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Danfoss

Keep cool with hydrocarbon refrigerants
Safety and **maximum performance**

98.6%

possible reduction
in global warming
potential with
Danfoss components
for hydrocarbon
refrigerants.



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Phase down of HFCs through the Montreal Protocol. A global and strategic approach to lower GWP

Background on the Proposed Phase Down of HFCs through the Montreal protocol, universally viewed as an overwhelming success. Guiding you through today's progress and refrigerant options, with emphasis on Global Warming Potential, energy consumption, system efficiency and other information that will help you stay on top of the game.

Hydrocarbons are very energy-efficient and climate-friendly refrigerants with very limited impact on global warming, and no impact on the ozone layer.

Hydrocarbons have been used in household refrigeration and some speciality applications for many years, and are now entering other applications, for instance display cabinets and large chillers.

Since hydrocarbons are flammable, safety always needs to be considered when designing, building and servicing systems.

Danfoss has extensive experience in working with flammable refrigerants and has raised the bar for safety by ensuring that every Danfoss component complies with the requirements for explosive atmospheres (94/9/EC) ac. ATEX zone 2/ category 3. Furthermore, some components are also available for ATEX zone 1 or 0 (please see the actual product data sheet).

All components comply with the requirements in the Pressure Equipment Directive (PED) (97/23/EC) fluid group I (flammable/toxic media).

Relevant norms & standards when working with hydrocarbon refrigerants

> ATEX 94/9/EC Directive

Specifies the requirements for equipment intended for use in potentially explosive atmospheres (both electrical and mechanical) Organisations in EU must follow the directive to protect employees from explosion risk in areas with an explosive atmosphere

> Pressure Equipment Directive 97/23/EC (PED)

The directive provides a legislative framework for pressurised equipment and assemblies

> EN378 1-4

EN378 defines "best practice" for design, operation and maintenance. It is a harmonised standard, which ensures that all essential requirements in the PED are fulfilled.

> ISO 5149 1-4

The international safety standard, defines "best practices" very similarly to EN378, but without referring to EU law

> IEC 60335: International Standard

Specifies all requirements for small hermetically sealed household appliances (supports the PED). It deals with the safety of electrical appliances for household and similar purposes



Background on the Proposed Phase Down of HFCs through the Montreal Protocol

In the first half of the 20th century chlorofluorocarbons (CFCs) became the refrigerants of choice in a wide range of applications including residential, commercial and mobile refrigeration and air-conditioning, and later became commonly used as blowing agents and propellants. CFCs were considered superior to previously used refrigerants because they were odorless, non-toxic, noncorrosive, and non-flammable, while supporting energy efficient systems. Later, hydrochlorofluorocarbons (HCFCs) with similar properties were developed to improve performance of air-conditioning and heat pump equipment.

In 1973, chemists at the University of California began studying the impacts of CFCs in the atmosphere. Their research was published in 1974 and subsequently substantiated. By the late 1970s it became accepted that these substances were primarily responsible for depleting the Earth's stratospheric ozone layer, permitting high exposures of ultraviolet (UV) radiation to reach Earth's surface, particularly in the polar regions.

In 1985, the British Antarctic Survey published a study in the journal Nature showing a far greater depletion of the polar ozone layer than previously anticipated. That same year, twenty nations including most of the major CFC producers signed the Vienna Convention, which established a framework for negotiating international regulations on ozone-depleting substances.

The Montreal Protocol (MP) was the global vehicle established in 1987 to eliminate the use of gasses with high ozone depleting potentials (ODPs). Virtually all United Nations members have since ratified the MP. Its features include:

- Differentiated reduction standards among developed and developing (designated "Article V" countries) countries. Developing countries were allowed longer phase-out times, so they could utilize technologies then being developed in developed countries
- Establishment of a "Multilateral Fund" to support transition in developing countries
- Virtually immediate phase-out of "non-essential uses"
- Rapid phase out of high ODP substances including CFC refrigerants such as CFC11 used in centrifugal chillers, and CFC12 and CFC502 most commonly used in commercial and residential refrigeration and automotive air-conditioning
- Slower phase out of low ODP substances including HCFC refrigerants. (The most common air-conditioning refrigerant was HCFC22, which had an ODP of approximately 0.05 (5% of CFC11). Because of its lower ODP, HCFC22 became an interim replacement

for common refrigerants CFC11, 12 and 502. HCFC22 was originally scheduled to be phased out in 2030, but subsequent action has accelerated that date. Europe and the United States have already phased out HCFC22 in new production. The US still permits small production quantities for servicing existing installed equipment.

