CO_2

Why the renewed interest in "old" refrigerants?

New chemicals are sometimes subsequently associated with disadvantages that had not been anticipated at the time of introduction. Such is the case with refrigerants – with ozone depletion and the greenhouse effect among the concerns raised.

In an effort to tackle these problems, it has proven beneficial to reintroduce some of the refrigerants commonly used before the more recent synthetic alternatives became available. These "old" refrigerants are also called the natural refrigerants, and include ammonia (NH_3), hydrocarbons and carbon dioxide (CO_2).

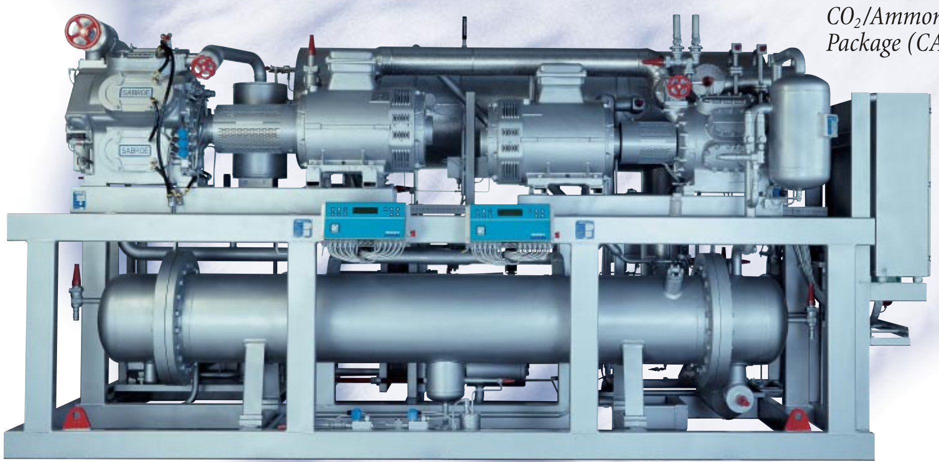
Synthetic refrigerants were originally chosen because natural refrigerants had certain disadvantages. They still have, but unlike synthetic refrigerants, the drawbacks of these natural refrigerants are well known and well documented. It is fairly unlikely that any new drawbacks associated with CO_2 will be discovered, not least because CO_2 is a natural component of the air surrounding us. In addition, CO_2 has many specific advantages that make it very interesting for use in industrial refrigeration, as shown below.

During the last few years, many commercial plants have started using CO_2, and their experience is that it is safe and reliable. In addition, the energy efficiency is as good as for many alternatives, or better.

Applications

For industrial refrigeration purposes, CO_2 is mainly applicable in the -35°C to -53°C temperature range. CO_2 can also be used with good results as a volatile secondary refrigerant at higher temperatures, as a number of installations have proved. However, the lower the temperature, the more efficient CO_2 will be compared with most other refrigerants. In addition, CO_2 is odourless, so a small leakage of CO_2 is no cause for alarm. CO_2 can therefore be used in low-temperature areas related to food and beverage, petrochemical and marine applications, such as

- supermarkets
- ice cream factories
- meat and poultry industry
- seafood industry
- cold stores
- freeze-drying
- CO_2 and other gas condensing plants.



CO_2/Ammonia Freeze Package (CAFP)

CO_2/R744 as refrigerant

Advantages

• Ozone Depletion Potential (ODP) = 0	Environmentally friendly and safe for the future
• Global Warming Potential (GWP) = 1	Environmentally friendly and safe for the future
• Non-flammable	
• Non-toxic	
• Odourless	No panic risk
• Available and low-priced	
• High volumetric performance, 3–12 times the performance of NH_3	3–12 times smaller compressor, pipes and auxiliaries
• High COP	Low power consumption
• High heat transfer coefficient	Smaller condensers and evaporators
• Low pressure loss	Smaller pipes and vessels, less insulation, etc.

