

COOL



The world's first HFC-free McDonald's restaurant

A pilot project in Vejle / Denmark



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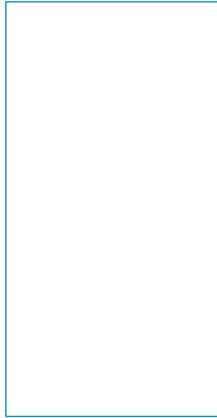
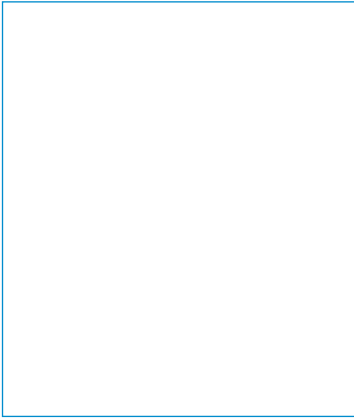
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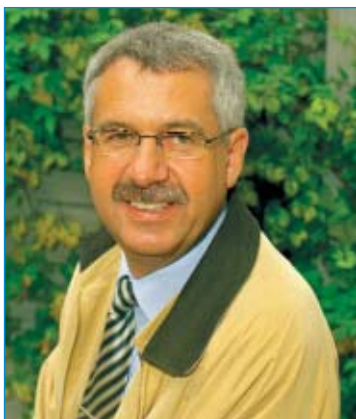
Opening Views

Industries have two faces with regard to the environment and sustainable development. First, their activities can contribute to environmental degradation as well as unsustainable consumption and production patterns.



Second, by rethinking how they do business, they can actively find innovative solutions to such problems. This initiative of McDonald's to showcase integrated solutions to ozone layer depletion and climate change illustrates the latter.

Klaus Töpfer,
Executive Director,
United Nations Environment Programme (UNEP)



Companies play a key role in modern environment politics alongside consumers and governments. McDonald's is showing us how companies can make a difference by setting new standards for environmental performance, and I hope that this will accelerate the use of HFC-free refrigeration and ventilation equipment.

Hans Christian Schmidt,
Danish Environmental Minister



The commercial incentive is equally important as all legislation in the field. The McDonald's restaurant in Vejle is particularly interesting, because never before have so many different kinds of refrigeration equipment in one place been converted to the new refrigerants.

Kim Gardø Christensen,
Danish Technological Institute (DTI)



The pilot test in Vejle is part of McDonald's overall commitment to social responsibility and the result of our long standing efforts regarding environmental protection.

Establishing a market demand for innovative technology is one way a major company can further and fasten the development of sustainable solutions.

Charlie Bell,
Chief Executive Officer, McDonald's Corporation



Greenpeace welcomes the bold step McDonald's has taken in opening this first-ever HFC/HCFC-free restaurant. The path from critical confrontation in Sydney to constructive dialogue and development has been impressive. We hope it sparks more sustainable innovation from the refrigeration industry and others in the food service sector.

Tarjei Haaland,
Greenpeace



“ From the meat freezer to the shake machine, the air-conditioning to the ice dispenser, all appliances in the restaurant operate completely free of Hydrofluorocarbons (HFCs) ”

