Preparing for A2L Refrigerants in Commercial Refrigeration

Considerations for leveraging A2L alternatives in your lower-GWP refrigerant transition

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White Paper

EMERSON

Abstract

Within the commercial refrigeration industry, A2L refrigerants have long been recognized as potentially viable alternatives to high-global warming potential (GWP) hydrofluorocarbon (HFC) refrigerants. With GWP ratings below 300 — and in certain instances below 150 — some A2L refrigerants are among the lowest-GWP alternatives available today.

A2Ls are composed of multiple chemical components, including those with high hydrofluoroolefin (HFO) content which can result in varying degrees of flammability, earning the A2L "lower flammability" refrigerant classification.

In the United States, A2L adoption in commercial refrigeration is still in its early stages. Further regulatory approvals and updates to safety standards and building codes are currently underway to enable widespread industry adoption. A recent update to the Underwriters Laboratories (UL) safety standard — UL 60335-2-89 — signaled the first key step in this approval process. Many industry experts believe this update sets the stage for an acceleration of A2L adoption within the next few years.

A2L refrigerants offer a unique solution within the refrigerant landscape. With charge limits exceeding those approved for R-290, A2Ls represent a potentially higher-capacity alternative in self-contained applications. They also likely have a place in distributed architectures, such as remote, outdoor condensing units (OCUs) or mini-racks used in smaller-format outlets. Regardless of which A2L applications may become more commonplace, they give companies new options with which to achieve regulatory compliance and meet operational sustainability goals.

But what does this mean for commercial refrigeration industry stakeholders? As you plan your long-term refrigerant transition, A2L refrigeration strategies are among the industry's growing list of viable equipment options. To prepare for the first significant wave of A2L adoption, original equipment manufacturers (OEMs) should initiate their equipment design cycles. Contractors, consultants and owners/operators should educate themselves in preparation for more widespread A2L adoption.

This white paper will review the next regulatory steps required for A2L adoption, explore A2L systems and equipment applications, and discuss A2L refrigerant servicing and safety considerations.

Regulatory path to approval

To ensure the safe use of lower-flammability A2L (and higher-flammability A3) refrigerants in commercial refrigeration, governing bodies are updating the safety standards and building codes that oversee A2L and A3 equipment designs and applications. Most recently, the UL approved the second edition of its UL 60335-2-89 standard, which includes A2L charge limit guidelines for self-contained and remote refrigeration systems.

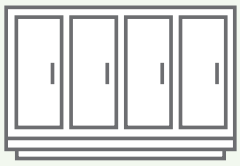
New charge limits in self-contained applications

For self-contained equipment, the proposal includes A2L charge limit guidelines based on whether equipment has an open design without doors or a closed design with doors. It is important to note that different A2L blends have varying degrees of flammability that must be taken into design consideration to mitigate the potential release and concentration of gas in an application.

The following example uses R-454C to calculate the charge limit in open and closed cases based on the refrigerant's lower flammability limit (LFL).

$m_1 = 8\ m^3 \times LFL$

5.1 lbs R-454C

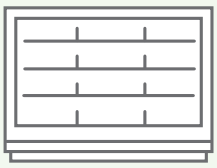


Closed Case

Self-Contained
Must pass Annex CC testing

$m_1 = 13\ m^3 \times LFL$

8.3 lbs R-454C



Open Case

Self-Contained
Must pass Annex CC testing

Definition of Self-Contained in UL 2-89
3.8.112DV SELF-CONTAINED – equipment consisting of a completely factory assembled, factory charged and factory tested refrigeration system in which all of the refrigerant-containing parts are permanently connected at the factory.

Per the Annex CC testing methodology defined in the UL 60335-2-89 standard, A2L refrigerant charge limits above 150 grams are contingent on constructing equipment to prevent flammable refrigerant concentrations surrounding the appliance in the event of a leak (or releasable charge). Thus, this method determines the gas concentration beyond the boundary of the appliance.

Variable "m" is the amount (mass) of refrigerant charge in the system, expressed in either pounds or kilograms. Variable "m_1" is the maximum allowable charge of a self-contained, factory-charged system, without the need for leak detectors or additional mitigation measures such as ventilation.

"LFL" is the lower end of the concentration range of a flammable gas, normally expressed in percentage by volume present in the air, which can ignite at a normal temperature and pressure. Below LFL, the vapor/air mixture will not ignite.

