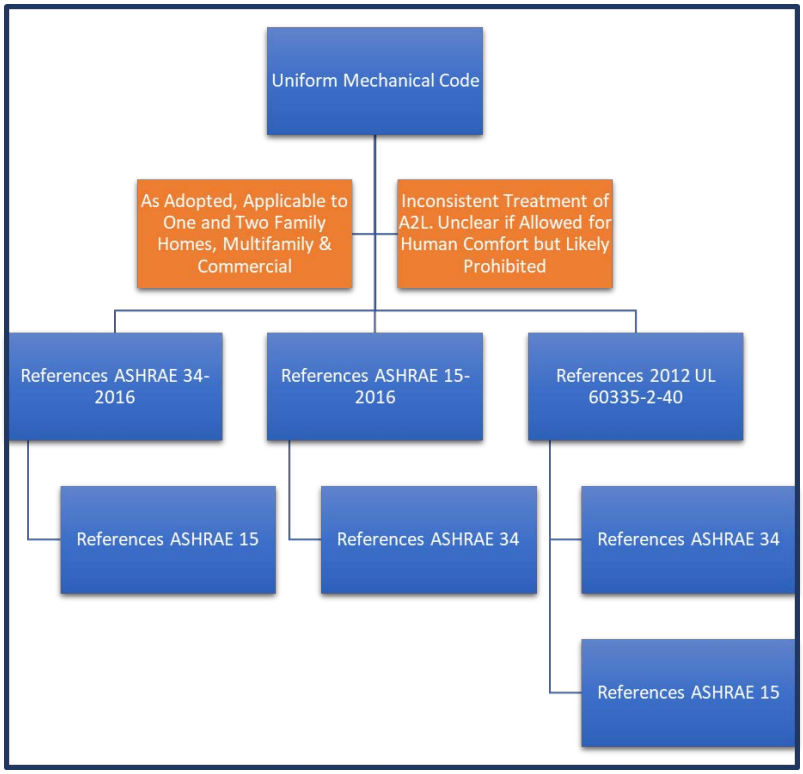
cases, the provisions would apply to one- and two-family homes. This report is not a comprehensive description of everything in the UMC or even in the refrigerant section. Rather it focuses on how A2L refrigerants are currently included, prohibited, or referenced via reference standard.

In the "Format of the Uniform Mechanical Code Section" of the UMC, there is a brief description of each chapter. In the description for the Refrigeration Chapter (Chapter 11) the UMC specifically discusses the inclusion of A2L and B2L refrigerants and safety requirements regarding systems using those refrigerants. As discussed later in this section, this does not appear to be a complete inclusion as A2L refrigerants are still prohibited from use in systems for human comfort. Significant portions of UMC Chapter 11 are directly sourced from ASHRAE 15-2016. One of many examples of this is 1104.2.1 which is a direct quote from ASHRAE 15 Section 7.3 with the exception of changing section numbers to match those in the UMC. Because so much content is taken directly from ASHRAE 15, it makes updating the code more complicated. A reference update to ASHRAE 15-2019 would also require changes section by section so that the referenced standard and text in the code do not conflict.

2018 UMC

Chapter 11 of the UMC deals with A2L refrigerants inconsistently. UMC 1103.1 references \ Table 1102.3 or ASHRAE 34 for refrigerant classification. Table 1102.3 states that the content is taken from ASHRAE 34 Table 4-1 and 4-2. However, the referenced standard is ASHRAE 34-2016, which did not include A2L refrigerants as their own safety group, while Table 1102.3 does classify refrigerants as A2L. UMC 1103.1.1 again references this ASHRAE table but states that, for purposes of this chapter A1, A2L, A2, A3, B1, B2L, B2, and B3 are individual and distinct safety groups. This would seem to indicate that, although the UMC references ASHRAE 34-2016, their intent is to treat A2L refrigerants more like ASHRAE 34-2019 – as its own safety group.

Section 1103.2 classifies probability that refrigerant leak will enter occupied area (high-probability or low-probability systems) according to ASRHAE 15 section 5.2. However, this is a reference to ASHRAE 15-2016. The language in this section of the UMC appears to be a direct reference to ASHRAE 15-2016 language. 2021 UMC does appear to have updated some of this language to match the 2019 version of ASHRAE 15, even though the referenced standard is still ASHRAE 15-2016.



This treatment is not applied consistently throughout the chapter. For example, in UMC 1104.3 A2, B2, A3, and B3 refrigerants are limited to 550 lbs. total for institutional occupancies. There is an exception to this section allowing no limit for A2L refrigerants in machinery rooms of institutional occupancies. If, as Section 1103.1.1 seems to suggest, A2L refrigerants are not a subgroup of A2 refrigerants, but their own separate and distinct group, there should be no need for this exception. The requirement would need to specifically state all separate safety groups in the limit. The section is written as if A2L is a subgroup of A2 and an allowance is being provided for a specific case.

Similarly, in UMC 1104.5 there is a total of 1100 lbs. of all flammable refrigerants combined. The wording “The total of Group A2, B2, A3 and B3 refrigerants, other than Group A2L and B2L refrigerants” seems to again suggest that A2L is a subgroup of A2 refrigerants. While it would be appropriate to include A2L exceptions in this paragraph, given that they are flammable, the wording indicates A2L is something that needs to be excepted from the larger A2 group.

UMC 1104.6 prohibits the use of A2, A3, B1, B2, and B3 refrigerants from use in “high-probability systems for human comfort.” No exception is included in this paragraph for A2L refrigerants. Reading Sections 1103.1 and 1103.1.1 the code could be interpreted as allowing A2L refrigerants for human comfort systems because they are a separate and distinct safety group and are not specifically prohibited here. However, looking at Sections 1104.3 and 1104.5 the code seems to indicate that exceptions for A2L are specifically necessary whenever the code is not applying the same restrictions as Group A2. This section is confusing at best, but a

conservative read of the code would result in enforcement not allowing A2L refrigerants for use in human comfort systems.

UMC 1106.2.5.2 and Table 1106.2.5.2 provide emergency ventilation rates for machinery rooms with A2L Refrigerants. Unlike the sections mentioned above, this section parallels another section which lists all other refrigerant types including non-flammable refrigerants. A2L refrigerants are not treated as an exception to A2 refrigerants here. They are the only refrigerant type with separate ventilation requirements for machinery rooms. Note that this table is similar, but not identical to tables found in the International Mechanical Code (Table 1106.5.2) and International Fire Code (Table [M] 605.17.2). ASHRAE 15 includes similar exhaust rates but is based on a graph rather than a table. While these safety requirements are good ideas, the codes would be less confusing if the sections were harmonized or simply referenced the most current ASHRAE 15 standard.

UMC 1107.1.7 provides alternative requirements for A2L refrigerants in machinery rooms to be used instead of NFPA 70 requirements. These requirements include mechanical ventilation and refrigeration detectors. UMC 1107.1.9 includes requirements for all flammable refrigerants for machinery room exhaust inlet locations. A2L is listed along with other refrigerants as its own safety group, rather than as an exception in this case.

Throughout Chapter 11, there are multiple references to both ASHRAE 15 and ASHRAE 34, linking to both requirements and classifications. There are also many references to both standards in the definitions of this code.

Similar to the IRC, UMC 903.0 requires that air-conditioners comply with either UL 1995 or UL 60335-2-40. The UL 60335-2-40 reference is to the 2012 version of the standard. There are also references to UL 60335-2-89. The reference here is to 2017 UL 60335-2-40, which is currently the only version of the standard and which does not yet mention A2L refrigerants in any way.

The 2018 version of this code needs extensive text revision to eliminate confusion and conflicts internal to the code, in addition to updated standards references.

2021 UMC Updates

1104.6 in the 2021 UMC clarifies that A2L refrigerants are also prohibited for use in high-probability systems for human comfort. As discussed above, this was unclear in the 2018 UMC. Other sections, such as 1104.3 retain the lack of clarity mentioned above by including an exception for A2L refrigerants from a requirement where A2 refrigerants are mentioned. As a separate safety group, A2L refrigerants should not need to be excepted from A2 requirements.