Serving the environment

An Introduction

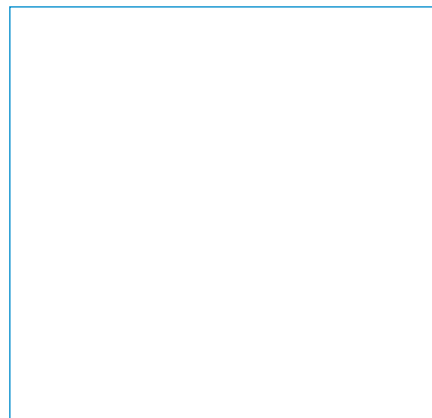
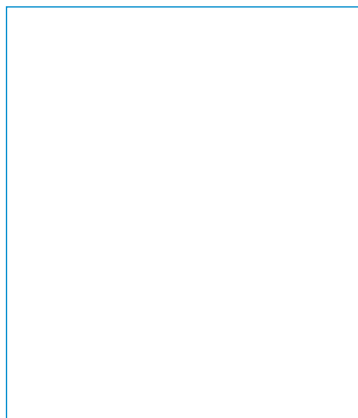
Visiting the McDonald's restaurant in the Danish town of Vejle, customers feel at home as in any McDonald's restaurant around the world. They meet the familiar mixed crowd of people enjoying a meal or just a drink: families, schoolchildren, business people. They can expect quality food, efficient and friendly service. Something the customers don't notice, however, makes the restaurant very special: It not only serves food, but also the environment.

Thanks to the technology selected by McDonald's, the refrigeration system in this pilot project protects the stratospheric ozone layer – the thin layer of gas in the upper atmosphere that filters out damaging UV-radiation – and also reduces the contribution to global warming. The design chosen for Vejle thus proposes one solution for two global environmental problems.

From the meat freezer to the shake machine, the air-conditioning to the ice dispenser, all appliances in the restaurant operate completely free of Hydrofluorocarbons (HFCs) – a substance that has widely replaced the ozone depleting Chlorofluorocarbons (CFCs) but contributes to the greenhouse effect or global warming. Aware of the negative impact HFCs have on the environment, McDonald's discussed with its suppliers the possibilities and availability of equipment using alternative refrigerants and came up with an action plan for a HFC-free restaurant in Denmark.

At present the equipment is being systematically tested and monitored under normal working conditions. Unnoticed by the customers but viewed with interest and high expectations by industry, governments and environmental NGOs.

This booklet showcases the decision-making process within McDonald's corporate management to evaluate non-CFC, non-HFC options, and provides first performance data.



Stepping up to the counter

A background

The “Refrigerant Summit”

In October 2000, environmental organisations and representatives of over 30 major refrigeration suppliers met in Oak Brook, Illinois, United States to discuss a subject as hot as it is cool: alternative refrigerant technologies to HFCs, potent greenhouse gases that are primarily used as refrigerants in refrigerating and freezing equipment and as blowing agents in insulation foam, e.g. in refrigerators and freezers.

The parties were invited by the United Nations Environmental Programme (UNEP), the U.S. Environmental Protection Agency, Coca-Cola and McDonald's, the world's leading local food service retailer with more than 30.000 restaurants that serve 47 Million customers daily in 119 countries.

Social and environmental responsibility

From the beginning, McDonald's has been committed to social responsibility, a commitment that has become increasingly more important as the company's business has grown. For a long time this includes positive action towards environmental protection. McDonald's for instance was the first foodservice company to announce the phase out of CFCs in its packaging in the late 1980s.

On environmental issues McDonald's is working with expert advisers and its suppliers to make further changes so that, as the company puts it, “resources used to meet today's needs will remain available for the needs of future generations”.

While energy use is the McDonald's restaurant's primary controllable factor in minimizing the impact on climate change, the use of refrigerants is another factor. An average restaurant contains about 33,7 kilograms of cooling refrigerants – according to a Danish



Technological Institute study – most of which are hydro-fluorocarbon-based. The global warming impact of HFCs is 1.000 times that of CO₂. Most of these refrigerants are used and self-contained within equipment systems, meaning they are only emitted into the environment when there is leakage, improper repairs or disposal. In the restaurant industry, it is estimated that leakage occurs at a 5% to 7% annual rate – about 5 kilos per year.

McDonald's volunteers for a pilot project

The refrigerant meeting was a way for McDonald's to find out how the company can accelerate the process of finding sustainable refrigerant technologies, since it showed that for the restaurant industry such technology was not yet available for straightforward implementation or just emerging for evaluation. What was needed at this stage seemed to be an incentive for the refrigeration industry to develop alternatives and to provide them with a test ground. Thus the management of McDonald's decided to volunteer for a pilot HFC-free restaurant and challenge its suppliers to find acceptable alternatives to current technology by creating a demand for non-HFC-refrigeration. For the suppliers as well as McDonald's the restaurant is an ideal opportunity to test the new equipment under working conditions and systematically collect the data necessary to determine future applications and expansion of the new technology.

