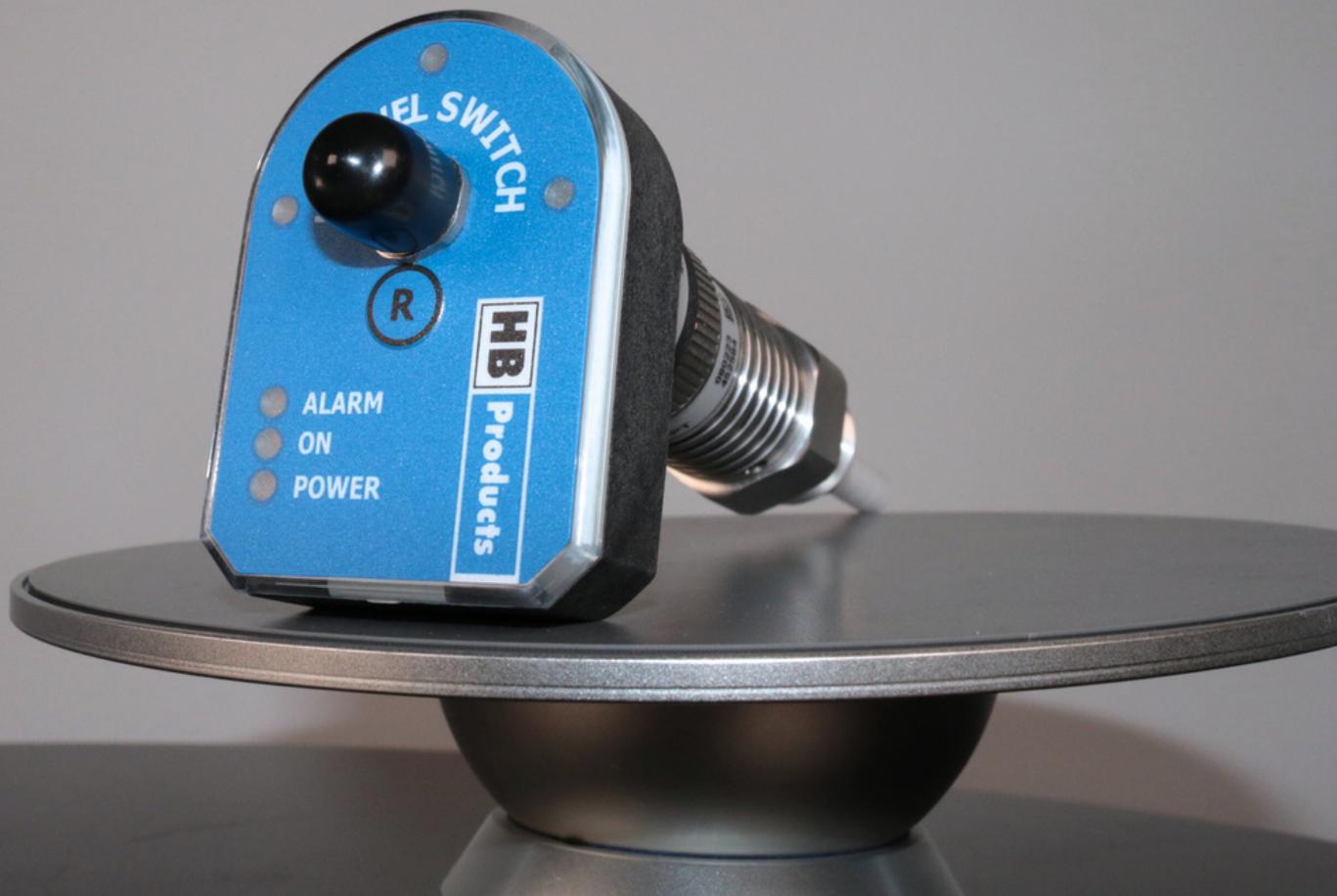


# Ammonium carbamate in CO<sub>2</sub> /NH<sub>3</sub> cascade refrigeration systems

---



The desire to use energy-efficient natural refrigerants while complying with safety requirements in food factories has led to increasing use of CO<sub>2</sub>/NH<sub>3</sub> Cascade systems. An ammonium carbamate sensor from HB Products can detect leaks of CO<sub>2</sub> into ammonia, saving costly repairs and downtime.

## Cascade systems

A cascade system is a multi-stage refrigeration cycle where the evaporator of the first step is used as the condenser of the second step. When using climate-friendly natural refrigerants, the refrigerant in the first stage is often ammonia (NH<sub>3</sub>) and the second-stage refrigerant is CO<sub>2</sub>.

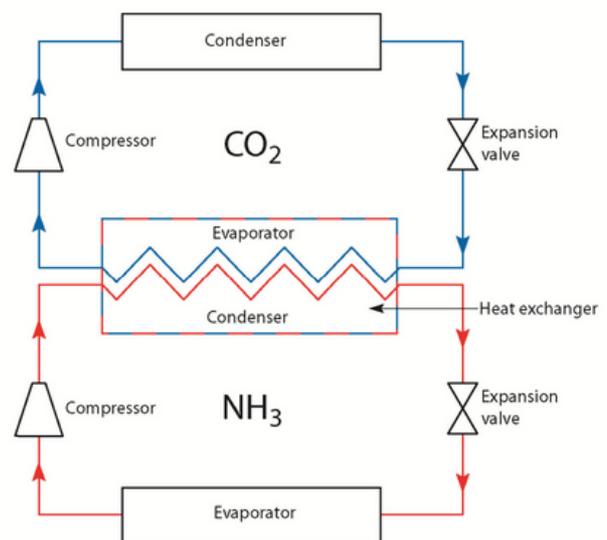
## What happens in case of a leakage?