As mentioned above, the UMC contains many sections that are directly quoting ASHRAE 15. Although the reference to ASHRAE 15 is to the 2016 version of the standard, there are cases where the language has been updated to match the 2019 version. This is not true across the board, however, and the UMC specifically departs from ASHRAE 15-2019 regarding the use of A2L refrigerants in systems for human comfort.

The 2021 version did update their referenced standard to 2017 UL 60335-2-20. However, this is not the most current version and does not contain safety protections specific to A2L refrigerants.

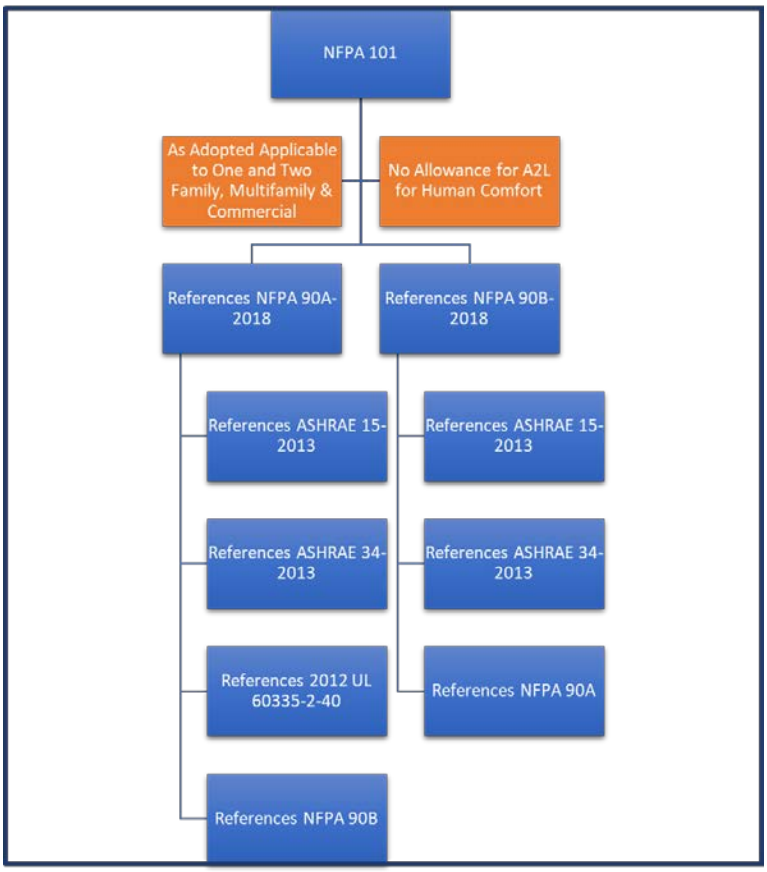
The 2021 version of this code needs updated standards references, and extensive text revision to eliminate confusion and conflicts with those standards, as well as some internal conflicts.

National Fire Protection Association

The National Fire Protection Association (NFPA), in addition to performing fire safety research and providing training and certifications, develops and extensive list of building codes and standards that are adopted across the country by state and local jurisdictions.[25]

[25] https://www.nfpa.org/Codes-and-Standards

NFPA 101



Most Recent Published Version: 2018 (2021 development is in final stages)

Code Update Schedule: Updated and published on a 3-year cycle

Coverage of A2L Refrigerants:

- Directly – None
- Indirectly – by standard reference

Allowance of A2L Refrigerants for use in direct systems for human comfort: No

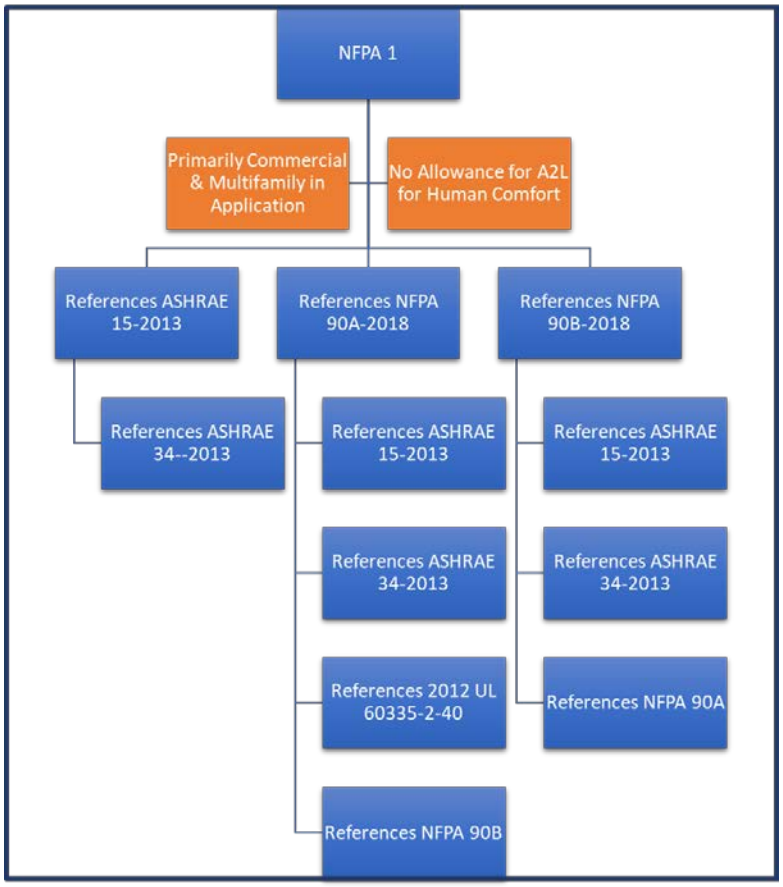
Relevant Referenced Standards: NFPA 90A-2018; NFA 90B-2108; ASHRAE 15-2013 (via NFPA 90A/90B; ASHRAE 34-2013(via NFPA 90A/90B); 2012 UL 60335-2-40 (via NFPA 90A)

NFPA 101 *Life Safety Code*[26] is applicable as adopted but has provisions for both commercial and residential buildings. This report is not a comprehensive description of everything in the NPFA 101. Rather it focuses on how A2L refrigerants are currently included, prohibited, or referenced via reference standard. The code does not directly include A2L refrigerants. The 2018 version references NFPA 90A for installation of air conditioning systems and NFPA 90B for installation of warm air heating and air-conditioning systems. NFPA 90A references ASHRAE 34-2013 and ASHRAE 15-2013, as well as 2012 UL 60335-2-40 as well as NFPA 90B. NFPA 90B references ASHRAE 15-2013 and ASHRAE 34-2013, but does not reference UL 60335-2-40.

[26] https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=101

This code would benefit from direct standards references to the most current referenced standards.

NFPA 1



Most Recent Published Version: 2018 (2021 development is in final stages)

Code Update Schedule: Updated and published on a 3-year cycle

Coverage of A2L Refrigerants:

- Directly – None
- Indirectly – by standard reference

Allowance of A2L Refrigerants for use in direct systems for human comfort: No

Relevant Referenced Standards: NFPA 90A-2018; NFPA 90B-2108; ASHRAE 15-2013 (via NFPA 90A/90B; ASHRAE 34-2013(via NFPA 90A/90B); 2012 UL 60335-2-40 (via NFPA 90A)

NFPA 1 *Fire Code*[27] is applicable in similar scope to that of the IFC. It is primarily for commercial construction and has some residential application as it deals with site infrastructure and fire safety. This report is not a comprehensive description of everything in NFPA 1. Rather it focuses on how A2L refrigerants are currently included, prohibited, or referenced via reference standard. This code also does not directly include A2L refrigerants. The 2018 version of the

[27] https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1

standard references ASHRAE 15-2013. It also references NFPA 90A and 90B, which, as mentioned above, point to ASHRAE 34-2013, ASHRAE 15-2013, and 2012 UL 60335-2-40.