Denmark, the ideal country

Denmark was chosen as the most opportune country in which to locate the test restaurant since it had already started initiatives to phase out HFC refrigerants and legislation was well on the way. In Denmark also the advanced local refrigeration expertise was capable of dealing with the technological challenge.

Government support

In order to find the most efficient solution McDonald's worked in close collaboration with the Danish Ministry of the Environment, the Danish Technological Institute (DTI), and four Danish companies.

A small proportion of the equipment based on hydro-carbon refrigerants was already commercially available but the majority of equipment was developed especially for this project. The Danish Technological Institute (DTI) has participated as partner to several of the suppliers in development, testing and certification of most of the refrigeration systems used, and in their subsequent monitoring and energy study funded by McDonald's Corporation. The Danish Ministry of the Environment provided support to the restaurant project in the form of a DKK 1.000.000 (approx. \$160.000 USD or 135.000 Euro) development grant to one of the suppliers (Nilan).

“ McDonald's volunteered for a pilot HFC-free restaurant and challenged its suppliers to find acceptable alternatives to current technology by creating a demand for non-HFC-refrigeration ”

Seeing what's on the menu

Conditions, site, equipment, evaluation and results

Test conditions

McDonald's has a close and long-term relationship with all suppliers, built up over many years of shared growth and development. This enables the company to engage in discussion and dialogue to find solutions to common challenges. In this case, the challenge was to replace all current refrigeration equipment with safe and reliable technology operating on natural refrigerants that can further reduce the global warming effects on the environment. McDonald's also asked its partners that the appliances to be supplied should be equal or better in efficiency and that they hold cost at maximum five percent extra capital cost of their standard equipment.

Test site

Vejle was chosen for the pilot as the next standard restaurant to be opened in Denmark. A decision that was welcomed by the franchisee and its staff as both are proud to take part in a project that aims at improving environmental conditions.

As a benchmark, a comparable McDonald's restaurant using conventional HFC refrigeration was used.

Test equipment

Refrigerating and Freezing Equipment at the HFC-free McDonald's Restaurant:		
Equipment	Current refrigerant	Alternative Refrigerant
Soda Machine (Post Mix Type)	R404A	R290 (Propane)
Juice Dispenser	R134a	Propane
Milkshake and Ice-cream Machine	R404A	Propane
Meat Freezer	R404A	Propane
Wall-hung Freezer	R404A	Propane
Ice Cube Machine	R404A	Propane
Salad Refrigerator	R134a	R600a (Isobutane)
Refrigerating Room	R134a	Propane & Carbon dioxide (CO ₂)
Freezing Room	R404A	Propane & Carbon dioxide (CO ₂)
Air conditioning / Heating System	R407C	Carbon dioxide (CO ₂)



- The air conditioning and heating system is using a single reversible CO₂ Heat Exchanger System that can switch from heating to cooling mode on the temperature demand. The refrigerating and freezing rooms use CO₂ / HC cascade system. All other equipment is operating on Hydrocarbons as a refrigerant.
- The total charge of Hydrocarbon-refrigerants in the pilot restaurant is approximately 4,3 kilograms.
- The propane refrigerant used is also known as liquefied petroleum gas (LPG). The total amount of propane stored indoors does not exceed 3 kg corresponding to the contents of a small standard LPG container for use in caravans, etc.
- To ensure safety of the restaurant, employees, and customers the Danish Technical Institute was commissioned to perform a Risk Assessment and Equipment Verification Study. CO₂ and HC monitoring systems were also installed for additional added safety.
- Insulation in the equipment described is HFC-free.

