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Keep it cool

Measuring carbon dioxide in refrigeration applications

CO_2, a widely used refrigerant in the early 20th century, was largely replaced by the chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) refrigerants in the 1940s. The damaging effect of the CFCs and HCFCs on the ozone layer became evident in the 1970s. These compounds are also effective greenhouse gases contributing to the climate change. Consequently, a gradual phasing out has been taking place in order to replace these compounds in various applications. The Montreal Protocol was opened for signatures in 1987 to phase out the ozone-depleting chemicals, including CFCs and HCFCs, resulting in nearly all countries joining the effort to protect the ozone layer. Simultaneous re-inventing of natural refrigerants has taken place. The re-birth of CO_2 refrigeration was initiated by the pioneering work of Gustav Lorentzen in the 1980s and his invention of the trans-critical CO_2 heat cycle.

Many factors promote the use of CO_2 as a refrigerant. It is inexpensive and energy-efficient. In addition, it has good heat transfer properties and is compatible with most materials. The challenges related to process design, high operating pressures and downtime safety issues can be overcome with modern technology. From an environmental point of view, CO_2 does not cause ozone depletion and has lower global warming potential than the traditional refrigerants. As a result, CO_2 refrigeration has found numerous applications in food and industrial processing, cold storages, food retail and transfer, and sports facilities. It is also emerging in car and residential air-conditioning.

Detecting leakage of colorless and odorless gas

CO_2 is a non-toxic and non-flammable gas. However, it does not support life and exposure to elevated concentrations of CO_2 can induce a risk to life. The effects of various concentrations of CO_2 on human health are summarized in Table 1. Unlike ammonia, it is impossible to detect leakage of the colorless and odorless CO_2 from the refrigeration system without proper sensors.

To ensure the safety of personnel in a CO_2 refrigerated facility, CO_2 transmitters should be installed in every human occupied space and as close to potential leakage points as possible. The number of transmitters should be based on risk assessment. Ventilation and air flow should be considered when planning transmitter installations. Carbon dioxide is twice as heavy as air and sinks and pools low to the ground, displacing oxygen in the air. Therefore, appropriate installation locations for the transmitters are at floor level.

Safety and system integrity are key issues

McAlpine Hussmann Ltd. has experience of integrating Vaisala CARBOCAP® Carbon Dioxide GMT220 Series Transmitters as leak detectors in CO_2 refrigeration applications.

McAlpine Hussmann Ltd. provides solutions for the display and refrigeration needs of supermarkets and grocery stores throughout Australasia. Their product range includes refrigerated and non-refrigerated display merchandisers, refrigeration systems, evaporative condensers, heat exchange coils, beverage coolers and walk-in coolers and freezers. They also offer installation, service and maintenance and aftermarket service through their service organization.

"Safety and system integrity are key issues," says Rob Whitehead, Application Engineer from McAlpine Hussmann Ltd. in New Zealand. "Local codes state that any refrigerated space open to public access must have local leak detection and alarms. We decided to go a step further and alarm every refrigerated room as well as the plant room. Each room has a local visual alarm set to activate at 3,000 ppm and a second set-point at 5,000 ppm programmed into the control system supplied by John McDaniels at Computer Process Controls. Having a separate programmable alarm point means we have been able to set the lower limit for the local alarm and know that the operators cannot adjust the set-points or isolate the alarm."

Vaisala sensors are accurate and durable

Rob Whitehead lists the requirements for CO_2 transmitters: "The leak detector has to be sturdy, have a remote sensor and a display. It needs to be able to talk to the control and alarm system."

The Vaisala CARBOCAP® Carbon Dioxide Transmitters GMT221 and GMT222 are especially designed for harsh and humid environments. The operating temperature range of the GMT221 transmitter is specified as -20 to +60°C. The transmitters have been tested in temperatures down to -40°C using both a constant low temperature and a rapid temperature gradient from -40°C to +70°C. The temperature dependency has been modeled down to -30°C. "The Vaisala system has allowed us the flexibility of mounting the detector units outside the refrigerated rooms at sufficient height to avoid the risk of mechanical damage," says Rob Whitehead.

The Vaisala CARBOCAP® sensors are accurate and durable. They have excellent stability in terms of time and temperature, which will reduce maintenance costs over the years. The Vaisala sensors enable reliable carbon dioxide detection for the wellbeing of people working in carbon dioxide refrigerated spaces or people enjoying an exciting ice hockey game in a carbon dioxide refrigerated ice stadium. ■

Many factors promote the use of CO_2 as a refrigerant.

Concentration	Effect
350–450 ppm	Typical atmosphere
600–800 ppm	Acceptable indoor air quality
5000 ppm	Average exposure limit over 8 hours
3–8%	Increased respiration and headache
above 10%	Nausea, vomiting, unconsciousness
above 20%	Rapid unconsciousness, death

Table 1: Effects of different concentrations of CO_2 on human health.