

CO₂ at the forefront

Use of R744 to refrigerate Danish supermarket to satisfaction of operator



Supermarket in Denmark

Line of Business:	Commercial Refrigeration
Application:	Supermarket Cooling
Country / City:	Denmark / Koge
Fluid:	CO ₂
Product:	Gas cooler / Condenser GVH

In the early 1970's, Mario J. Molina discovered that chlorofluorocarbons deplete the ozone layer, which is essential to our survival here on earth. At first, this discovery was pretty much disregarded, but today our awareness level is much higher. These so-called CFCs meet with world-wide disapproval. For a long time, halogenated hydrocarbons (HHC) were considered a clean alternative. They have little or no effect on ozone depletion, but many experts feel that they do have a considerable greenhouse effect and contribute to global warming. This correlation let states such as Austria and Denmark to go beyond the steps that were already planned by the European F-Gas Regulation over the next few years.

This background led to the development of one of the most advanced refrigeration plants in the European Union - in Copenhagen, Denmark.

Legal situation in Denmark and Austria

In Denmark, this came into force at the beginning of 2007: for new installations, a maximum of 10 kg of fluorinated hydrocarbons are permitted in refrigeration systems. For Austria, a quantity limit for HHC was discussed during 2007, but no directive materialised. Plants with refrigerating capacities that require larger quantities can be filled with natural refrigerants such as, for example, with the ammonia (R717) which is still unusual for small capacities, propane (R290) which is technically possible, but flammable or the still exotic-appearing carbon dioxide (R744). Neither for HHC is there a limit.

Since March 1, 2001 in Denmark, whether F gases or natural refrigerants will be used in a plant is an important factor for economic refrigeration, because since then, the Danish State levies a tax of 13.50 € per CO₂ equivalent ton that is used in a refrigeration plant. This CO₂ equivalent is referred to as the Global Warming Potential or GWP and expresses the substance's contribution to the greenhouse effect. The GWP of CO₂ is used as the reference and is given the value of 1 by definition.

Example: A plant is to be filled with 250 kg of R404A refrigerant. R404A has a GWP value of 3,800. This means that one ton of R404A has the same greenhouse effect as 3,800 tons of CO₂.

Therefore: $0,25 \text{ tons} \cdot 13,50 \text{ €}/(\text{ton CO}_2) \cdot 3.800 \text{ tons CO}_2 = 12.825 \text{ €}$

Therefore, 51,30 € in tax must be paid for each kilogram of R404A.

These are naturally substantial sums that have to be considered when deciding which refrigerant should be used. In the given example, the responsible technician from the Knudsen Køling Company clearly decided in favour of CO₂ as the refrigerant.

Knudsen Køling

Knudsen Køling is a medium-sized company located in Køge, Denmark. As well as refrigerating plant construction, the company also offers a complete range of refrigeration and freezing units. The refrigeration units are manufactured in Køge, where the company is headquartered. The evaporators needed when CO₂ is the refrigerant used are outfitted with electronic expansion valves and integrated in stainless steel refrigeration units.



Refrigeration unit in the Super Best supermarket

Getting into position in time to meet the challenges of the next years

Knudsen Køling paved the way for the future in a timely manner. While some were pressured into finishing a planned refrigeration plant within 2006 in order to still be able to fill it with HHC, the team at Knudsen already successfully moved on to the alternative, CO₂. Many technical questions had to be clarified before the project could get underway, for example:

- How can the high pressure of CO₂ be coped with?
- What is the best design for the piping so that the oil return functions properly?
- How should the high pressure be controlled?
- What about the high compression temperatures?

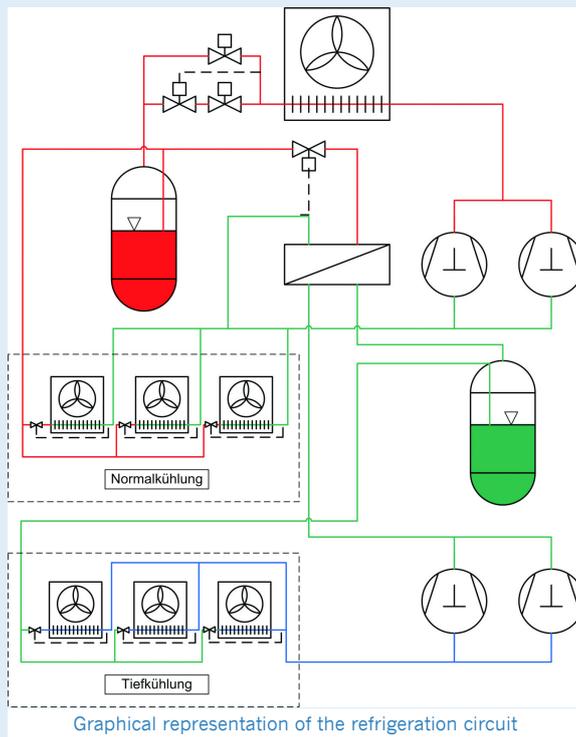
At Knudsen Køling, the answers to these questions were not left to chance. The plant in Køge, location of the company's headquarters, was built up for testing and the optimal operating

point for the plant during transcritical operation was determined. Therefore, it is now possible to operate the plant at all points in time at the most energetic, economic operating point.