This code needs updated standards references, and would benefit from direct references to additional standards.

NFPA 90A

Most Recent Version: 2018 (2021 development is in final stages)
Standard Update Schedule: Updated and published on a 3-year cycle
Coverage of A2L Refrigerants:

- Directly – None
- Indirectly – by standard reference

Allowance of A2L Refrigerants for use in direct systems for human comfort: No
Relevant Referenced Standards: NFPA 90B-2018; ASHRAE 15-2013; ASHRAE 34-2013; 2012 UL 60335-2-40.

NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*[28] does not directly include any requirements or mention of A2L refrigerants. It does include, by reference ASRHAE 15-2013; ASHRAE 34-2013 and 2012 UL 60335-2-40. The versions of these standards referenced do not allow A2L refrigerants for use in direct systems for human comfort. NFPA 90A also references NFPA 90B, which will be covered next. This report does not include a detailed description of everything in NFPA 90A, but instead describes how A2L refrigerants are included.

The primary need of this code is for updated standards references, but it would benefit from an explicit allowance for A2L refrigerants along with safety requirements.

NFPA 90B

Most Recent Version: 2018 (2021 development is in final stages)
Standard Update Schedule: Updated and published on a 3-year cycle
Coverage of A2L Refrigerants:

[28] https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=90A

- Directly – None
- Indirectly – by standard reference

Allowance of A2L Refrigerants for use in direct systems for human comfort: No

Relevant Referenced Standards: NFPA 90A-2018; ASHRAE 15-2013; ASHRAE 34-2013.

NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems*[29] does not directly include any requirements or mention of A2L refrigerants. It does include, by reference ASRHAE 15-2013 and ASHRAE 34-2013, but not UL 60335-2-40. The versions of these standards referenced do not allow A2L refrigerants for use in direct systems for human comfort. NFPA 90B also references NFPA 90A, which does include references to UL 60335-2-40. This report does not include a detailed description of everything in NFPA 90B, but instead describes how A2L refrigerants are included.

The primary need of this code is for updated standards references, but it would benefit from an explicit allowance for A2L refrigerants along with safety requirements.

Referenced Refrigerant Standards

Multiple technical standards set requirements related to refrigerants or refrigeration equipment, which have added classification, requirements, and guidance on A2L refrigerants. These refrigerants are referenced in model codes. The standards commonly referenced in the United states are ASHRAE 34, ASHRAE 15, UL 60335-2-40 and UL 60335-2-89. This report does not provide a detailed walkthrough of everything contained in these standards, some of which include hundreds of pages of technical content and appendices. Rather the report general summarizes the purpose of each standard and discusses how the standards include A2L refrigerants.

ASHRAE

The American Society of Heating Refrigeration, and Air-Conditioning Engineers develops consensus standards on a variety of issues including plumbing, mechanical, energy efficiency, and sustainability.[30]

[29] https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=90B

[30] https://www.ashrae.org/

ASHRAE 34

Most Recent Published Version: 2019

Standard Update Schedule: Updated via continuous maintenance; new version published on a 3-year schedule

Coverage of A2L Refrigerants:

- Directly – safety classification and limits
- Indirectly – by reference

Allowance of A2L Refrigerants for use in direct systems for human comfort: Yes, when used in conjunction with ASHRAE 15-2019.

Relevant Referenced Standards: ASHRAE 15-2019

The primary role of ASHRAE Standard 34 is to provide designations and safety classifications for refrigerants. Along with these characterizations, ASHRAE 34 also provides restrictions of refrigerants based on classification. The standard provides common terminology for identifying the chemical make-up of various refrigerants. It also creates safety groups based on flammability and toxicity using various calculations. For example, flammability classifications are based on flame propagation, Lower Flammability Limit, heat of combustion, and burning velocity. This section provides an overview of ASHRAE 34 provisions related to A2L refrigerants. It does not provide a comprehensive review of all ASHRAE 34 requirements.

In addition to classifying flammability and toxicity, Table 4.1 sets Refrigeration Concentration Limits and Occupational Exposure Limits for refrigerants. Table 4.2 performs the same function for refrigerant blends.

ASHRAE 34-2019 introduces the A2L safety group as a standalone classification, separate from the broader A2 group. This distinction is significant because it also allows a separate set of safety requirements to be developed for this “lower flammability” classification of refrigerants with the possibility of using them in more applications than the standard “flammable” A2 group. The “A” in this system refers to lower toxicity while “B” refrigerants have higher toxicity levels. ASHRAE 34 references and is intended to work in conjunction with ASHRAE Standard 15, which provides safety requirements for refrigerants based on the classifications found in

ASHRAE 34. The ASHRAE 15-2019 introduced A2L refrigerants as their own safety group for the first time, rather than a subgroup of A2 refrigerants.[31]

ASRHAE 15

Most Recent Published Version: 2019

Standard Update Schedule: Updated via continuous maintenance; new version published on a 3-year schedule

Coverage of A2L Refrigerants:

- Directly – multiple requirements
- Indirectly – by reference

Allowance of A2L Refrigerants for use in direct systems for human comfort: Yes

Relevant Referenced Standards: ASHRAE 34-2019

ASHRAE Standard 15 establishes safety standards for refrigeration systems. These standards include design, installation, operation, and testing requirements for equipment, machinery rooms, requirements for ventilation, restrictions on refrigerant use by occupancy, location, and refrigerant classification, leak detection and sensors, and pressure limiting devices among other requirements. This section provides an overview of ASHRAE 15 provisions related to A2L refrigerants. It does not provide a comprehensive review of all ASHRAE 15 requirements.

The 2019 version of the standard introduced separate safety requirements for A2L refrigerants. In prior versions of the standard, all A2 refrigerants were prohibited from use in high-probability systems for human comfort (most direct air conditioning and heat pump systems). The 2019 version allows the use of A2L refrigerants in these systems and provides specific safety requirements for their use. ASHRAE 15 references and is intended to work in conjunction with ASHRAE Standard 34.

ASHRAE 15 section 7.2 references the refrigerant concentration limits let in ASRHAE 34. Outside of these concentration limits, ASHRAE 15 requires that all refrigerants be located outdoors or in a machinery room. The standard includes a set of requirements for when a machinery room is present. In the 2019 Standard A2L (along with B2L) refrigerants are

[31] ANSI/ASHRAE Standard 34-2019. Designation and Safety Classification of Refrigerants

excepted from the machinery room requirements of other flammable refrigerants. Instead there is a specific set of requirements found in section 8.13.

Section 7.5.2 specifically prohibits the use of most flammable refrigerants (A2, B2L, B2, A3, and B3) in high-probability systems for human comfort. A2L refrigerants are specifically exempted from this provision. Requirements for A2L refrigerants used in high-probability systems for human comfort are set in Section 7.6. This section includes listing and labeling requirements, conditions necessary to require refrigerant detectors, and specific requirements related to specifications, operations, controls, and location of refrigerant detectors.

As mentioned above, specific requirements for A2L machinery rooms are found in section 8.13. This section includes specifications for isolation of the room, prohibition of open flame, limits on surface temperatures, refrigerant detector and alarm requirements, mechanical ventilation requirements, and controls. Ventilation rates for machinery rooms are based on equations and charts, rather than the tables used in the IMC, IFC, and UMC.

The remainder of the standard does not separate A2L refrigerants for specific additional requirements, except when dealing with all flammable refrigerants. In most cases the requirements listed are applicable to all refrigerants. These requirements include piping material and connection specifications, operational, installation, and testing requirements, as well as discharge and disposal of refrigerants.[32]

UL

UL develops a wide variety of test standards and performs testing and certification.