The concentration of chlorine in the stratosphere has peaked and is now declining. While concentrations are still much higher than pre-CFC levels, the general scientific consensus expects a substantial improvement over the next fifty years. See Figure 1.

The Montreal Protocol is virtually universally viewed as an overwhelming success. Former United Nations Secretary General Kofi Annan stated, "Perhaps the single most successful international agreement to date has been the Montreal Protocol."

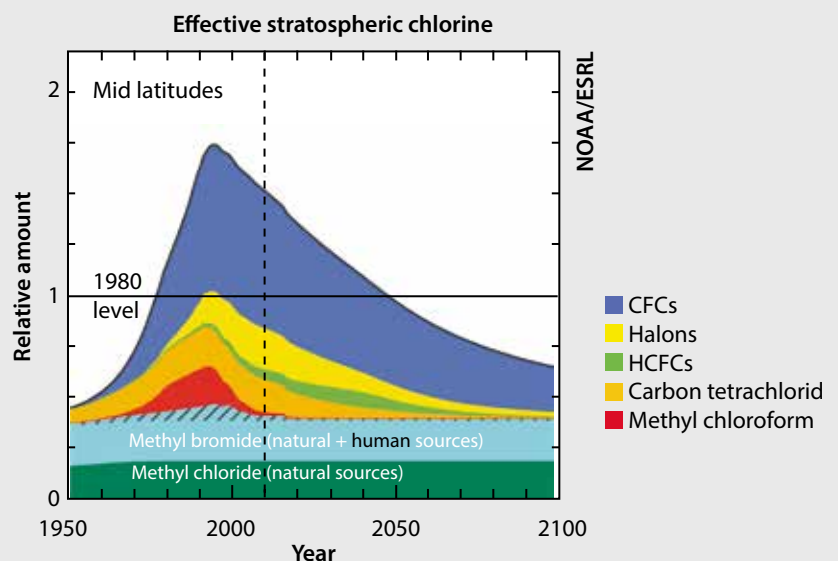


Fig. 1: Recent Progress montreal Protocol and the Ozone Layer

Source: US EPA, UNEP/WMO Ozone Assessment, 2006.

Figure 2 displays the improvement that has been achieved in both ozone depleting potential and global warming potential as the industry migrated from CFCs to HCFCs to HFCs.

Nevertheless, most common HFCs have global warming potentials (GWP) in the range of approximately 1500 to almost 4000 times that of carbon dioxide. This has placed HFCs under the scrutiny of environmental advocates, regulatory agencies and of course industry. HFCs have been dubbed "potent greenhouse gasses".

There are two dimensions to the global warming issue for air-conditioning and refrigeration.

1. The direct, more-visible, but smaller impact is the GWP of the refrigerant used. Of course, refrigerants are not intended to leak into the atmosphere, and in fact there is no resulting global warming contribution unless and until the refrigerant does leak. Industry is already making efforts to

reduce the direct impact by reducing system leak rates, reducing size of refrigerant charges, enhancing service techniques, and developing methods to recover, recycle and reuse or destroy used HFCs.

2. The indirect and less-visible issue is the larger contributor to global warming. Over 80% of air-conditioning and refrigeration systems' global warming contribution is estimated to be emitted from plants producing electricity. Because of this, emphasis must be placed on not sacrificing energy efficiency when shifting to alternate refrigerants.

The concept of Total Equivalent Warming Impact (TEWI) was developed to simultaneously consider and balance the direct refrigerant climate impact and the indirect energy-efficiency impact of refrigeration and air-conditioning systems.

To understand the implications of changing refrigerants, the system design

and risk associated with its use must be considered. Even though alternative refrigerants may be thermodynamically quite viable, they cannot be applied in existing systems designed to use HCFC and HFC refrigerants. Considerable design changes and investments to ensure sufficient safety are often needed. Many of our customers have already invested once in the change from CFCs or HCFCs to HFCs, so further investment will likely be required.

Hydrocarbons (HCs) propane and iso-butane are naturally occurring substances with very low GWP. Thermodynamically, they are very good refrigerants, but they are flammable.

