

**Background article by Georges Hoeterickx, board member of eurammon, the European initiative for natural refrigerants**

## **Cooling supermarkets the eco-friendly way**

To date, most refrigerated display counters and freezer cabinets in supermarkets use fluorinated greenhouse gases as their refrigerants. Leakages lead to refrigerant emissions which contribute to the greenhouse effect. Apart from this, if the refrigerant charge is too low, the plants' performance drops, and replenishing incurs additional costs. Add to that the fact that the EU F-gas regulation, which came into force in 2007, increased the cost of using FCs and HFCs in refrigeration plants. All this leads to the operators of such facilities having a very strong interest in alternative solutions. At the same time, in light of climate change, energy efficiency and reducing emissions of greenhouse gases are becoming ever more important. The increased use of natural refrigerants for supermarket refrigeration can make a significant contribution to achieving this.

### **Carbon dioxide cascade system combines low and normal temperature cooling**

In Denmark, the use of more than 10 kilograms of fluorinated gases (F-gases) in newly installed refrigeration systems has been prohibited by law since 2007. For this reason the Danish supermarket chain Super Best opted for a carbon dioxide based cascade system at its Copenhagen branch. Refrigeration specialists Knudsen Kølning designed a refrigeration system that uses two refrigeration circuits combined by a plate heat exchanger. This allows three different temperature levels to be achieved, two of which are used for cooling and one for heat rejection.

The first low temperature level is needed in frozen food cabinets and the deep freeze chambers in the cellar. At an evaporating temperature of  $-28^{\circ}\text{C}$ , the carbon dioxide is used to maintain an ambient temperature of  $-20^{\circ}\text{C}$ . The second temperature level is used for refrigerators and cold stores requiring an air temperature of a few degrees above  $0^{\circ}\text{C}$ . This is achieved by supplying the evaporators with carbon dioxide at an evaporating temperature of  $-10^{\circ}\text{C}$ . The third and highest level ensures reliable heat rejection by condensation of gas,

depending on the ambient temperature. Overall the cascade system has a refrigeration capacity of 150 kilowatts.

Güntner components are used for the various temperature levels generated by the system and the cold stores are fitted with evaporators. The heat dissipation enables an evaporator to function as a gas cooler at elevated ambient temperatures and hypercritical processing. To guarantee the operational safety of the system even at pressures of around 120 bar, Güntner used 0.7 mm thick stainless steel for the gas cooler and the entire piping network. Thanks to its low-noise design, the gas cooler can even be used in locations with very low noise requirements, e.g. residential areas. The injection to the evaporators and the cooling unit is controlled by Danfoss electrical components. There are currently eleven of these combined deep-freezing/normal refrigeration systems installed throughout Europe, as well as 100 deep freezer systems in use in supermarkets.

### **A pioneering solution using carbon dioxide and hydrocarbons**

Another company favouring natural refrigerants is Tesco, the largest supermarket chain in the UK. True to its goal of taking the lead in environmentally sustainable refrigeration solutions in the retail industry, Tesco commissioned Johnson Controls to install a refrigeration system operating on carbon dioxide and the hydrocarbon refrigerant R1270 at its 60,000 square feet store in Shrewsbury. Consequently, the store is the first supermarket in the United Kingdom using solely natural refrigerants for its cooling needs.

To achieve this, Johnson Controls divided the machine rooms into two sections, each comprising a cascade system with R1270 circulating in the refrigerant loop. Carbon dioxide serves as the coolant, which – due to its particularly excellent heat transfer performance – is used to regulate the display cabinets for both positive and negative temperatures. The hydrocarbon charge, which is located in a separate part of the machine room dedicated to the purpose, is kept to a minimum.