UL 60335-2-40

Most Recent Published Version: 2019
Standard Update Schedule: Updated via continuous maintenance; does not appear to be on a set publication schedule of new versions
Coverage of A2L Refrigerants:

- Directly – multiple requirements
- Indirectly – by reference

[32] ANSI/ASHRAE Standard 15-2019. Safety Standard for Refrigeration Systems

Allowance of A2L Refrigerants for use in direct systems for human comfort: Yes, when used in conjunction with ASHRAE 34 and 15.
Relevant Referenced Standards: ASHRAE 34; ASHRAE 15. Note: the UL standard does not reference a specific version of the ASHRAE standards.

UL60335-2-40 is a safety and test standard for equipment including heat pumps and air conditioners, which provides safety requirements, manufacturing specifications, testing requirements, and listing and labeling requirements for heat pumps, air-conditioners, and dehumidifiers. The primary purpose is for specifications and testing for manufactured products as well as requirements for installation and use. The standard provides particular requirements for flammable refrigerants and references ISO 5149 for refrigerant safety requirements not covered by the standard. ISO 5149 does include A2L refrigerants as a separate safety group with specific requirements. This section provides an overview of UL 60335-2-40 provisions related to A2L refrigerants. It does not provide a comprehensive review of all UL60335-2-40 requirements.

Topics covered in the requirements include vibration testing, piping/tubing protection, joint and connection material requirements, refrigeration charge limits, sensors and leak detection, ventilation, surface temperature limits, competence of service personnel, and electrical component requirements among other things. The standard specifically addresses warning labels needed for A2L refrigerant systems. In addition, the standard includes content requirements for product manuals including competence of service/maintenance personnel. Several Normative Annexes are dedicated entirely to A2L refrigerant systems. Depending on the refrigerant charge and its relation to the Lower Flammability Limit, the standard may require natural or mechanical ventilation, refrigerant detectors, alarms and shutoff control. UL 60335-2-40 references both ASRHAE Standard 34 and ASHRAE Standard 15. Like the two ASHRAE standards, the 2019 version of UL 60335-2-40 includes provisions for A2L refrigerants as a separate safety group from A2 refrigerants.[33]

UL 60335-2-89

Most Recent Published Version: 2017

[33] 2019 UL 60335-2-40 Standard for Safety. Household and Similar Electrical Appliances – Safety – Part 2-40: Particular Requirements for Electrical Heat Pumps, Air Conditioners, and Dehumidifiers

Standard Update Schedule: Updated via continuous maintenance; does not appear to be on a set publication schedule of new versions

Coverage of A2L Refrigerants:

- Directly – none
- Indirectly – by reference

Allowance of A2L Refrigerants for use in direct systems for human comfort: Yes, when used in conjunction with ASHRAE 34 and 15.

Relevant Referenced Standards: ASHRAE 34; ASHRAE 15. Note: the UL standard does not reference a specific version of the ASHRAE standards.

UL 60335-2-89 was first established in 2017. The standard sets safety and test standards for commercial refrigeration appliances. Although this standard does not apply to air conditioners or heat pumps used for human comfort, it does apply to appliances such as refrigerated display cases or heat pump water heaters.[34] Heat pump water heaters have seen increased market share for domestic hot water systems in residential occupancies recently. Any inclusion of A2L refrigerants for domestic hot water systems would need to consider UL 60335-2-89 and the most up to date references to ASHRAE 34 and 15. The standard does not directly include any specific refrigerants, including A2L refrigerants. Instead it references ASHRAE 34 and 15.

A Path Forward for Model Codes

This section of the report identifies several important steps for updating the model code that should be considered in order to achieve the goal of safely allowing broader inclusion of A2L refrigerants in the code, especially for use for human comfort systems. These steps are then applied to each model code discussed in this report. This section does not include all possible safety requirements that could be considered for A2L refrigerants.

This section also identifies the code update schedule for each model code, in addition to approximate important dates. None of the model code development organizations have published update schedules for their next cycle as of the writing of this report. Dates below are estimates based on past action.

[34] 2019 UL 60335-2-40 Standard for Safety. Household and Similar Electrical Appliances – Safety – Part 2-89: Particular Requirements for Commercial Refrigeration Appliances with an Incorporated or Remote Refrigerant Unit or Compressor

Referenced Standards

- Update Codes to Reference Latest ASHRAE 34, ASHRAE 15, UL 60335-2-40 and UL 60335-2-89
- Consider directly referencing refrigerant standards if these references are currently reached by indirect reference through other standards.

Check for Conflicts with Standards

- Identify code requirements that conflict with updated standards
- Ensure that any text directly quoted from standards uses current standard langauge
- Identify areas where specific code language is less stringent than current standards

Internal Consistency

- Ensure that A2L refrigerants are not treated as a subgroup of A2 refrigerants. Examples of this would include a requirement for A2 refrigerants with an exception for A2L refrigerants.
- Update standards across all applicable codes. For example, the mechanical, residential, and fire codes may all contian references that need updates

Consider Exceptions & Additions

- Identify broad code requirements for refrigerants that should include an exception for A2L refrigerants
- Identify added safety requirements beyond technical standards to enhance safety of A2L refrigerants in code

Specific Allowance

- Identify opportunity to explicitly allow A2L for human comfort systems
- Remove specific prohibitions of A2L refrigerants for human comfort systems

ICC Code Changes

Step	Status	Action	Relevant Code Section	Notes
Referenced Standards	Update Needed	Update IRC references 2019 UL 60335-2-40; Add Reference to M1404.1 tp I:60335-2-40	2021 IRC • M1403.1 • M1404.1 • M1411.1 • M1412.1 • M1413.1 • Chapter 44	Consider direct reference to ASHRAE 15-2019. Consider Direct Reference to UL 60335-2-89 Referenced standards are updated in chapter 44. The text reference sections are also identified here.
		2019 UL 60335-2-40,	2021 IMC • 1101.1.1 • Table 1101.2 • 1102.2.1 • 1103.1 • 1106.4.2 • Chapter 15	Referenced standards are updated in chapter 15. The text reference sections are also identified here.
Check for Conflicts with Standards	Update Needed	Eliminate conflicts related to ASHRAE 15-2019 and ASHRAE 34-2019 found in IMC Chapter 11. Example of direct conflict includes refrigerant classification Table 1103.1. Consider harmonizing ventilation rates and system classifications to avoid confusion.	2021 IMC • Chapter 11 Generally • 1103.1 • Table 1103.1 • 1106.4.2 • Table 1106.4.2	Consider Harmonizing 1103.3 System Classification with ASHRAE 15 definitions Consider Harmonizing 1106.4.2 with ventilation rates in ASHRAE 15
	Consider Update	No absolute conflict in IFC but consider harmonizing ventilation rates to avoid confusion	2021 IFC • 605.17.2 • Table 605.17.2	Consider harmonizing 605.17.2 ventilation rates with ASHRAE 15

Internal Consistency	Update Needed	Multiple sections in IMC chapter 11 refer to A2 refrigerants. If referenced standards are updated, A2L will need to be added to these sections when appropriate rather than assumed. Table 1103.1 needs A2L classifications. 1106.3 should not list A2L as an exception. Requirements are addressed in 1106.4	2021 IMC • Chapter 11 Generally • 1103.1	
		Several places in the IFC refer to A2L as exceptions in requirements for A2 Refrigerants. These should be corrected	2021 IFC • 605.13 • 605.16	
Consider Exceptions & Additions	Consider Update	For all ICC codes consider where any broad refrigerant, flammable refrigerant or A2 refrigerant requirement should not be applicable to A2L refrigerants. Consider also any added safety requirements for A2L refrigerants including direct references to ASHRAE 15 sections or other requirements.	2021 IRC • Chapter 14 2021 IMC • Chapter 11 2021 IFC • Section 605	Additional A2L safety requirements may be needed as safeguards in order to make ICC voting members and adopting jurisdictions comfortable with updated standards
Specific Allowance	Update Needed	Identify A2L refrigerants as their own class throughout Chapter 11. Add specific code statement in 1104.3 allowing A2L refrigerants for use in high-probability systems for human comfort. Consider defining specific limits to this use as seen with other refrigerants.	2021 IMC • Chapter 11 generally • 1104.3 • 1104.3.2 • Table 1104.3.2	IMC 1104.3 currently prohibits the use of A2L refrigerants in high-probability systems for human comfort because A2L refrigerants are included in A2. Table 1104.3.2 sets refrigerant charge limits for A2 Refrigerants below the amount used in

				most Air-conditioning or heat pump systems.