So far, their use is primarily in applications with very small refrigerant charges in which ignition points such as relays, switches and thermostats are isolated and protected. Applications include domestic and small commercial refrigerators and freezers. Hydrocarbon use is quite common in Europe and Asia. Several US manufacturers are now moving to HCs, and the US regulatory process has been adapted to permit HC refrigerant use in systems with small charges (no more than 150g).

In most of the world outside North America, hydrocarbons can be used in commercial applications with charge above 150g, with strict requirements for the safety of the installations. This is especially popular in the EU. A promising application is heat pumps, in which hydrocarbons (particularly propane) are extremely efficient. Danfoss can supply controls and compressors for these applications.

For many years Danfoss has also supplied industrial refrigeration products for hydrocarbons to the petrochemical industry where the charges are very large. All hydrocarbon systems are safe as long as safety standards are followed.

While hydrocarbons are excellent natural refrigerants, they are not universal replacements for HFCs and in fact for a number of applications HFCs are currently the only commercially available solution.

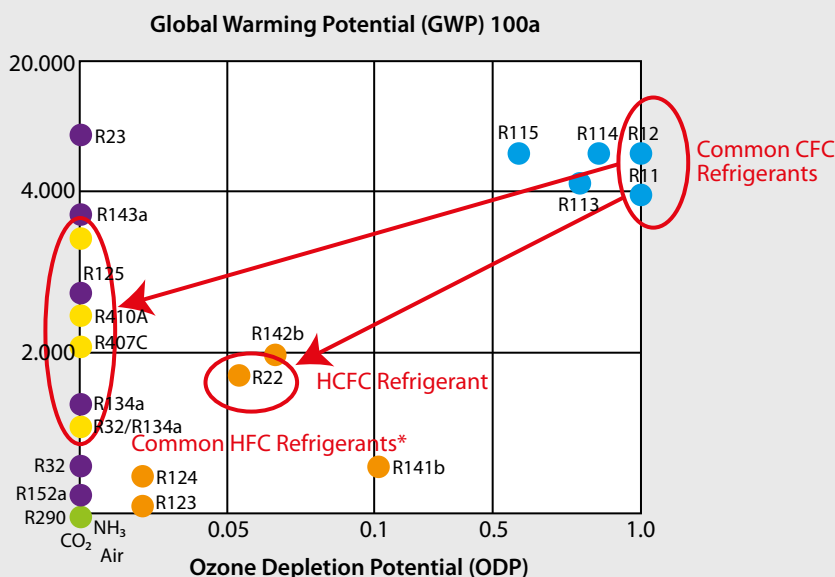


Fig. 2: Matrix of Refrigerant GWP versus ODP

* HFC refrigerants have zero ODP, so the ellipse is only indicating the range of GWP.

Refrigeration Controls

Thermostatic expansion valves type TUBE and TUCE

- › Bi-flow function
- › Capacities up to 20 kW
- › Max. working pressure 34 bar
- › Stainless steel, hermetically tight solder version
- › Bimetal connections for fast and safe soldering
- › Connections 1/4" and 3/8" inlet, 1/2" outlet
- › External pressure equalization
- › Adjustable superheat type (TUBE) available for laboratory use

Expansion valves type TGE

- › Bi-flow with expansion in both directions
- › Capacities up to 130 kW
- › Head pressure independent
- › Balance port (BP)
- › Max. working pressure 46 bar
- › Cylindrical bulb design, with new bulb strap
- › Inlet in 5/8" or 7/8", outlet 7/8"
- › External pressure equalization
- › Adjustable superheat setting

Solenoid valves type EVR

- › Direct or servo operated solenoid valve especially designed for liquid, suction, and hot gas lines
- › Media temperatures up to 100 °C
- › Solder connections up to 7/8 in
- › Extended ends for soldering make installation easy. It is not necessary to dismantle the valve when soldering
- › Wide choice of coils for a.c.
- › Safe mounting with screw-on system
- › MOPD up to 21 bar

Shut-off valves type BML

- › Manual shut-off valve for installation in liquid, suction and hot gas lines
- › Connections size up to 22mm (7/8") ODF
- › Capacities (K_v) 0.3 -2.9 m³/h

Check valves type NRV and NR VH

- › Non-return valves for liquid, hot-gas and suction lines
- › NR VH with stronger spring to avoid resonance problems with compressors connected in parallel
- › Connections size up to 22 mm (7/8") ODF.
- › Capacities (K_v) 0.56 -5.5 m³/h

