

Exploring the business case for automatic leak detection in response to new EPA AIM Act requirements

Refrigerant transition and market forces drive need for minimizing refrigerant loss in legacy and emerging systems.



Intro/Abstract

The transition from legacy hydrofluorocarbon (HFC) refrigerants to emerging lower-global warming potential (GWP) substitutes is reshaping the commercial refrigeration landscape. Over the next several years, supermarket retailers will find themselves at various phases of an industry-wide technological transition — from prolonging their existing investments to migrating to new refrigeration systems and architectures.

Many have recently transitioned to the relatively newer generation of lower-GWP HFCs — such as R-448 — as an intermediate step prior to investing in next-gen technologies. Others are investing in their futures today by deploying “future-proof” CO₂ (R-744) refrigeration, which already complies with refrigerant regulations and has a proven global track record of success.

As state, national and global regulations enforce an aggressive HFC phasedown schedule, HFC prices are expected to rise significantly over the next several years. Meanwhile, the Environmental Protection Agency (EPA), under the authority of the American Innovation and Manufacturing Act (AIM Act), has introduced refrigerant management guidelines that include much more stringent requirements for HFC leak rates, recovery, reclaim and reuse.

To offset rising HFC costs, comply with refrigerant regulations, and ensure maximum performance in both HFC and R-744 systems, operators will need to employ robust leak detection technologies. This white paper will demonstrate how active (i.e., direct) and passive (i.e., indirect) automatic leak detection (ALD) strategies can help retailers to achieve those goals.

Evaluating the impacts of refrigerant leaks

Environmental concerns

According to the EPA's GreenChill estimates, the average HFC supermarket refrigeration system has an annual leak rate of 25 percent — leaking up to 1,000 pounds of a typical 4,000-pound refrigerant [charge](#). HFCs are potent greenhouse gases (GHGs) with significantly worse environmental impacts than carbon [dioxide](#).

The Environmental Investigation Agency (EIA) estimates that a single supermarket emits 875 pounds of HFCs annually: the equivalent annual carbon dioxide emissions of driving more than 300 cars. With 38,000 supermarkets in the United States, these leaking emissions are equivalent to 49 billion pounds of coal consumption.

Having recognized the impact of refrigerant leaks, many retailers have incorporated leak reduction targets as part of their public sustainability pledges — even leveraging these commitments for competitive differentiation. Under the EPA's recommended framework to evaluate all sources of GHG emissions using science-based targets, refrigerant leakage impacts both Scope 1 (i.e., direct emissions from refrigerant leaks) and Scope 2 (i.e., indirect emissions from refrigeration system energy consumption).

Realizing that all refrigeration systems will inevitably leak to some degree, selecting a lower-GWP refrigerant is a key step in lowering Scope 1 emissions. With a GWP of 1, R-744 is becoming a preferred next-gen refrigerant for owners/operators of large, centralized CO₂ booster systems. R-744 provides retailers with a sustainable, A1 (i.e., non-flammable) alternative that complies with refrigerant regulations and offers reliable performance. Its unique thermodynamic characteristics (i.e., high pressures) require precise leak detection to minimize leaks and maintain maximum system performance.

Bottom-line considerations

Gone unchecked, refrigerant losses can have significant impacts on a supermarket operator's bottom-line profits. As systems leak their refrigerant charge, they can experience proportionate decreases in cooling performance and energy efficiency. Consequently, the inability to maintain setpoints can lead to perishable product loss and an acceleration in the degradation of quality.

The costs to replace refrigerant losses can have tremendous financial impacts over the course of a system's lifespan. And as HFC refrigerant supplies continue to decline — and prices rise — over the next several years with the global HFC phasedown, early detection and minimization of these leaks will be more important than ever.

Regulatory forces/market drivers

Global HFC phasedown

Under the authority of the AIM Act, the EPA has aligned its HFC phasedown with the schedule outlined in the Kigali Amendment to the Montreal Protocol. As of 2024, the consumption and production of HFCs were reduced to 40 percent from its 2011–2013 baseline.

The reduction in HFC supplies immediately impacted market prices, with some stakeholders reporting a 5X increase in prices relative to [2023](#). The next steps in these HFC phasedowns are on the horizon, with a 70 percent reduction set for 2029.

Refrigerant management requirements drive automatic leak detection (ALD) adoption.

The EPA recently passed a new HFC Refrigerant Management rule (2024), which outlines a set of requirements for proper refrigerant management and the implementation of ALD systems. First, operators would be faced with a requirement to repair existing systems leaking more than 20 percent.

Next, ALD systems would be required on new and existing equipment installations containing more than 1,500 pounds of refrigerant. Per the AIM Act's technical support documentation, subsection H, automatic leak detection (ALD) is defined as "refrigerant leak detection technologies that are calibrated to continuously monitor a refrigerant-based system for evidence of leaks and alert an operator of a leak [detection](#)." ALD technologies utilize two primary methods of detection:

- 1. (Active) Direct system** — Directly detects the concentration levels of refrigerant in the air
- 2. (Passive) Indirect system** — Models system behavior and interprets measurements (i.e., liquid levels, temperature or pressure) which indicate the presence of leaks in a refrigeration system

Note: Currently, the EPA is not prescribing which type of system to use; operators may use either or both.