ICC Update Schedule

The ICC codes are updated on a 3-year schedule. Codes are typically divided into two groups, with changes to the first group handled in the first year of the cycle, and changes to the second group of codes handled in the second year of the cycle. The third year has sometimes had a small number of codes, but most of this year is used for the publication process. The typical hearing schedule requires code change proposals in January, with committee hearings in April/May and public comment hearings in October/November. Final ICC online voting happens a few weeks after the public comment hearings. Only the committee can vote on changes during committee hearings, while only ICC Voting Members can vote during public comments hearings and final online vote. There are several points in which the general public can influence changes made to the code:

1. Participate in code action committees to identify any industry consensus positions
2. Submit proposed code changes
3. Testify at committee hearings
4. Submit public comments based on hearing results
5. Testify at public comment hearings

In past code cycles, the IMC, IFC, and IRC mechanical changes have happened with Group A codes in the first year of the cycle. If we assume the same code groups for the 2024 code

cycle, and we assume the same general schedule, the approximate important dates shown to the right can be assumed for any effort to add A2L refrigerants in a more comprehensive way to the ICC codes.

IAPMO Code Changes

Step	Status	Action	Relevant Code Section	Notes
Referenced Standards	Update Needed	Update UMC references to ASHRAE 34-2019, ASHRAE 15-2019 and 2019 UL 60335-2-40	UMC 2021 • 903.1 • Chapter 11 Generally • 1102.1 • 1102.3 • 1103.1 • 1106.1 • Chapter 17	Referenced standards are updated in chapter 17. The text reference sections are also identified here.
Check for Conflicts with Standards	Update Needed	Update Chapter 11 sections quoting specific ASHRAE 15 text to reference current text. Update table 1102.3 to use current ASHRAE 34 tables. Amend 1104.6 to allow A2L refrigerants for human comfort.	UMC 2021 • Chapter 11 Generally • Table 1102.3 • 1104.6 • Table 1106.2.5.2	Consider update to table 1106.5.2 to match ventilation rates in ASHRAE 15
Internal Consistency	Update Needed	Update Chapter 11 to eliminate situations where A2L refrigerants are treated as exceptions to A2 refrigerants.	UMC 2021 • Chapter 11 Generally • 1104.3 • 1104.5	
Consider Exceptions & Additions	Consider Update	For UMC, consider where any broad refrigerant, flammable refrigerant or A2 refrigerant requirement should not be applicable to A2L refrigerants. Consider also any added safety requirements for A2L refrigerants including direct references to ASHRAE 15 sections or other requirements.	UMC 2021 • Chapter 9 and Chapter 11	Additional A2L safety requirements may be needed as safeguards in order to make UMC voting members and adopting jurisdictions comfortable with

				updated standards
Specific Allowance	Update Needed	Add specific code statement in 1104.6 allowing A2L refrigerants for use in high-probability systems for human comfort. Consider defining specific limits to this use as seen with other refrigerants.	UMC 2021 • 1104.6	1104.6 currently prohibits the use of A2L refrigerants in high-probability systems for human comfort.

IAPMO Update Schedule

The IAPMO process uses technical committees and a ballot process to develop the UMC code on a 3-year cycle. Rather than hearings with public testimony, the technical committee meets multiple times during the process to consider changes and comments, and to vote on the final version of the new code. There are several times when the public can influence the UMC development.

1. Submit proposals
2. Submit comment based on report on proposals
3. Submit appeal
4. Participate in Association Technical Committee meeting
5. Submit appeal
6. Participate in appeal hearing if applicable

Although IAPMO has not yet posted the schedule for technical committee meetings and proposal deadlines for the 2024 code cycle, we can use the 2021 code cycle schedule as framework for what we can probably expect. Code change proposals are submitted in March, the 1st year of the cycle, which in this case would be 2021. The technical committee goes through a review process and votes on all proposed changes by the public and by IAPMO members. A report on

all accepted changes is published in August 2021. Comments on the committee actions described in the report on proposals are due January 2022. The committee then meets and reviews comments from the public and IAPMO members and votes on changes. A report on all accepted comments is distributed in August 2022. In September 2022, an IAPMO Association Technical Meeting is held at which IAPMO members can submit proposed amendments and the public can attend, speak, and make motions. Only IAPMO members can vote. Finally, IAPMO Standards Council hears appeals if necessary. Final ballots and hearings occur October/November 2022.

NFPA Standard Changes

Step	Status	Action	Relevant Code Section	Notes
Referenced Standards	Consider Update	For NFPA 101, consider adding direct references to ASHRAE 34, ASHRAE 15, UL 60335-2-40 and UL 60335-2-89.	• Chapter 2 • Consider adding references directly in code text	Currently all referenced standards are only reached through NFPA 90A and 90B references. This makes finding the actual requirements difficult. Referenced standards are found in Chapter 2
	Update Needed	For NFPA 1, update ASHRAE 15 reference to 2019 standard. Consider adding direct references to ASHRAE 34, UL 60335-2-40 and UL 60335-2-89	• Chapter 2 • Consider adding references directly in code text	Currently, other than ASHRAE 15, all referenced standards are only reached through NFPA 90A and 90B references. This makes finding the actual requirements difficult. Referenced standards are found in Chapter 2

	Update Needed	For NFPA 90A and 90B, update ASHRAE 34, ASHRAE 15, an UL 60335-2-40 references to 2019 versions. Note: UL 60335-2-40 not applicable here.	• Chapter 2	Changes here should follow through to NFPA 101 and NFPA 1 through reference, but may be less clear than a direct reference.
Check for Conflicts with Standards	Not applicable	Not applicable	• N/A	Text does not directly include refrigerant requirements
Internal Consistency	Not applicable	Not applicable	• N/A	Text does not directly include refrigerant requirements
Consider Exceptions & Additions	Consider Update	If standard references are updated consider adding safety requirements in direct code text	• TBD	
Specific Allowance	Consider update	Consider a direct reference allowing A2L refrigerants for high-probability systems for human comfort	• TBD	This is unlikely as the code currently does not have any specific information on refrigerants

NFPA Update Schedule

NFPA has not finalized the 2021 NFPA 101, but they are in the final stages of development in 2020. Final amending motions are being heard for this cycle in June 2020. The ability to add new changes for that cycle passed at the beginning of the 3-year cycle. We can establish and approximate schedule based on the schedule from last cycle. The public has several opportunities to participate in the standard update process including:

1. Submit public input
2. Submit Comments based on first draft report
3. Submit a notice of Intent to Make a Motion (NITMAM) based on the second draft report
4. Participate in the Association Technical Meeting
5. Submit Appeals
6. Participate in appeals if necessary

The schedule used in prior cycles would include a public input deadline in June of 2021, followed by technical committee meetings and deliberation. The first draft report that results from these meetings is published February 2022. Comments based on the first draft report are due May 2022, followed by more technical committee meetings and deliberation. The second draft report that results from these meetings is published January 2023. Anyone who wishes to make a motion at the Association Technical Meeting must submit an NITMAM, which is due February 2023. Certified amendments are deliberated at the Association Technical Meeting June 2023.

Note that NFPA 1 is modified in a similar way, with minor variations in dates (e.g. public comments due June 2022 and NITMAM due March 2023). Furthermore, the NFPA 1 committee structure in effect following the 2021 standard has now been broken into 3 committees with a coordinating committee. This new structure may cause schedule changes in the next cycle. NFPA 90A and 90B both follow the same general schedule as NFPA 101.

State Code Adoptions and Amendments

Several States have passed legislation or implemented regulations requiring the phase-out of HFCs or high-GWP refrigerants. One State (Washington) has also passed building code changes to allow A2L refrigerants in systems for human comfort such as air-conditioners or heat pumps.