Filter driers type DCL and DML

- › Protects refrigeration and air-conditioning systems from moisture, acids and solid particles
- › Connections size up to 22 mm (7/8") ODF
- › Capacities up to 100 kW

Sight glasses, types SGP X, SGP I and SGP N

- › Sight glasses for monitoring condition and moisture content of refrigerant and the flow in oil return lines.
- › SGP I for R290, R600 and R600a, and SGP N for R1270.
- › Connections size up to 22mm (7/8") ODF

Differential pressure controls type RT 260 AE and RT 262 AE

- › Connection G 3/8A + welded nipple Ø6.5/10 mm
- › Regulating range 0.1 to 4 bar

Differential pressure controls type MP 55E

- › Protects refrigeration compressors against low lubricating oil pressure
- › Wide regulating range (ΔP 0.3 to 4.5 bar)
- › Connections 1/4" ODF

Pressure controls type RT

- › Connection G 3/8A + welded nipple Ø6.5/10 mm
- › Range RT 5E: 4 to 17 bar
- › Regulating ranges available from -0.8 bar as minimum up to 30 bar as maximum

Pressure Thermostat type RT

- › 2 m capillary tubes
- › Range -5°C to 30°C
- › High temperature versions available up to 250°C

Pressure controls type KP

- › Protects against excessively low suction or high discharge pressure
- › The high pressure controls are equipped with failsafe double bellows, and low pressure controls with reduced bellow travel to enhance life time
- › Manual and automatic reset available
- › Regulating ranges -0.2 to 7.5 bar and 8 to 32 bar
- › Connection 1/4" ODF

Pressure Transmitters type AKS

- › Designed for precise and energy optimised control
- › Factory calibrated, no adjustment necessary
- › Effective moisture protection for harsh environments
- › Wide variety of voltage and current outputs available
- › Wide variety of pressure ranges available

Electronic Refrigeration Controllers type ERC

- › Manages all energy consuming parts in the refrigeration appliance
- › Designed to cut energy consumption
- › IP rated body for high moisture resistance
- › Internationally approved hardware (CE, UL, GOST, and many more)
- › For use in all climates, indoors as well as outdoors

- › IECEX approved for use with hydrocarbon refrigerants
- › Can be used on all light commercial applications

Water Valves, types WVFX, WVO and WVS

- › Maintains stable condensing pressure in systems with water cooled condensers
- › Precise control without setting drift.
- › Double sealing between the refrigerant and the water line
- › Water valves can be used together with a double walled heat exchanger and water circuit in such a system does not need to be considered as part of the installation for flammable refrigerants (EN378-1:2008, clause 4.4.2.2)
- › Insensitive to water pulsating pressure.
- › Insensitive to dirt
- › Wide operating range
- › Complete flow range from 1.4 – 125 m³/h

KVL Crankcase pressure regulating valves

- › Limits the maximum crankcase pressure
- › Refrigeration system can operate under large load variations
- › Very easy adjustment of the set point.
- › Product quality is maintained throughout a long operating lifetime

KVR Condenser pressure regulating valves

- › Maintains a constant and sufficiently high condensing pressure even in low ambient and low load conditions
- › Stainless steel bellows gives a very long operating life
- › Easy and accurate adjustment with Allen key
- › Pressure gauge for adjustment or indication

KVC Hot Gas Bypass Capacity regulating valves

- › Protects the compressor against too low suction pressure
- › Keeps suction pressure above the compressor's minimum pressure limit
- › Adapts the compressor capacity to the actual evaporator load
- › Proportional regulation
- › Hermetic design

KVP Condenser pressure regulating valves

- › Protects against too low evaporator temperature
- › Maintains desired humidity in the cold room
- › Guarantees longer storage time and reduced food spoilation
- › Food is kept at the highest possible quality level by minimizing dehydration

Compressors and Condensing Units for R290

Running with R290 for light commercial refrigeration in LMBP applications

- › Such as bottle coolers and vending machines, water and beer coolers, display freezers, food and delicatessen
- › Small dimensions make compact cabinets
- › Low sound emission
- › Reduced installation and running costs