Disadvantages

• High design pressure	Equipment to avoid excessive pressures at standstill Hot gas defrost (equipment for high pressure ~ 50 bar)
• Limited flexibility	Min. evaporating temperature -56°C Max. condensing temperature +5°C
• Complex plants	Cascade cooler more expensive than conventional intermediate cooler
• Heavier than air	In case of leakages, CO_2 gathers at floor level and displaces the air
• Odourless	In case of leakages, there is no warning on the basis of smell (CO_2 detectors are recommended).

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Primary system comparison

Compared with two-stage ammonia overfeed systems, CO_2 cascade systems have

- lower operating costs below -35°C evaporating temperature
- lower initial costs for low-temperature applications – the break-even point varies for each individual installation
- lower booster compressor installation costs (3–12 times lower swept volume)
- lower piping costs
- extra costs for CO_2 condenser (cascade cooler)
- no ammonia in production rooms and drastically reduced ammonia charge in machine rooms
- positive operating pressures in plant and compressors reduce air and moisture problems.

Secondary system comparison

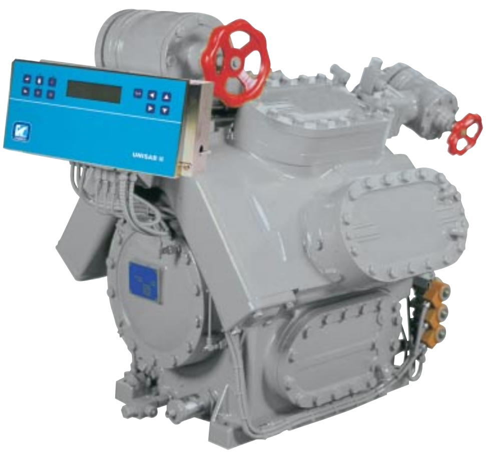
In freezing conditions, when compared with a single-phase secondary system, a CO_2 two-phase secondary system provides

- lower operating costs
- lower piping costs
- better heat transfer on the evaporating side, which means smaller heat exchangers (air coolers)
- equal or lower costs for CO_2 systems compared with traditional single-phase systems.

System solutions for CO_2

The current range of system solutions includes

- cascade systems with CO_2 at the low-temperature stage and NH_3 or other refrigerants at the high-temperature stage
- secondary systems with phase-change of CO_2.



All information is subject to change without previous notice.

FAQs (frequently asked questions) about CO_2

1. Is the equipment available?
2. How is the pressure dealt with, both during operation and at standstill?
3. How should a CO_2 system be defrosted?
4. Which lubricants should be used?
5. What is the working range?

Equipment

Sabroe provides a full range of 40-bar reciprocating compressors and 30-bar maximum operating pressure screw compressors, as well as cascade coolers, liquid coolers and pressure vessels. Complete CO_2/ammonia cascade units are also available.

Pressure

During operation

- secondary systems for low temperatures are kept below 25 bar
- discharge side, including cascade cooler, operates at pressures up to 40 bar
- suction side, including evaporators, separators etc., is kept below 25 bar.

At standstill

Different solutions are possible, depending on the plant design and the application

- condensation of the liquid in the storage tank
  - storage tank placed in the cold store, if available
  - receiver with thermal storage
  - self-cooling of the storage tank with bleed off
  - a small recondensing unit placed in the storage tank
- storage of the charge in gaseous phase
- combination of the above.

Defrosting

- electrical defrosting
- water defrosting
- defrosting by means of warm brine in a separate system in the evaporators
- hot gas defrosting is limited by the design pressure of equipment in the plant. Hot gas defrosting requires 45–50 bar.

In general, precautions must be taken regarding excessive pressure during defrosting.

Lubricants

Lubricants can be avoided if the secondary system with phase-change of CO_2 is used

- POE oils (miscible) – used with success
- immiscible PAO oils can be used, but the oil return from plant to compressor is complicated
- overfeed systems and traditional oil draining cannot be used because oil is lighter than CO_2 and floats on top.

Working range

- only above the triple point -56°C
- the upper value depends on the application.

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