Washington

In July 2020, Washington will become the first state to allow the use of A2L refrigerants for direct air conditioning and heat pump systems for human comfort. In May 2019, the Washington Governor signed HB1112-2019-20/SB5426-2019-20 into law[35], beginning a phase out for high GWP refrigerants. In November 2019, the Washington State Building Code Council voted to adopt the 2018 IRC, 2018 IMC, and 2018 IFC with amendments. These amendments updated the ASHRAE 34, ASHRAE 15, and UL 60335-2-40 references to the 2019 versions of those standards. These codes take effect in July, 2020. Although the adoption missed several text and reference updates that cause some confusion/conflicts in the code, the intent to allow the use of A2L refrigerants as described in the 2019 referenced standards was clear.

Gaps in Washington Code Adoption

Although the steps Washington took to incorporate A2L refrigerants into their code make them a leader in the United States on this issue, their approach is not one that can be followed exactly by other states or in the model codes due to several gaps in the adoption details.

Gap #1

Amendments to the 2018 IMC did update the reference for ASHRAE 15. The 2019 version provides safety standards for the use of A2L refrigerants and directly references ASHRAE 34. However, several ASHRAE 34 references exist in the IMC and the

[35] https://app.leg.wa.gov/billsummary?BillNumber=1112&Year=2019&Initiative=false

reference standard for ASHRAE 34 was not updated but still references the 2016 version, which did not include A2L refrigerants as their own safety class. Furthermore, the refrigerant concentration limit tables from ASHRAE 34 are copied directly into the IRC in section 1103.1. This table uses the ASHRAE 34-2016 values which do not include classifications for A2L refrigerants. Although a code official could follow the trail from ASHRAE 15-2019 to ASHRAE 34-2019 there could be an argument made that the IMC references ASHRAE 34-2016 and should use that version. In addition, code enforcement processes are likely to rely on what is actually printed in the code book. With tables not including A2L refrigerants as the easiest requirements to reference, these refrigerants could be mistakenly denied. At best the lack of update to ASHRAE 34-2019 in the IMC causes confusion, and it possibly causes a conflict between code and referenced standard. The IRC amendments did update the ASHRAE 34 standard, but this code would not apply to many building types. Although code enforcement in Washington State may be able to interpret the intent of the amendments to include ASHRAE 34-2019, this approach should not be portrayed as a model for code adoption in other states.

Gap #2

As mentioned above, Washington's adoption of the 2018 IMC included amendments to the referenced standard for ASHRAE 15, updating to reference the 2019 standard. ASHRAE 15-2019 specifically allows A2L refrigerants to be used in high-probability systems for human comfort via section 7.5.2 and provides safety requirements for such use in section 7.6. However, the 2018 IMC Section 1104.3.2 does not allow high probability systems with more than 6.6 pounds of A2 refrigerants for non-industrial occupancies. Because the 2018 IMC did not include A2L refrigerants as their own safety group, this paragraph includes A2 and A2L. Although the code references the updated ASHRAE 15 standard, this paragraph stands in conflict with ASHRAE 15 Section 7.5.2 unless the code official interprets the reference to not include A2L refrigerants. Like Gap #1, this is at best confusing, and at worst a possible conflict in the code which will cause code enforcement to side with the more stringent requirement. For other states and the model codes to follow, language excepting A2L refrigerants from IMC 1104.3.2 would be important to avoid confusion and to allow access for A2L refrigerants in most systems.

Gap #3

The 2018 IFC includes several references to ASHRAE 15. However, Washington did not update the reference in the IFC to the 2019 version of ASHRAE 15. This is likely a smaller issue because the ASHRAE 15-2019 is referenced by the IMC. In fact, IFC 605.17 includes the exact provisions listed in the corresponding IMC chapter and the section already references A2L refrigerant machinery rooms. A thorough change in the model code or other states would also include an updated reference here, but code officials should be able to find the intent of the update through the IMC amendments in this case.

Gap #4

Several changes that were passed in the 2021 ICC codes, included provisions to reference both UL 60335-2-40 and UL 60335-2-89.[36] The rationale behind these proposals was that the code would need to be able to reference labeling and testing requirements for A2L Refrigeration systems that are found in these standards. Although the Washington changes do reference UL 60335-2-40, there is no reference to UL 60335-2-89 which sets safety standards for commercial refrigeration appliances. Although this standard does not apply to air conditioners or heat pumps used for human comfort, it does apply to appliances such as refrigerated display cases or heat pump water heaters. The addition of UL 60335-2-89[37] should be considered as a reference for a more complete adoption model for other states or the national model codes.

Florida

The 2020 Florida Building Code,[38] based on the 2018 ICC Codes, passed amendments to update several Relevant Standards. In the adoption of the 2018 IRC, Florida updated references to ASHRAE 34-2019 and to 2019 UL 60335-2-40. In the adoption of the 2018 IMC, Florida updated references to ASHRAE 34-2019, ASHRAE 15-2019, and 2019 UL 60335-2-40.

[36] Comments and reason statements from ICC proposal documents

[37] 2019 UL 60335-2-40 Standard for Safety. Household and Similar Electrical Appliances – Safety – Part 2-89: Particular Requirements for Commercial Refrigeration Appliances with an Incorporated or Remote Refrigerant Unit or Compressor

[38] https://codes.iccsafe.org/codes/florida

Gaps in Florida Code Adoption

The Florida Code amendments accomplished updates of referenced standards that the 2021 ICC Codes in that UL 60335-2-40 was updated in the 2019 standard in addition to ASHRAE 34 and ASHRAE 35. However, several gaps still remain for full inclusion of A2L refrigerants.

Gap #1

The 2021 IMC added table 1101.2, which provides specific appliance safety standards for different equipment classifications. This table would be a helpful addition to the Florida Building Code, especially because it also adds a reference to UL 60335-2-89.

Gap #2

Several text changes are needed in the mechanical code to avoid conflicts with the newly referenced AHSRAE 15-2019 standard. As described in the section on the IMC above, 1104.3. 1104.3.1, 1104.3.2 and Table 1104.3.2 need clarification to explicitly allow A2L refrigerants for use in human comfort systems in order to be consistent with ASHRAE 15. In addition, Table 1103.1 needs to be updated to include A2L refrigerants in the list in order to be consistent with ASHRAE 34. See the section on suggested text changes to the IMC for detailed guidance.

Gap#3

The residential code could also use a direct reference to UL 60335-2-40 in section M1404.1 as mentioned above in the section on the IRC.

California

California passed Senate Bill No. 1383 in 2016 to begin a phased reduction of high-GWP refrigerants.[39] California has passed other legislation and regulation reducing the use of hydrofluorocarbons and other high GWP provisions including CARB California SNAP[40] regulations, SB 1013[41], which adopted EPA SNAP Rules 20 and 21[42], and the Refrigerant Management Program.[43] In addition to these rules, California is working on a rulemaking to

[39] https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB1383
[40] https://ww2.arb.ca.gov/node/3335/about
[41] https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB1013
[42] https://www.epa.gov/snap/snap-regulations
[43] https://ww2.arb.ca.gov/our-work/programs/refrigerant-management-program

phase out hydrofluorocarbons in stationary air conditioning and heat pumps although this rulemaking has not yet been finalized. If enacted, the code will still need to be updated in order to allow the use of A2L refrigerants as a replacement.

California's 2019 Mechanical Code, which is based on the 2018 UMC, contains the same conflicts and inconsistent treatment for A2L refrigerants discussed in the review of the UMC. Although there are significant steps taken toward recognizing A2L refrigerants as their own safety group, the code still often treats them as a subgroup of A2 refrigerants. The California Mechanical Code still prohibits the use of A2 refrigerants in systems for human comfort and does not except A2L from this requirement. Because of the lack of consistency in this code in its treatment of A2L refrigerants, this leaves ambiguity regarding whether A2L refrigerants could be used. The code does still reference the 2016 versions of the relevant ASHRAE and UL standards. Therefore, even with an interpretation that A2L refrigerants are not included in A2, the code would lack the necessary safety protections included in the updated referenced standards.

