Leak Detection Technologies for A2L Refrigerants in HVACR Equipment

Summary of AHRTI Final Report Findings

Introduction

Emerging global standards are requiring the implementation of low-global-warming (LGW) refrigerants, many of which are flammable.[1] As such, new standards will also require the use of sensors for detecting refrigerant leaks in order to prevent flammable conditions or explosions.

In 2017 the Air-Conditioning, Heating and Refrigeration Technology Institute, Inc. (AHRTI) published a report entitled *Leak Detection of A2L Refrigerants in HVACR Equipment* (Report No. 9009). It assessed what were, at the time, technologies potentially capable of detection of LGW refrigerants for this application:

1. Infrared (IR), including Non-dispersive infrared (NDIR) and photo-acoustic infrared (PIR)
2. Electrochemical Cell (EC)
3. Metal Oxide Semiconductor (MOS)
4. Catalytic (Pellistor)
5. Heated diode sensors

Molecular Property Spectrometer (MPS)-based sensor technology—released in 2019—was not available at the time, and was not included in the study.

The AHRTI study sought to make an assessment about the overall suitabiliy of available sensor technologies for detection of LGW refrigerants, and made comparisons amongst the alternatives using common criteria. Of course, the study could make no conclusion regarding a given technology's performance versus performance standards that are, as of July 2019, still being defined (e.g. ASHRAE 15 Addendum d, ASHRAE 15.2p, and UL 60335-2-40). The study called attention to this fact, stating that, "it is expected that manufacturers will focus research and development efforts to ensure that appropriate sensors are available to meet the updated standards, although the timeline for development is still uncertain."

Summary of the AHRTI Study Findings

The study concluded that two of the sensor types under consideration—Electrochemical Cell (EC) and Catalytic (Pellistor)—are not suited for this application:

- Regarding EC sensors, the study concluded: "Ultimately, given that this technology cannot currently detect fluorinated compounds (nor is it practical to adapt EC cell sensors to detect fluorinated refrigerants), the short sensor lifetimes, and the intensive recalibration requirements, this technology is not likely to be appropriate for use in HVACR systems containing A2L refrigerants."
- Regarding Catalytic sensors, the study concluded: "Ultimately, given that this technology is susceptible to poisoning from the combustion products of fluorinated compounds, the short sensor lifetimes, and the frequent recalibration requirements, this technology is not considered to be appropriate for use in HVACR systems containing A2L refrigerants."

The study's findings of the remaining viable sensor technology options—IR, MOS and heated diode—are compiled in Table 1, alongside the MPS-based sensor technology characteristics for comparison. Regarding IR and MOS, the study concluded: "Sensor models using IR and MOS technology currently exist that detect A2L refrigerants; however, most sensors that are currently available or are coming available this year [2017] cannot measure A2L refrigerants up to the specified detection ranges and have additional concerns for adaptation, particularly in residential settings, including relatively short lifetimes, maintenance requirements, and costs."

[1] As stated in the report: "Several of these proposed refrigerants fall into the ASHRAE safety category created in ASHRAE Standard 34-2010: Designation and Safety Classification of Refrigerants, A2L, which are a sub-class of A2 (i.e., lower flammability) refrigerants."

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	NDIR	MOS	Heated Diode	MPS
Features				
Size	1 to 20 lbs	1x1x1 in	n/a (handheld system)	20 x 16 mm
Power Requirements	13-30 VDC, 4-5 Watts	12-24 VDC, 1-5 W	Battery-operated (alkaline, Li, NiMH, AC Adapter)	9.0 mA @ 3.3 VDC
Refrigerants Detected	All types (HFC, HFO, HC, CFC, HCFC	CFC, HFC, HCFC, HFO	HFC, HFO, and blends	HFC's, HFO's, Alkanes (R290) and blends
Calibration	PIR: Required every 6 months (and when a change in gas measurement is required). NDIR: Calibration is not required. Re-zeroing is required every 0.5°C temperature change or every year	Recommended every 6 months	Automatic or manual zeroing	5+ years
Detection system response	Produces either a 4-20 mA or HART signal; connects to alarm system	connection to alarm system	Alarm (audio/visual)	Configurable digital response or analog output
Limitations				
Measurement Range	0-10,000 ppm	20-10,000 ppm	6.6 oz/yr to <0.1 oz/yr, High/low sensitivity range	0-100 %LEL reporting
Response Time	Single-zone: 5-30 seconds Multi-zone: 5-300 seconds	15-90 seconds to T90	0.5-1 seconds (30 second warm-up time, ~9 second recovery time)	<20 seconds T90
Operating Temperature	-40 to 75°C	-34 to 70°C	-20 to 50 °C	-40 to 75 C, compensated
Humidity Range	0-100 (some sensors require non-condensing environment)	0-95 %	Unknown, but can be affected by moisture	0 to 99 %, compensated
Vibration	depends on application (sensor can be placed inside a strong structure that protects it from harm)	Depends on application. Operating principles of the technology shouldn't be affected by normal workplace vibrations	n/a	Frequency range/displacement: 10Hz – 30Hz/2mm peak to peak Frequency range/acceleration: 30.8Hz-150Hz/2g Sweep rate: 1 octave/minute Number of sweeps: 1hr/axis Axis of vibration: X, Y, and Z 50G, 11ms, Half Sine Axis of Shock: X, Y, and Z
False triggering chemicals	none	Gasoline, diesel, and propane exhaust; Fumes from solvents, paints, and cleansers	moisture, oils, other flourinated refrigerants (sensor cannot selectively detect refrigerants)	%LEL levels of certain hydrocarbons like Propane, Pentane, Hexane, etc. (1-3 %vol)
Interferring chemicals	Acetylene; overexposure of refrigerant gas	Ethanol, silicones, highly corrosive gases, alkaline metals, overexposure to refrigerant, heavy condensation	moisture, oils, overexposure to refrigerant gas	none
Reliability				
Lifetime	Handheld: 5 years; Stationary: 10-15 years; sampling pumps have limited electrical motor life expectancy	3-5 years; Sensor lifetime decreases with continued exposure to poisioning/false-triggering gases	2-3 years, up to 5 years	5+ years
Repairable	replace air filters every year to prevent particles from entering the cell and contaminating sensor	Sensing element can be replaced if damaged by poisoning or once lifetime is exceeded	sensing element and filters can be replaced	Plug-and-play replacement
Self testing abilities and/or indication of malfunction	certain devices incorporate active diagnostics that continuously monitor the system for proper operation	none observed	N/A	Yes, sensor performs built-in self testing diagnostics.

Table 1 – Compilation of AHRTI performance findings. Information in the NDIR, MOS and Heated Diode columns are quoted directly from AHRTI report. Information in the MPS column is provided for comparison purposes.

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Background -- MPS™ LGW Refrigerant Gas Sensors

The MPS™ represents the first completely innovative technology for flammable gas detection (including flammable LGW refrigerants) in over 40 years, and was designed to overcome the shortcomings of existing technologies.

The MPS uses a micro-electromechanical system (MEMS) transducer, comprising an inert, micrometer-scale membrane with an embedded heater and thermometer. This transducer measures changes in the thermal properties of the air and gases in its proximity. Multiple measurements, akin to a thermal "spectrum," as well as environmental data are processed to classify the type and concentration of flammable refrigerant present.

Additional information about this product can be found at:
https://www.nevadanano.com/mps-lgw-refrigerant-gas-sensor/