Self-contained equipment can be designed to operate properly with less than the m_1 charge of refrigerant. Since R-454C has an LFL of 0.291 kg/m^3, a closed-door case can be charged with up to 2.33 kg (5.1 lbs.) of this refrigerant. An open case with R-454C can be charged with up to 3.78 kg (8.3 lbs.). As long as self-contained equipment is below the m_1 charge, no special leak detection or mitigation is required. Equipment with a flammable refrigerant charge greater than 150 g must also pass Annex CC testing for leaks.

Allowing higher charges in remote systems

In remote or field-erected systems, UL 2-89 also allows some A2L refrigerants to be used in charge sizes up to 75.7 kg (166 lbs.). However, utilizing larger charges of A2L refrigerants in remote systems requires additional safety mitigation measures. It is important to note that specific charge calculations will be based on the LFL of the particular A2L refrigerant and the specific type of application.

Further approvals needed

The UL 2-89 update is only the first key step in a larger series of regulatory approvals needed to enable the use of A2Ls in U.S. commercial refrigeration. The following regulatory and safety standard updates will also need to be passed:

- Environmental Protection Agency (EPA) Significant New Alternatives Policy (SNAP) approval of specific A2L refrigerants
- Model code updates in the upcoming code revision cycle
- State and local building code updates

Presently, Emerson and other industry experts expect the ASHRAE 15 update and EPA SNAP approvals (for at least some A2Ls) to take place in 2022. Although the next model code update is planned for 2024, select states have legislated in automatic building codes. Thus, our industry could see some A2Ls sanctioned for use as early as 2023, with more widespread use expected in 2024. In the meantime, installing an A2L-based refrigeration strategy would typically require the approval of local authorities having jurisdiction (AHJ), such as fire marshals and/or building inspectors.

In addition, the passing of the American Innovation and Manufacturing (AIM) Act in 2020 further paved the way for A2L use in the transition to lower-GWP refrigerants. It provided the EPA the authority to phase down HFCs through sector-based controls and address service requirements. And in May 2021, EPA SNAP Rule 23 approved the use of A2Ls in residential AC/HP applications. With the adoption of UL 2-89, industry stakeholders expect guidance and/or SNAP approvals to soon follow.

In California, the California Air Resources Board (CARB) implemented a 150 GWP limit for new refrigeration systems in new facilities containing more than 50 pounds of refrigerant starting in 2022. A2Ls are among the few refrigerants that can achieve this lower-GWP threshold.

Understanding flammability characteristics

In commercial refrigeration, the precedent for the use of flammable refrigerants has been set with the A3, R-290 (aka propane) — which is commonly used in self-contained refrigeration fixtures. Understanding the flammability characteristics of A2L and A3 refrigerants is important when evaluating safety considerations, relative risks, and the establishment of safety codes and standards.

Compared to R-290's higher flammability classification, A2Ls are classified as having a lower flammability rating. The difference between these classifications can be demonstrated via the following key flammability metrics:

Lower/upper flammability limits (LFLs/UFLs)

The LFL of A2Ls is roughly eight times higher than R-290. As a result, it is less likely to ignite at comparable concentrations of R-290 and allows for potentially larger charge sizes for higher-capacity applications.

Minimum ignition energy (MIE)

R-290 has a very low MIE, and as such, can be more easily ignited by lower energy sources such as static electrical discharge. By comparison, A2L MIEs are significantly higher, typically not igniting unless exposed to an open flame or strong electrical energy source — making A2Ls relatively safer to use around certain electrical components.

Burning velocity (Su) and heat of combustion (HOC)

Su and HOC are significantly lower in A2Ls than R-290, resulting in a much lower severity of ignition events.

Potential A2L applications

From stand-alone systems and remote condensing units to more traditional refrigeration rack systems, A2Ls have the potential for broad applicability in commercial refrigeration systems and equipment. Component manufacturers and OEMs are developing or planning to develop A2L-qualified equipment in the following categories:

Self-contained units

Given the higher permissible charge limits of A2Ls in self-contained applications, OEMs will be able to create units with larger capacity than smaller-charge, R-290 systems. This will enable the use of higher-horsepower compressors than is currently possible in current R-290 applications — which will enable OEMs to support larger refrigeration loads with one compressor, rather than having to use multiple R-290 compressors for an equivalent load.

For end users, owners/operators and design consultants, these higher-capacity, self-contained systems add much needed flexibility and expanded options to their stand-alone refrigeration portfolios.