If California adopts the 2021 UMC as their next mechanical code significant amendments will be needed to ensure the ability to use A2L refrigerants for human comfort systems. In addition to updating references to ASHRAE 34, ASHRAE 15, and UL 60335-2-40 to the most current version, at a minimum section 1104.6 would need to be modified to specifically allow A2L refrigerants to be used in systems for human comfort. A more comprehensive package of amendments would also update all ASHRAE 15-quoted language in the UMC to the most recent version and remove any language that treats A2L refrigerants as exceptions to A2 refrigerants in the UMC text.

New Jersey

A-5583/S-3919 was signed into law in January, 2020,[44] beginning the phase out of HFC refrigerants in the state. The legislation also allows the New Jersey Department of Environmental Protection to adopt a list of approved alternative refrigerants, and directs the department to provide a report on substitute refrigerants by December, 2020.[45] New Jersey

[44] https://nj.gov/governor/news/news/562020/approved/20200121k.shtml
[45] https://www.njleg.state.nj.us/2018/Bills/A9999/5583_I1.HTM

adopted the 2018 ICC codes including the IMC and IRC, but did not amend the refrigerant text or references to ASHRAE 34, ASHRAE 15, or UL 60335-2-40.

Vermont

Vermont Governor signed S.30 into law June 2019, beginning the phase out of HFCs in the state.[46] Vermont does not adopt the IMC or UMC so their code adoption path related to A2L refrigerants will look different from most states. NFPA 1 and NFPA 101, which the state adopts as part of their code, do both have paths to ASHRAE 15 and 34, as well as UL 60335-2-40 directly or through NFPA 90A and 90B.

State	Low-GWP or HFC Regulation or Legislation Passed	Relevant Codes	ASRHAE 34, ASHRAE 15, UL 60335-2-40 Amendments	Notes
California	Yes	2018 UMC	No	CA often amends and has its own version of the UMC published. This is applicable to residential and commercial construction
Florida	No	2018 IMC 2018 IRC	Yes	Amendments with some gaps
New Jersey	Yes	2018 IRC 2018 IMC	No	Does amend code when adopting
Vermont	Yes	Through Reference NFPA 1 and NFPA 101	No	Publishes State-Specific Code Changes IMC references to

[46] https://legislature.vermont.gov/bill/status/2020/S.30

				NFPA 1 and IRC references to NFPA 101
Washington	Yes	2018 IRC 2018 IMC 2018 IFC	Yes	Amendments with some gaps

Other States

Other states that are currently implementing or drafting regulation to phase out HFCs have the following codes in place:

State	Relevant Codes	Amended ASRHAE 34, ASHRAE 15, UL 60335-2-40	Other Notes
Connecticut	2015 IRC 2015 IMC	No	
Colorado	2018 IMC	No	No State Residential Code, but many local jurisdictions adopt IRC
Delaware	By County and Municipality	No	Sussex County has adopted the 2012 IRC; adoption of the IMC is unclear. Newcastle County has adopted the 2018 IRC and 2015 IMC. Kent County has adopted the 2012 IRC/IBC and all other 2012 ICC codes by reference.
Hawaii	2012 IRC NFPA1 2012	No	

Maine	2015 IRC	No	
Maryland	2018 ICC Codes	No	Mechanical codes (and mechanical sections of IRC) adopted at local level; Most counties adopt full IRC and IMC
Massachusetts	2015 IRC 2015 IMC	No	
New York	2015 IRC 2015 IMC	No	
Pennsylvania	2015 IRC 2015 IMC	No	
Oregon	2015 IRC 2018 IMC	No	
Rhode Island	2015 IRC 2015 IMC	No	Amendments did include additional requirements for IMC Chapter 11 regarding refrigerant safety but no specific references to A2L.
Virginia	2015 IRC 2015 IMC	No	

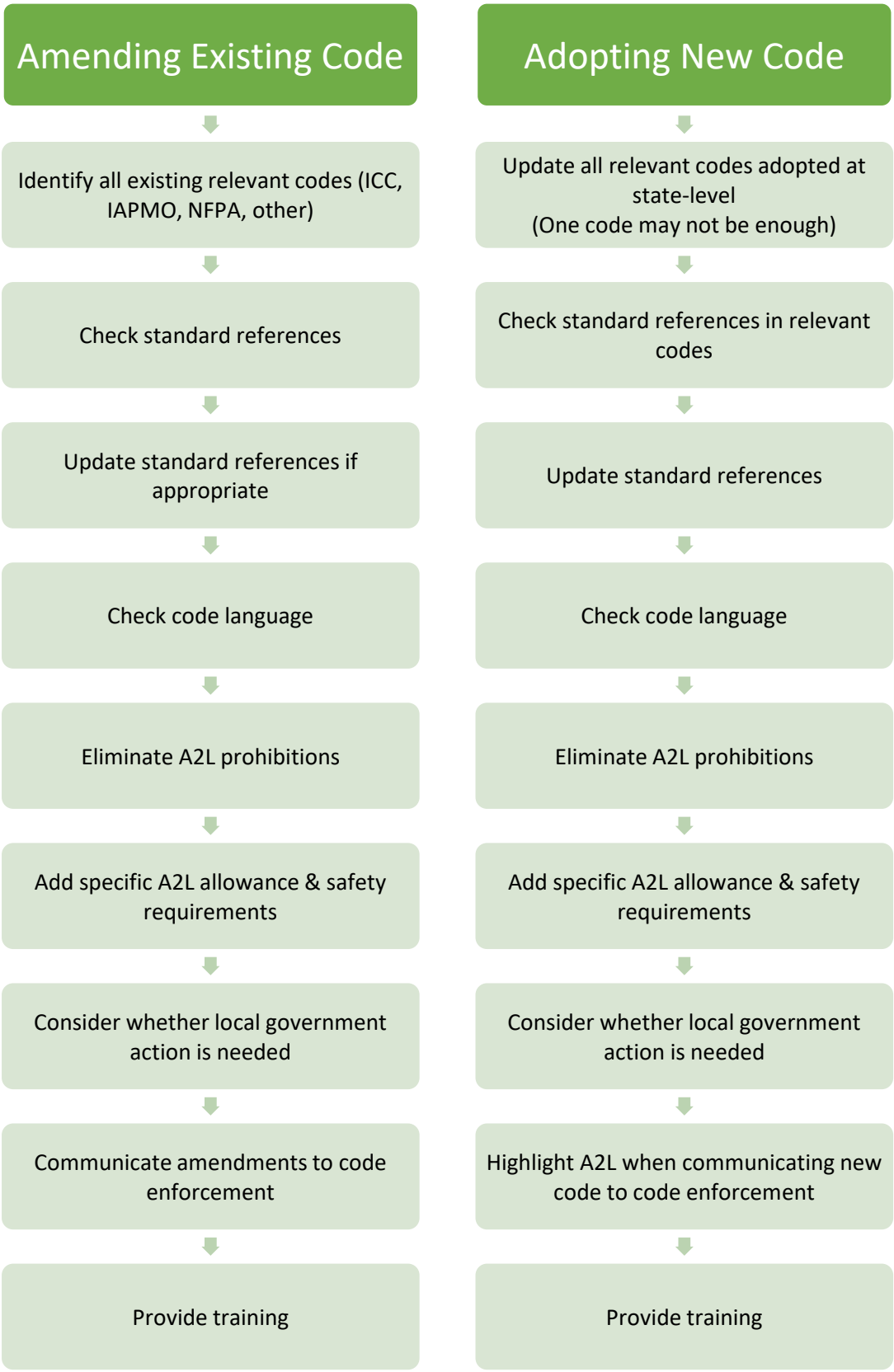
A Path Forward for State Code Adoption

Although the most effective and efficient way to implement code changes is through the model code, states wanting to reduce or eliminate the use of high-GWP refrigerants will need to consider code amendments at the state level. Likewise, when codes are adopted by counties or municipalities, amendments at this level may be necessary in order to comply with state legislation or regulation. When passing legislation or regulation, or when considering adopting or amending codes, it is important that states ask the following questions:

- Does the state have the authority to adopt/amend all relevant codes or does that authority exist with local government?
- If local governments adopt any codes, are they codes that are relevant to refrigerants?
- If local governments adopt relevant codes, can the state identify and recommend appropriate action?
- If the state adopts the code, can the state amend the existing code or is a new code adoption necessary?
- Does a model code with A2L allowances and updated standard references exist that can be adopted without amendment?
- Does one agency adopt all relevant codes, or are multiple agency's processes necessary to cover everything?