Each of the refrigeration plants is capable of 255 kW of cooling at medium temperature and 45 kW at low temperature. The plants are fitted with desuperheaters, using dry coolers, and a short glycol loop. Depending on the ambient temperature, this circuit condenses the compressed gas as close as possible to the condensing temperature of 20°C. The fans on

the dry coolers are driven by an inverter drive, managed by a temperature controller. This helps ensure that the plants' output is continually adapted to the current prevailing conditions, so that the required refrigeration is achieved while keeping energy consumption to a minimum. The operational safety of the entire refrigeration system is guaranteed by using a central control and monitoring system that can identify any possible leaks early on.

The refrigeration solution provided by Johnson Controls is based on proven technology which is widely used across the globe, with in excess of 100 supermarkets successfully installed and maintained. The innovative feature of this project is the fact that it uses ground water to cool the refrigerant circuit. This natural heat sink enables the system to work under stable conditions all year round, regardless of high ambient temperatures during the summer months.

### **Constant cooling even at high ambient temperatures**

Drake Foodmarkets took an ambitious step at its Foodland store in Angle Vale in South Australia. Since December 2007 in this Adelaide suburb the supermarket chain has been operating the first supermarket in the southern hemisphere that uses a transcritical carbon dioxide refrigeration system. The project was supported by the Australian government, which paid for the higher design and installation costs, compared to a conventional direct evaporation plant, as part of a program to cut greenhouse gases.

The system, which is filled with about 450 kg of carbon dioxide, uses direct evaporation of the refrigerant. At -10°C it is evaporated at the cooling points for normal refrigeration and at -35°C at the cooling points for freezing. The gaseous carbon dioxide is compressed by a total of twelve piston compressors – eight single-stage compressors for normal refrigeration and four two-stage compressors for deep freezing. In total, these units have a total capacity of 250 kW.

The greatest challenge for the refrigeration system is the South Australian climate, with temperate winters and hot summers. The high-pressure side had to be designed to cope with ambient temperatures of 40°C and beyond. Such high temperatures prevent condensation at the end of the cooling circuit, since the compressed carbon dioxide exceeds its critical point of 31°C, and is thus unable to change state and condense above 31 °C.

To solve this problem, an evaporative air pre-cooling unit was fitted ahead of the air-cooled condenser. When the ambient temperature rises above 28°C, this unit cools down the air stream which enters the condenser and removes the heat from the compressed carbon dioxide gas. This allows the refrigerant to be cooled to below outside air dry-bulb temperature, raising the system's efficiency even if the heat rejection process continues at supercritical pressure. In addition, the plant also has a system to control high pressure, which allows for very precisely controlling the subcooling that the liquefied refrigerant undergoes as it exits the condenser.

#### **About Georges Hoeterickx**

Georges Hoeterickx became member of the eurammon executive board in 2004. Born in Leuven in 1955, the Belgian native is Director Business Development for Evapco Europe in Belgium. Hoeterickx studied at De Nayer University from which he graduated an electro-mechanical engineer. He obtained his Master of Business Administration from Limburg University in 1989. After a long career with companies like Baltimore Aircoil and ABB Europe he joined Evapco Europe in 2008. During his career Georges Hoeterickx gained experience in all kinds of heat rejection and refrigeration systems, applied in Europe and the Middle East.

#### **About eurammon**

eurammon is a joint European initiative of companies, institutions and individuals who advocate an increased use of natural refrigerants. As a knowledge pool for the use of natural refrigerants in refrigeration engineering, the initiative sees as its mandate the creation of a platform for information sharing and the promotion of public awareness and acceptance of natural refrigerants. The objective is to promote the use of natural refrigerants in the interest of a healthy environment, and thereby encourage a sustainable approach in refrigeration engineering. eurammon provides comprehensive information about all aspects of natural refrigerants to experts, politicians and the public at large. It serves as a qualified contact for anyone interested in the subject. Users and designers of refrigeration projects can turn to eurammon for specific project experience and extensive information, as well as for advice on all matters of planning, licensing and operating refrigeration plants. The initiative was set up in 1996 and is open to European companies and institutions with a vested interest in natural refrigerants, as well as to individuals e.g. scientists and researchers.

Internet URL: [www.eurammon.com](http://www.eurammon.com)

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