

# Photoacoustic technology: the key to accurate A3 gas leak detection



# Introduction

A3 refrigerants play a crucial role in the HVAC and refrigeration industry's efforts to comply with the European Union's F-gas regulations. As these refrigerants become more widespread in installations across the continent, the industry must find ways of addressing potential safety issues related to A3 refrigerants' high flammability.

Regulations require solutions such as integrating gas sensors into A3 refrigerant installations to quickly detect gas leaks and initiate system shutdowns as a safety measure. Clearly, the more accurate the gas sensor, the safer the installation. And with numerous gas sensing technologies entering the market, which technology is best suited for fast, accurate propane leak detection?

At Danfoss, we've worked at the forefront of sensing technology innovation since 1969. We work with our customers to guide them through the refrigerant transition, helping them to find and implement safe, affordable and energy-efficient solutions for their refrigerant systems. That includes identifying the most effective sensing technologies for detecting gas leaks.

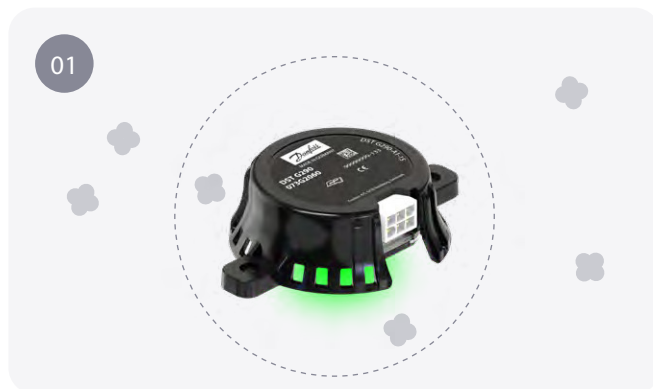
After extensive research and testing, our Sensing Solutions team discovered that **photoacoustic technology** is uniquely effective in quickly detecting the presence of A3 gasses like propane (R290). In this whitepaper, we share their findings and explain how we have leveraged this technology in the design of our latest gas sensor, the DST G290.



# How photoacoustic technology works

Photoacoustic (PA) technology operates based on the principle that gas molecules absorb infrared (IR) light at specific wavelengths unique to their molecular structure. PA technology leverages the unique absorption characteristics of a particular gas to detect its presence. This characteristic makes PA sensors exceptionally selective, allowing precise detection of the target gas, for example, propane.

↓ Figure 1: How a PA sensor works



A PA sensor consists of compact housing equipped with an infrared light source and a highly sensitive microphone. The design ensures that the target gas can enter the chamber, while external factors are effectively excluded.



An optical IR filter plays a critical role in the system's performance. This filter narrows the emitted IR light to a specific wavelength band that corresponds to the absorption band of the target gas. For example, when detecting propane, the filter ensures that only light at wavelengths absorbed by propane molecules is emitted.



Upon exposure to this light, propane molecules absorb the energy, causing their bonds to vibrate or stretch. This vibration results in a localized increase in temperature within the sensor's housing. Due to the confined space, this temperature rise leads to a corresponding increase in pressure.



These pressure variations are detected by the sensitive microphone, which converts them into electrical signals. The resulting photoacoustic signal is directly proportional to the gas concentration, allowing for precise quantification of the target gas.



# The **benefits** of photoacoustic technology

PA technology integrates molecular absorption physics, thermal dynamics and acoustic signal processing to achieve high accuracy, sensitivity and selectivity in gas detection applications. The Danfoss Sensing Solutions team found this technology to be reliable, allowing for continuous surveillance of gas levels in the application. PA technology is also robust, making it ideal for harsh environments with extreme temperatures and conditions.

## **Pairing** PA technology with Danfoss' unique sensor design

Based on these findings, the Danfoss team chose to leverage PA technology when developing the new DST G290 sensor for propane. The DST G290 features Danfoss' patented inverted design which protects the sensor core against common environmental contaminants such as water, oil sprays, dirt, dust, and UV radiation. This innovative design is critical for maintaining the sensor's longevity and accuracy in harsh conditions. Furthermore, the sensor core is encapsulated within a semi-permeable membrane, which allows targeted gasses to pass through while blocking harmful substances. This membrane is instrumental in ensuring the sensor's continuous and error-free operation for up to 15 years, significantly reducing the need for maintenance or replacements.

When installed, the design optimally positions the sensor for effective protection without compromising its functionality. The specially designed sensor housing facilitates the diffusion of target gases, ensuring that the sensor can continuously monitor environmental conditions with-

out interruptions. The design also incorporates acoustic decoupling, which mitigates the impact of rapid environmental changes, further stabilizing performance.

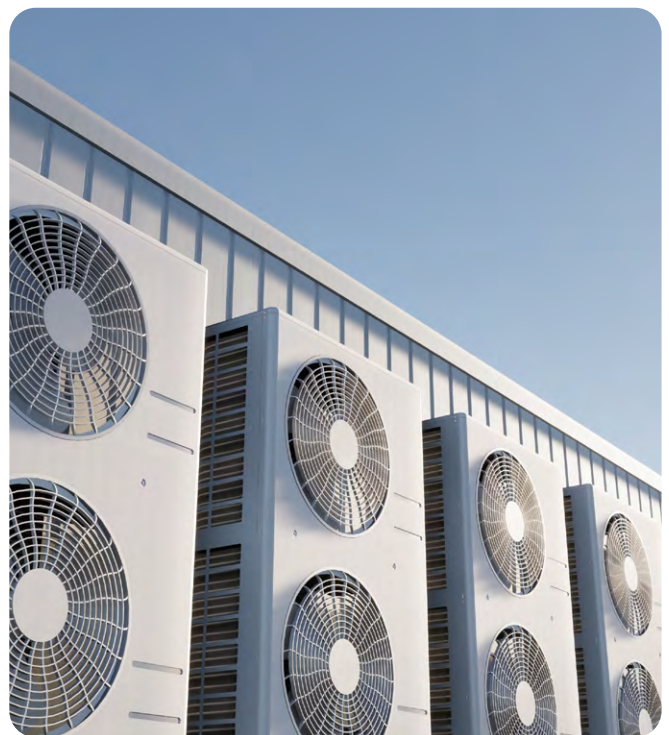


# The result: rapid, accurate propane leak detection

The combination of PA technology with Danfoss' patented sensor design proved to be a powerful one. The DST G290 gas sensor:

- Has a response time of <30 seconds and a warm-up time of 6 seconds.
- Has an accuracy of  $\pm 2.5\%$  LFL (lower flammability level).
- Operates across a broad temperature range of -40 to 80 °C and a full humidity range of 0 to 100% RH.
- Includes full signal chain diagnostics to prevent silent failures and maintain system integrity.
- Has a lifespan of over 15 years based on internal testing.
- Is CE marked, RoHS-compliant, and IEC 60335-2-40-certified by a third-party agency.

To find out more about the DST G290 and how it can benefit your application, please contact your Danfoss representative.



## Fact box: An award-winning gas sensor

The DST G290 Gas Sensor won the 2025 Innovation Product award at the China Refrigeration Expo 2025. This was Danfoss' second consecutive win, following last year's Innovation Product award for the groundbreaking DST G-series for A2L gas sensing using Thermal Conductivity technology.

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