The operating pressure in the CO<sub>2</sub> cycle is significantly higher than in the NH<sub>3</sub> cycle. Therefore, a leakage in the heat exchanger can cause CO<sub>2</sub> to enter the NH<sub>3</sub> part of the system.

If not detected very quickly, a leak of CO<sub>2</sub> into NH<sub>3</sub> will cause a chemical reaction that creates ammonium carbamate, a corrosive salts. These salts can block valves, pipes and the rest of the system when transported with the flow of refrigerant. The salts may also accumulate in the evaporator and reduce the heat-transfer efficiency.

Operators are keen to shut down systems before these salts reach the compressors, as this can damage them and result in very costly downtime.

The leaks often happen in plate heat exchangers. These can rarely be repaired, but can be replaced, so the system can be put back into operation quickly



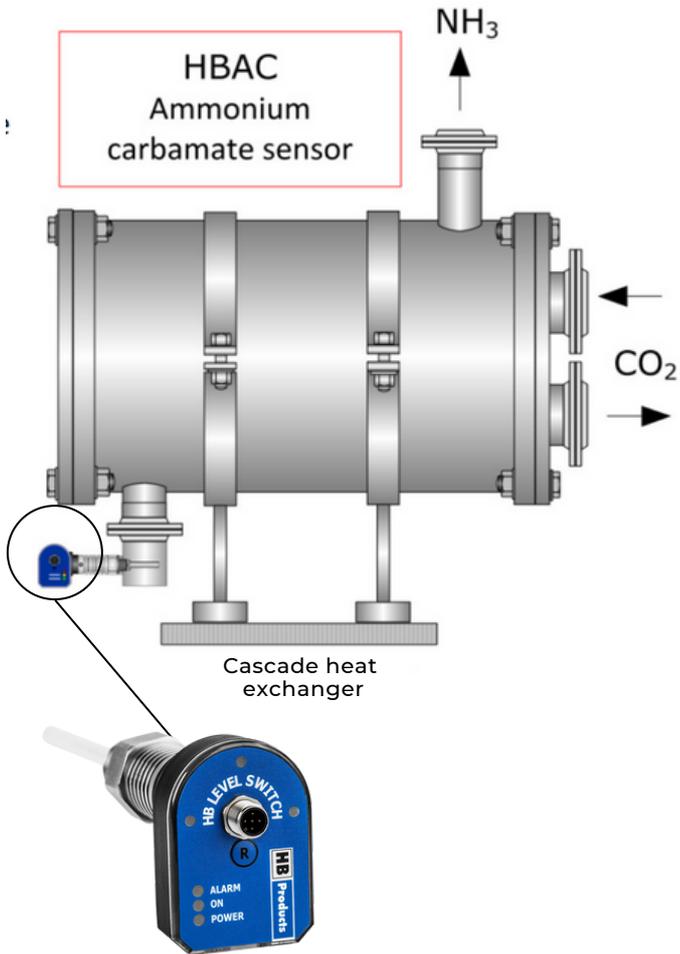
## The solution

To solve this problem, HB Products has developed a sensor that detects ammonium carbamate. It is placed in the liquid ammonia, where it detects changes in permittivity (dielectric constant), meaning how well the liquid conducts electric signals. The permittivity of ammonium carbamate is much higher than ammonia.

The sensor is very fast, detecting the rapid increase in conductivity/permittivity the moment CO<sub>2</sub> enters the NH<sub>3</sub> system.

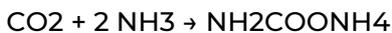
The sensor can deliver a digital alarm signal, or an emergency stop in the NH<sub>3</sub> cycle, shutting down the system before the ammonium carbamate blocking the system.

Ammonium carbamate can be removed from the system mechanically, or by using warm air, but this is very time consuming, meaning costly downtime. Installing the HB Products sensor can therefore give very early warning of potential leaks before damage occurs to the rest of the system, saving money and time.



### How is ammonium carbamate created?

The chemical reaction occurring when CO<sub>2</sub> leaks into ammonia is:



This means that one mole CO<sub>2</sub> and two mole NH<sub>3</sub> produce one mole ammonium carbamate (NH<sub>2</sub>COONH<sub>4</sub>). Converted into mass, this means that approximately 44g carbon dioxide and 34 g ammonia produce 78 g ammonium carbamate. At -10 °C and a pressure of 26.49 bar (boiling point) 44 g carbon dioxide in the gas phase takes up a volume of approximately 0.8 L. Crystalline ammonium carbamate has a density of 1.6 g/cm<sup>3</sup> which – with the mentioned 78 g – takes up nearly 50 mL. Although this calculation is a good starting point, you shouldn't assume that – in case of a leakage – only 0.8 L CO<sub>2</sub> will enter the NH<sub>3</sub> cycle.

HBAC.....

[LEARN MORE](#)

Contact us.....

[CONTACT](#)