The EPA's HFC Refrigerant Management rule requires the selected ALD to be calibrated accordingly per an operator's chosen ALD method:

Direct system calibration requirements

- Accurately detect a vapor concentration level of 10 parts-per-million (ppm) of the specified refrigerant
- Alert an operator when a vapor concentration of 100 ppm of the specified refrigerant is detected

Indirect system calibration requirements

- Trigger an alarm to alert an operator when the system indicates leaks of 50 pounds of refrigerant or 10 percent of total refrigerant charge

The HFC Refrigerant Management rule also introduces reporting and/or recordkeeping requirements for operators, including quarterly leak audits. In lieu of quarterly audits, ALD systems can be used to automatically capture data to meet the new standard, eliminating the costs of performing these audits while alleviating the challenges of manual reporting and/or recordkeeping.

State-level refrigerant management proposals

Some individual states have already adopted or proposed similar measures to the EPA's refrigerant management proposal. The California Air Resources Board (CARB) currently requires ALD systems to be used in installations containing more than 2,000 pounds of refrigerant above 150 GWP. It uses the same direct and indirect ALD calibration metrics as the EPA's HFC management proposal and includes similar reporting requirements.

Other state-led proposals for leak detection include:

- Washington — proposed for January 2025
- New York — proposed for June 2025

Although the use of ALD technology is a common recommendation for all state-specific rules, it's important for operators to familiarize themselves with their state's individual requirements.

Additional EPA rulings reshape the refrigerant landscape

To reduce the demand for HFCs, the EPA's Technology Transitions rule establishes GWP limits across the spectrum of new commercial refrigeration equipment — which will take effect over the next several years. The EPA has continued to approve refrigerant substitutes under its Significant New Alternatives Policy (SNAP) program to help meet these emerging GWP limits, including flammable A2L and A3 refrigerants under SNAP Rule 26.

Since the A1 CO₂ (R-744) was one of the first alternative refrigerants approved under the SNAP program, it has more than a decade of successful deployment in large centralized systems used in food retail environments.

As food retailers evaluate the refrigerant landscape and work toward sustainability targets, they face important and imminent equipment decisions.

1. Prolonging the life of their existing equipment investments (i.e., HFC systems)

and/or

2. Transitioning to an established alternative (i.e., R-744)

Implementing and maintaining a robust refrigerant leak detection program is an effective way to support both strategies.

Leak detection technology overview

Today, food retailers have a variety of refrigerant leak detection options and technologies to monitor various refrigerant sources and build an integrated leak detection program. Throughout a refrigeration system, the compressor rack is the most common source for leaks (39 percent). In addition, display cases account for 21 percent of leaks; 12 percent can be attributed to walk-in coolers and freezers (WICFs).

The following leak detection strategies provide varying degrees of detection sensitivity and can be applied separately in specific locations or deployed across multiple zones and controlled from a central location.

Individual zone leak detection

Discrete leak detection devices are installed in specific areas of a facility, such as WICFs or rack rooms. These devices are diffusion-based instruments that leverage infrared or semiconductor technologies, typically mounted on a wall in proximity to a potential leak source. Zone leak detection can typically detect the presence of refrigerant gas in higher concentrations — from 75 to 10,000 ppm.

Indirect (passive) leak detection

Indirect leak detection methods such as “Copeland’s Slow Loss Leak Detection” are typically installed at the refrigeration rack level. This solution leverages temperature, pressure and float sensors (which already exist on most rack systems) to infer the presence of

leaks by continuously monitoring temperature, pressure and liquid levels. The use of sensors often minimizes the need for dedicated leak detection instruments.

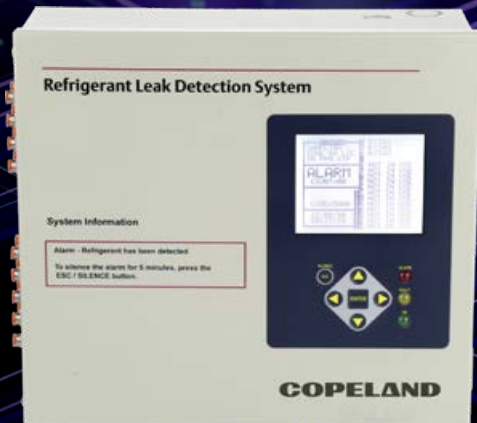
Data is then processed with machine-learning (ML) algorithms via a supervisory or rack control system, such as the Copeland E3 supervisory control platform. ML algorithms identify deviations or trends in the data to detect the presence of leaks. This ALD strategy can help operators to meet the 50 pounds or 10 percent of the refrigerant charge leak detection requirement.