When adopting or amending a new code, states can use the guidance in this report found in the Path Forward for Model Codes section, but there will be more variables to consider at the state adoption level. For example, a state that adopts both NFPA 101 as their building code along with the UMC as their mechanical code will need to update and clarify references in both codes in order to avoid conflicts in the code or confusion in enforcement. Likewise, a state currently using the 2012 ICC codes that adopts the 2021 IMC could pass amendments to update standards references and eliminate conflicts, but if they do not update their IRC, there will still remain conflicts in the code and the ability to use A2L refrigerants will not be comprehensive. In other cases, the IRC is adopted at the state level but the IMC is adopted by counties and municipalities. If a state is not adopting a new code, they will need to pass amendments to their current code. The complicated nature of code adoption in the states makes it even more important to amend the code with clear language specifically allowing the use of A2L refrigerants in high-probability systems for human comfort, while adding specific safety requirements for these systems and clearly referencing updated refrigerant safety standards in the same section of the code.

For any state amending their existing code, adopting a new code with state amendments, or adopting a model code that has made the changes necessary for inclusion of A2L refrigerants, communication and training for code enforcement personnel will be necessary to ensure that newly allowed A2L refrigerants are being allowed in practice, and are being installed with code required safety measures.


Amending Existing Code
Identify all existing relevant codes (ICC, IAPMO, NFPA, other)
Check standard references
Update standard references if appropriate
Check code language
Eliminate A2L prohibitions
Add specific A2L allowance & safety requirements
Consider whether local government action is needed
Communicate amendments to code enforcement
Provide training
Adopting New Code
Update all relevant codes adopted at state-level
(One code may not be enough)
Check standard references in relevant codes
Update standard references
Check code language
Eliminate A2L prohibitions
Add specific A2L allowance & safety requirements
Consider whether local government action is needed
Highlight A2L when communicating new code to code enforcement
Provide training

Following this process, along with the recommended changes identified for model codes, will help states meet their goals to introduce A2L refrigerants as an allowable alternative to high-GWP refrigerants. This will be an especially important step for any state passing legislation or regulation phasing out high-GWP refrigerants. For states without legislation or regulatory action, this can open the ability to use A2L refrigerants for industry that will already be adjusting manufacturing based on other state's prohibitions. The remaining complication will be communicating with counties and municipalities who adopt a portion or all of the code. For states that do not adopt a state-wide code, a specific allowance for A2L refrigerants when passing legislation or regulation eliminating high-GWP refrigerants. In addition, if a state code is not passed, it may be possible for the state to adopt ASHRAE 34, ASHRAE 15, UL 60335-2-40 and UL 60335-2-89 directly as safety standards apart from the code.

International Adoption of A2L Refrigerants

According to a white paper by Danfoss, which details standards adoptions around the world related to flammable refrigerants, several countries have begun formal phase-out of HFCs or incentive programs encouraging low-GWP refrigerants. These countries include China, Japan, Australia, and the EU. Most countries have standards that are harmonized with standards available in the US, providing similar code adoption paths.

ASHRAE 34 refrigerant classifications are referenced by ISO 5149, which is used in China, India, and Australia. EN 378, which is used in the EU also references ASHRAE 34. ASHRAE 15 is used in the US and references ASHRAE 34 (although the US has does not have broad adoption of the current versions of these standards). UL 60335-2-40 and UL 60335-2-89 are substantially harmonized, with some national variations, with international counterparts IEC 60335-2-40 and IEC 60335-2-89)[47]. Some differences do exist between the standards.

In Australia's case, they instituted an official training program and competency certification for A2L refrigerants and technician safety practices.[48] A 2019 overview article on A2L refrigerants

[47] Danfoss (2018). *Refrigerant Options Now and in the Future: A white paper on the global trends within refrigerants in air conditioning and refrigeration seen from a Danfoss perspective*

[48] https://www.hvacrnews.com.au/education/official-training-now-available-for-a2-a2l-refrigerants/

also listed Germany, Italy, and France, along with China, India, Japan, and Australia, as countries with the majority of A2L refrigerant air conditioning and heat pump systems.[49]

Risks as Addressed by Relevant Codes and Standards

Risks	Addressed in Codes/Standards	Notes
High Concentration of A2L Refrigerants	ASHRAE 34-2019 ASHRAE 15-2019 UMC 2018 IMC 2018/2021	UMC and IMC limits mostly refer to total refrigerant or total flammable refrigerant limits.
Unknown Refrigerant Leaks	2019 UL 60335-2-40 ASHRAE 15	Both standards include requirements for refrigerant leak detectors and sensors. UL includes significant details on location, controls, calibration, and performance
Need to Dilute Refrigerant Concentration Due to Leak	2019 UL 60335-2-40 ASHRAE 15 IMC 2018/2021 UMC 2018 IFC 2018	UL includes natural or mechanical ventilation requirements for occupied rooms with A2L refrigerants. The amount of ventilation and the choice between natural or mechanical ventilation depends on volume of space and availability of natural ventilation; ASHRAE requires ventilation based on refrigerant concentration and LFL, as well as requirements for machinery rooms; UMC, IMC, and IFC have ventilation

[49] ACHR News (2019). *Understanding A2L Refrigerants for Air Conditioners.* https://www.achrnews.com/articles/141733-understanding-a2l-refrigerants-for-air-conditioners

		requirements for machinery rooms
Pressure Relief Devices	2019 UL 60335-2-40 ASHRAE 15-2019	
Pipe Material Requirements	IMC 2021	These are requirements added in 2021 to the IMC that are not included in earlier versions or the ASHRAE or UL standards
Piping Joints & Connections	2019 UL 60335-2-40 IMC 2021	IMC requirements are new to 2021 version
Technician Competency	2019 UL 60335-2-40	UL contains an informative appendix discussing the competence of installation or service technicians
Testing	2019 UL 60335-2-40 ASHRAE 34-2019	
Listing, Labeling and Identification	2019 UL 60335-2-40 ASHRAE 15-2019	

Training

Of the various objections to the transition toward A2L refrigerants, the call for training is the most persuasive. Countries that have already begun using A2L refrigerants for human comfort systems generally refer to the same or similar safety standards as those in the US, establishing a safety track record for these systems that may not need to be altered from a technical perspective. Australia, however, has instituted a wide-spread training program and certification through official channels that is pointed to as a model for training workforce on safety issues related to handling A2L refrigerants. Australia has even instituted requirements for communication with the fire department when systems using flammable refrigerants are present.

The standard HVAC technician, who may not have previously worked with small appliances containing flammable refrigerants, or with large commercial refrigeration systems with machinery rooms, may have not received any relevant training that will help them with the

installation, charging or removal of heat pumps and air-conditioners that would be using A2L refrigerants. Likewise, firefighters and other emergency personnel may not be trained to expect or look for flammability labels or markings on heat pumps and air-conditioners. At a minimum, training for HVAC contractors and fire department personnel is needed during this transition. A certification or licensing program could also be considered for contractors. Multiple organizations have either developed training or are in the process of developing training including NFPA, The Air Conditioning Contractors of America (ACCA), ASHRAE, North American Technician Excellence (NATE).