Fix speed Compressors and Condensing Units range

- › Available in T, N, SC platforms (3-21 cm³)
- › Application at high ambient temperature possible
- › High appliance and system robustness at rough operating conditions
- › Insensitive towards unstable electric power supply
- › Prewired and ready to braze Condensing Units

Variable Speed SLV15CNK.2 Compressor and Controller

- › Variable speed 2000 – 4000 rpm, with permanent magnet motor
- › Intelligent controller for whole appliance will save up to 40% energy
- › Monitor system performance, intelligent controller for ultimate control and alarm management, HACCP compliance easy
- › Built-in data logging function allows food quality and safety
- › Protection: current, speed, temperature; electronic thermostat

DC BD Compressors for R290 and R600a

Running with R290 or R600a for stationary LMBP applications, freezers and solar powered systems

- › Such as ice cream freezers and boxes, pharmaceutical applications up to 200 litres...
- › 10-45V and 12-24V DC
- › Electronic control unit with built-in speed control, thermostats signal, thermal protection, safety against destructive battery discharge, electronic thermostat and fan speed control on selected models via the software "Tool4Cool®"
- › Complete R600a compressor range is also available through Danfoss sales network



Compressors for R600a



Compressors and condensing units for R290

Micro Plate and MicroChannel Heat Exchangers

Micro Plate Heat Exchangers

Micro Plate Heat Exchangers (MPHE) have a smaller hold-up volume compared with competing traditional BPHE (Brazed Plate Heat Exchanger) technologies, with the clear benefit of reduced refrigerant charge in hydrocarbon-based applications. MPHE products are dedicated not only to specific applications but also to different duties within them:

Chillers

- › Dedicated C-range for chillers
- › Internal volume reduced by 25% compared with standard BPHE
- › Full coverage across all applicable chiller solutions capacities
- › Evaporators and condensers
- › Efficient operation at full and part load
- › Rugged and reliable for long service with minimal maintenance
- › Minimal use of materials
- › Small footprint

Heat pumps

- › Dedicated H-range for heat pumps
- › Wide heating capacity range
- › Evaporators and condensers
- › Efficient operation at low heat flux and close temperature approaches, assuring high COP and seasonal efficiency
- › Rugged and reliable for long service with minimal maintenance
- › Minimal use of materials
- › Small footprint
- › Internal volume reduced by 40% compared with standard BPHE

MicroChannel Heat Exchangers

MicroChannel Heat Exchangers (MCHE) have hold-up volumes as much as 77% lower compared with competing technologies. The clear benefits of high efficiency, low refrigerant charge, compactness and reliability are available from dedicated models across a wide range of applications, featuring:

- › Low air-side pressure loss saves on fans and energy
- › All-aluminium construction for durability and 100% recyclability
- › Working temperature up to 125 °C
- › Working pressure up to 45 bar
- › Catalogue units available for:
 - Commercial air conditioning 11-51 kW
 - Condensing units 2-5 kW
 - Air dryers 3-7 kW
 - Cabinet cooling 2-5 kW
 - Cold rooms 2-12 kW
- › Custom designs available on request







Use of flammable refrigerants such as hydrocarbons

The use of low GWP flammable refrigerants is increasing so flammable refrigerants, whether natural or chemical substances, are now used at an increasing rate in general refrigeration applications globally.

The increasing use of hydrocarbons means that refrigeration contractors and service technicians without prior experience of flammable refrigerants are now starting to work with these substances.

There is therefore an increased risk of hazardous situations and to limit the risks for customers and end-users in countries where safety standards are not an integrated part of the legislative system, Danfoss requires a formal agreement to be signed when our customers buy products applicable for flammable refrigerants

in non-industrial refrigeration applications. Countries where the agreement is currently not needed are: Australia, Canada, EFTA countries, EU countries, New Zealand, and US.

The agreement works as a guide. It builds on the most important international standards to improve safety.

The main points include:

- › Follow the relevant norms and legislation.
- › Ensure that only competent people are working with flammable refrigerants, including technicians servicing the refrigeration system.
- › Have business liability insurance.
- › Where Danfoss products are used, only components and spare parts approved for flammable refrigerants shall be used.

At Danfoss we take a committed approach to improving the climate by providing the world of refrigeration and air conditioning with greener technology offering a variety of products for hydrocarbon based solutions for light commercial and commercial refrigeration applications, chillers and heat pumps.

For questions and more information please contact your local Danfoss sales office.

