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Whitepaper | A2L HVACR

Thermal conductivity: **the best technology for the A2L HVACR market**

As the industry transitions to low-GWP refrigerants, HVACR professionals need to make a myriad of decisions: Which low-GWP refrigerants are best suited for my system? Which sensor technologies will be the most effective in the long-term? Which suppliers can I count on to provide sustainable sensor designs that are right for my system and refrigerant options?

The answers to these questions go beyond ensuring customer satisfaction and business profitability. It's also a matter of safety. Take A2L refrigerants as an example. As they become more prevalent, HVACR professionals will need to sift through the increasing number of refrigerant leak detection sensor options and decide which sensor technology will be the safest, most effective for their customers.

Danfoss Sensing Solutions has worked with sensing technology since 1969. As a company, Danfoss is committed to guiding its customers through the refrigerant transition and finding solutions that prioritize safety, energy efficiency and affordability. Danfoss' team of refrigerant and sensing technology experts have worked together to identify which sensing technology is most suitable for detecting A2L gas leaks. The results show that **thermal conductivity** is the best option. This white paper covers the results of that research and answers two key questions:

1. **why thermal conductivity is the best technology for quickly and accurately detecting A2L gas leaks**

and

2. **how product design impacts a thermal conductivity sensor's effectiveness and durability.**

How **thermal conductivity sensors** work

Thermal conductivity is a property that describes a material's ability to transfer or conduct heat or energy. A thermal conductivity (TC) sensor is a refrigerant gas sensor that measures the concentration of a specific gas in the air. It uses the gas' thermal transfer properties as a tool to measure its presence. TC sensors can measure this accurately by comparing how much the TC level changes from that of clean air.

1

The TC sensor uses the thermal transfer properties of gases as a measurement tool for the presence of gas. The thermal conductivity of gases is inversely proportional to molecular weight. Therefore, thermal conductivity decreases with increasing molecular weight.

2

For example, typical molecular weight of **clean air** is **28.96 g/mol**. It has a higher thermal conductivity than a refrigerant such as **R454B** that has a molecular weight of **62.61 g/mol**.

3

Using the thermal conductivity reading of air as the reference, when exposed to R454B, the thermal conductivity goes down (thermal resistance goes up).

4

By controlling the current to the heating element, the thermal response of the temperature sensor will depend on the thermal conductivity of the gas present in the gap between the heating element and the temperature sensor.

Fact box: Bringing the right **gas sensor technology** to market

Since the start of the refrigerant transition, our multidisciplinary team of experts has worked together with our customers to explore and test various gas sensing technologies.

We wanted to combine our 55+ years of experience in developing HVACR applications, with the latest research in this area, so we could base our solution on the technology and product design that would deliver the best results for our customers' systems. Our TC sensor is the result of this collaboration, and it also marks the first step in our gas sensing journey. The next step in the journey will take us to Monterrey, Mexico, where we're establishing a manufacturing footprint at our Danfoss campus. This location places us in proximity to our customers and will make it easier for us to partner with them to develop new gas sensing technologies. Our local presence will also improve speed-to-market and lead times and reduce transport emissions, so we can effectively meet the market's increasing demand for sensor technology and support our customers' growth.

explains **Mark R. Otten**, Segment Manager for Cooling & Heating, at Danfoss Sensing Solutions.

Why thermal conductivity technology **enables accurate A2L leak detection**

Thermal conductivity technology allows you to accurately calibrate the sensor under a wide range of operating conditions – making it the best choice for harsh environments. The Danfoss team has tested TC sensors in high humidity environments and under varying temperatures, and they showed little or no signs of damage.

The TC sensor also provides a series of self-test diagnostics to monitor the sensor's health and to warn if it's outside the operation range. The sensor's Automated Self Calibration (ASC) adjusts the measurement over time to remove minor drifts and delivers ~0% Lower Flammability Limit (LFL) level in clean air signal. To detect drifts greater than the ASC can correct, the TC sensor includes a built-in limit supervision self-test diagnostic that continuously monitors the measurements. Since the sensor self-calibrates, the error margin is smaller than if it needed to be calibrated by a third party.

This combination of robustness and accurate calibration make the TC sensor an effective technology for detecting A2L gas leaks. And by making key decisions in the sensor design, you can further increase the TC sensor's accuracy, as the next section will explain.

How an inverted sensor design **improves leak detection accuracy**

As highlighted in the previous section, TC sensors need to operate in harsh environments. Thus, the sensing element needs to be placed within the sensor in a way that protects it from sustained UV exposure and elements such as dust, oil and water spray. The Danfoss team discovered that by using a patented, inverted design – where the membrane is mounted on the back side and away from the top surface – you can protect the sensor from exposure to outside elements and ensure a 15-year lifetime.

Using a circular TC sensor with an inverted design offers additional benefits:

- The circular design is more aerodynamic. This enables gas to reach the membrane more quickly and provides a more accurate reading and faster reaction time.
- The circular design also retains heat more effectively, which prevents condensation on the housing. This, in turn, avoids false alarms.

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Building **the most accurate, reliable TC sensor** on the market

With the design in place, the Danfoss Sensing Solutions team conducted further research and testing to eliminate any delay in LFL measurements and minimize the discrepancy between each sensor tested. The goal was to develop a TC sensor that is highly reliable. The test data shows that the LFL% gap in the Danfoss Sensing Solutions TC sensor is greater than 2.5% – the highest sensitivity currently on the market. In the concentration range of 11% LFL or less than 25% LFL, Danfoss Sensing Solutions TC sensors provided better accuracy and the fastest response time on the market.

In summary:

- Thermal conductivity technology provides an accurate way of detecting A2L gas leakage.
- Danfoss Sensing Solutions TC sensors are equipped with self-diagnostic and automatic calibration capabilities that ensure a reliable detection.
- Danfoss Sensing Solutions TC sensor features a patented, inverted circular design that improves product lifetime under harsh conditions.

As the gas sensing market expands, we will be there, bringing innovative design and 50 years of sensing technology experience to develop innovative, reliable sensors that support the refrigerant transition. Get in touch with your local Danfoss representative to learn more about our sensing technology.