Multi-zone (active) leak detection

Multi-zone strategies such as the Copeland Refrigerant Leak Detection System (RLDS) leverage aspirated technology with infrared sensors to support leak detection from four to 16 zones. This centralized system can be mounted in a rack and/or machine room with tubing piped throughout a facility to each individual zone.

Infrared sensor heads can be mounted closer to sources of leaks or near the floor level to provide the earliest detection of leaks. This multi-zone approach offers high sensitivity with the ability to detect the presence of refrigerant gas in minute and high concentrations from 1 to 10,000 ppm.



Evaluating the ROI of ALD in the face of rising HFC costs

For food retailers seeking to identify refrigerant leaks quickly, comply with regulations, and keep refrigerant losses to a minimum, direct and indirect ALD systems provide precise and effective leak detection strategies. Limiting refrigerant leaks keeps systems operating in their commissioned states, which ensures maximum energy efficiency and helps to maintain temperature precision.

Of course, refrigerant replacement and system maintenance costs are also key financial considerations, especially for operators of HFC systems that will face rising refrigerant prices over the next several years.

Consider a typical supermarket scenario in which a system is charged with 2,500 pounds of the HFC R-407A. Even with a modest leak rate of 15 percent, the escalating costs of HFCs will have significant economic impacts. As refrigerant prices increase exponentially — starting at a baseline of \$30 per pound — a retailer's refrigerant spend alone could skyrocket (see Figure 1).

	Baseline	Year 1	Year 2	Year 3
lbs/store (R-407A)	2,500	2,500	2,500	2,500
Refrigerant cost/lb	\$30.00	\$45.00	\$90.00	\$135.00
Price increase	–	50%	100%	50%
Leak rate	15%	15%	15%	15%
Total spend	\$11,250	\$16,875	\$33,750	\$50,625

Figure 1: Projected cost increases of HFC refrigerants over the next few years, considering a moderate leak rate of 15 percent

Note: These costs don't even consider the servicing fees required to recharge systems or fix repairs that often arise from refrigerant losses — not to mention the worst-case scenario of potential food loss from a system that has been rendered ineffective from refrigerant leaks.

ROI potential for an active multi-zone ALD system

In California under CARB rules, where quarterly leak documentation is already required, a multi-zone ALD system with automatic reporting capabilities could all but eliminate the need for conducting manual checks. Even using a conservative estimate, where a full-system leak check would take technicians four hours to complete and cost approximately \$1,500, an ALD could potentially save a store \$6,000 in annual reporting requirements. Factoring in the prevention of bulk refrigerant losses and associated replacement costs, operators have an even greater potential for ROI.

By investing in multi-zone leak detection technologies, supermarket owner/operators could avoid these losses altogether.

ROI potential for a passive ALD system

In a passive ALD scenario, early detection of minute refrigerant leaks provides advance warning of larger leaks, which offers multiple potential benefits that can impact an operator's bottom line.

- Preventing the expenses and performance impacts of refrigerant loss (i.e., refrigerant replacement costs and inaccurate setpoints)
- Eliminating the need for and costs of quarterly/monthly inspections

Again using CARB's quarterly documentation requirements and associated servicing costs as examples, employing a passive solution can provide a substantial ROI opportunity — while avoiding the potential for a bulk refrigerant loss scenario. Considering Copeland's monthly rate for a slow leak detection solution, a passive approach represents the potential for significant savings within each store location.

Conclusion: Explore the Copeland ALD solutions

Copeland provides robust ALD solutions using both active and passive technologies. The RLDS Multi-Zone Leak Detector is an active, aspirated ALD solution that provides leak detection from four to 16 zones, leveraging infrared sensor technology which issues audible alarms and/or the option to communicate through Modbus or BACnet to a central building management system (BMS), such as the Copeland E3 supervisory control.

Equipped with these communication capabilities, the RLDS Multi-Zone Leak Detector ensures that service personnel will be notified when a leak is occurring. It also helps retailers to maintain the documentation needed to track leak detection program metrics and support regulatory compliance.

For an advanced passive ALD solution, Copeland offers a proprietary slow leak detection algorithm solution within the Connect + enterprise management software's condition-based maintenance offering. Seamlessly integrating with Copeland's E3, the solution features proprietary ML algorithms which provide early detection at very low leak rate levels.

Both Copeland's active and passive ALD solutions meet the regulatory leak threshold requirements among the EPA's HFC Refrigerant Management rule, CARB and other state-specific rules.

Whether you seek to prolong the lifespan of your existing HFC system or deploy a CO₂ booster system, the RLDS can help preserve your system investment, lower refrigerant costs, and comply with refrigerant management regulations.

To learn more about the active RLDS Multi-Zone Leak Detector — or explore Copeland's full range of passive leak detection devices and indirect leak detection technologies — please visit our [leak detection resource center](#).

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