Remote condensing units

A2Ls will enable OEMs of remote condensing units to offer lower-GWP, scalable and higher-capacity distributed refrigeration solutions to their food retailers and foodservice customers. This includes the development of OCUs that support one-condensing-unit-per-fixture scenarios, as well as emerging multiplex refrigeration capabilities, where one condensing unit provides the refrigeration load to multiple fixtures.

Distributed scroll racks/packs

OEMs of distributed scroll racks/packs should also start planning their eventual transition to A2Ls. Today, many OEMs already offer lower-GWP HFC options — such as R-448A and R-449A with GWPs of 1,387 and 1,397, respectively — but A2Ls will give them the ability to offer their customers distributed solutions that address concerns about both long-term scalability and regulatory compliance.

Essentially, scroll racks/packs are scaled down, distributed versions of conventional rack systems that offer more refrigeration flexibility and a lower-GWP retrofit to HFC systems. Not only can they be installed within proximity to specific refrigeration zones, but they can also be used to replace aging and inefficient sections of existing centralized direct expansion (DX) systems with lower-GWP, A2L technologies.

A2L versions of these systems have already been successfully trialed and deployed in Europe. This approach enables retailers to significantly lower their overall refrigerant charge and reduce their carbon footprints.

Qualifying A2L refrigerants

Emerson is committed to supporting our OEM and end user customers who are making the transition to A2L refrigerants. We are in the process of qualifying our Copeland™ scroll and

Discus™ compressor lines to use the following lower-GWP A2Ls with high HFO content:

- R-454A (238 GWP)
- R-454C (148 GWP)
- R-455A (146 GWP)

Each refrigerant offers unique thermodynamic properties and excellent performance characteristics that are similar to common A1 HFC refrigerants such as R-404A or R-448A. Note: blended refrigerants may have different degrees of glide and therefore may require additional design considerations. Because performance characteristics will vary depending on the specific applications, it's important to check with Emerson's application engineers to determine the optimal A2L refrigerant for your application.

Although select A2L-qualified compressor models are available for sale today, samples of all compressors being qualified for A2Ls (and their performance data) are available now to help our OEM customers begin their equipment design cycles.

Emerson's E3 supervisory control platform and connected devices provide built-in A2L refrigeration system optimization logic to manage performance and execute required actions in the event of a leak — such as shutting off the compressor and other components or activating shut-off/isolation valves.

To support the next generation of refrigeration technologies, Emerson recently completed the construction of a 100,000 sq. ft. research and development facility with extensive refrigerant testing capabilities, including A2Ls:

- 62 performance stands
- 300 test stands
- 110 on-staff engineers and technicians
- Dedicated assembly lab
- 1,900 sq. ft. doubled power electronics lab

Today, our engineers are actively working with our OEM partners to develop the next generation of A2L equipment.

Flammability mitigation and safety best practices

The potential for flammability will make the use of leak sensors and detection equipment a mandatory requirement in remote A2L systems with charge > m_1. These systems should be designed to detect and isolate A2L refrigerant leaks via a combination of tools and controls:

- Sensors within cases to detect leaks
- Isolation and/or safety shut-off valves in the refrigeration system to limit releasable charge
- Electronic controls with A2L logic to perform required actions in the event of a leak — such as shutting off the compressor and/or other components
- Refrigeration and/or facility management system controls
- Case controls
- Ventilation and/or circulation fans within cases or walk-in units

Servicing A2L systems will leverage many of the best practices in place for installing or repairing HFC systems. However, technicians will need to use A2L-rated equipment, such as gauges, cylinders and recovery machines. Purging, evacuation and leak/pressure tests will be required processes during A2L installation and repairs.

Meet the market need for A2L equipment

As the refrigerant transition accelerates in the next few years, lower-GWP A2L refrigerants will become increasingly viable alternatives to high-GWP HFCs. Today, food retailers and foodservice operators are evaluating all refrigerant options that will help them to meet their operational goals and regulatory targets. Moving forward, the EPA and CARB will continue to require the use of lower-GWP refrigerants, and emerging A2L alternatives will play an expanding role.

Although A2L refrigerants still face some regulatory hurdles before they can be widely adopted in the United States, they have proved to be operationally safe and effective in Europe and other regions. Continued advances in refrigeration technologies will only improve upon these early installations.

With A2L regulatory approval expected within the next few years, commercial refrigeration OEMs need to start planning their equipment design cycles today. At Emerson, we are already launching A2L-qualified compression technologies and components that can help OEMs and retailers to make the transition to A2L refrigerants in the United States. Contact us to begin preparing for your future with A2L refrigerants.

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Information presented herein may not represent the latest regulatory standards and/or updates.