Plant refrigerant: CO₂

The system



In principle, the system is made up of two refrigeration circuits that are thermally coupled by a plate heat exchanger. This results in three temperature levels, of which two are used and the third, the highest, provides reliable heat dissipation:

- Evaporation at -28 °C. This temperature level is needed in deep-freeze equipment and in the deep-freeze

cells in a building's basement. The air temperature in this area is -20 °C.

- Condensation and evaporation in a plate heat exchanger at -10 °C. At a -10 °C evaporation temperature, the evaporators in cold rooms and refrigeration units will bring the air temperature into the positive range.
- Condensation or gas refrigeration, depending on the ambient temperature.



S-GVH gas cooler condenser with fans wired in pairs to the repair switch

On the high pressure side of this cascade, the compressor rack, made up of nine compressors, provides regulated refrigerating capacity up to a total of 100 kW. Add to that a compressor rack with 4 compressors and a total refrigerating capacity of 50 kW for the deep-freeze level. Frequently, rack refrigeration plants are designed for evaporation temperatures of -15 °C and -35 °C for the deep-freeze level. However, designs with higher evaporation temperatures have many disadvantages for the operator which are quite noticeable during operation. Due to the minimal difference between the ambient temperature and the evaporation temperature, the air will not be greatly dehumidified.

For this reason, the coolers do not frost over as much and the defrosting intervals are reduced. An increase in the evaporation temperature of only 1 Kelvin also saves about 4 % of the compressor power due to the higher COP. The operating costs of a refrigerating plant exceed the investment costs in a relatively short period of time (1.5 to 4 years, depending on



the design). For this reason, especially in times of increasing competition, the economical operation of refrigeration plants is an important factor in successfully running a supermarket.

The components

Compressors from Bock Company were chosen for the compressors in both cascade system levels. To control the evaporation injection and the cooling point, electronic components from Danfoss Company were installed. Piping was designed completely in stainless steel to provide adequate compression strength, because, especially in a CO₂ circuit, extremely high pressures can arise on the pressure side of the refrigeration plant. Güntner expertise was also used for the cooling chambers and high-efficiency GDF model evaporators were selected for normal cooling and GHF models were used for deep-freezing.



Compressor rack

The heat dissipation system: the Güntner CO₂ gas cooler/condenser - a special Güntner solution



Güntner CO₂ gas cooler/condenser

For heat dissipation, the plant design relied on Güntner's long standing experience and competence. The condensers that function as gas coolers under high ambient temperatures and supercritical process control are especially designed for the stresses and strains that can arise when CO₂ is used as the refrigerant. In addition to the gas cooler inlet temperature, which corresponds to the temperature at the condenser end for short pipelines, the challenge is also to ensure operating safety in the plant at operating pressures of 120 bar. You are not necessarily on the safe side using conventional copper pipes.



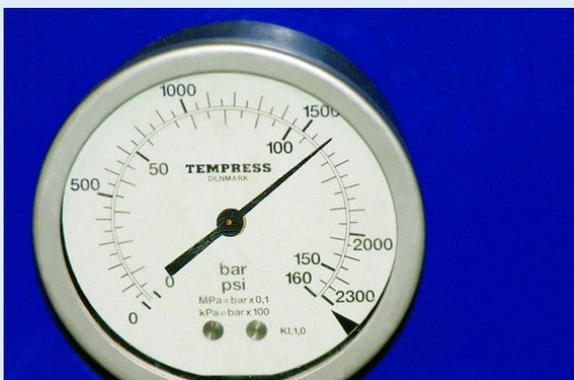
A Knudsen Køling refrigeration unit

For this reason, when CO₂ is used, Güntner relies on stainless steel, which is manufactured with a wall thickness of 0.7 mm according to pressure systems safety regulations. Before it leaves the factory, every CO₂ gas cooler is pressurized to a test pressure of 172 bar to guarantee that there is no leakage. The test is recorded and the results are included in the delivery. Due to the extremely quiet and energy-saving design of the gas cooler and the fans, it is almost noiseless and therefore well suited to being installed in highly-populated areas with strict noise control regulations.



Gas cooler condenser in stainless steel

Güntner takes its responsibility towards the environment and our society very seriously. Efficient system solutions with long-term operating safety ensure the conservation of resources, health and quality of life and are an integral part of our vision. In this way, the Copenhagen supermarket achieved an ideal situation: Operators and consumers can enjoy reliably cooled products.



Pressure display

Only an expert glance at the pressure display lets you know that something is different ...