Test evaluation

The purpose of the pilot test was to have a balanced and informed assessment as a basis for future developments and as a sound decision-making tool. The focus was put on the following aspects:

a Energy consumption is an important impact. Equipment using alternative refrigerants but using more electricity would be counter-productive. Therefore an energy study was performed by the DTI to validate energy usage compared to a standard HFC restaurant in nearby Esbjerg. To provide guidance on the global warming aspects, the TEWI (total equivalent warming impact), was calculated.

b Safety and reliability is a priority for all restaurants, the crew and the customers. The pilot provides experience on how safety aspects have to be addressed in the building, regarding training of the crew, handling and servicing of equipment.

c Legal issues: A further question to be answered is how does the new technology fit into current and future legal parameters, national and/or global.

d Costs have to be realistically assessed to be a commercially viable option.

Test Results

Life Cycle Analysis on a refrigeration plant will show that more than 90% of the environmental impact comes from the phase of operation (usage). The TEWI calculation defined for the test restaurant in Vejle was, therefore, a fairly good measure to establish the potential.

- Results have been very encouraging. The test restaurant consumed approximately 12% less electrical energy.
- According to the TEWI calculation, during summertime (4 months)/wintertime (8 months) the emission (kgCO₂) from the restaurant in Vejle were 19%/32% lower than the conventional restaurant in Esbjerg. Therefore, the emissions in lifetime for the restaurant in Vejle will be approx. 27% lower
- The energy study concludes that three out of ten pieces of refrigeration equipment account for 97% of refrigeration electricity usage. These are the HVAC (Heating, Ventilation and Air-Conditioning system), the freezer/cooler and the shake/sundae machines. McDonald's will focus most of its developmental work and testing on these three pieces of equipment. The most promising and challenging equipment from the HFC-free restaurant is the HVAC system.

- Although we learned much about CO₂ freezing technology, this new technology still needs to be optimized with greater efficiencies and proper component development. Also, the HC-refrigerant usage will need to be reviewed and changed to newer alternate refrigeration technology, if equipment is used in a global application.
- HC-refrigeration technology entails many safety aspects and regulatory hurdles, especially above the 150-gram charge threshold. With the new development in CO₂ technology, McDonald's will advocate CO₂ as a potential global solution.

	Control restaurant in Esbjerg				HFC-Free restaurant in Vejle			
	Refrigerant	Charge Warming Potential (gr)	Global (KgCO ₂ /Kg)	CO ₂ (Kg/CO ₂)	Refrigerant	Charge Warming Potential	Global	CO ₂
Post-mix	R404A	1616	3200	10601	Propane	646	3	4.0
Juice	R134a	155	1300	413	Propane	70	3	0.4
Shake	R404A	2835	3200	18598	Propane	1419	3	8.7
Meat freezer	R404A	270	3200	1771	Propane	100	3	0.6
Wall freezer	R404A	270	3200	1771	Propane	100	3	0.6
Ice cube	R404A	1200	3200	7872	Propane	450	3	2.8
Salad cooler	R134a	100	1300	267	Isobutane	40	2	0.2
Walk-in	R134a	10000	1300	26650	Propane	1000	3	6.2
HVAC	R407C	17000	3000	104550	CO ₂	12000	1	24.6
Direct emissions (kg CO ₂ in lifetime)	172493 12%				58 0%			
Indirect emissions (kg CO ₂ in lifetime)	Energy consumption (kWh) Per week In lifetime 2383 1858740 1208181				Energy consumption (kWh) Per week In lifetime 2202 1717560 1116414			
Total emissions	1380674				1116472			
Reduction in Vejle					19%			

Assumptions:

Leakage rate	7%/year	Recovery rate	0
Lifetime	15 years	CO ₂ emissions per kWh	0.65 kg CO ₂ /kWh



Placing the order

Equipment by supplier

The cool from within: Compressors and components for HC - and CO₂ - Systems by Danfoss

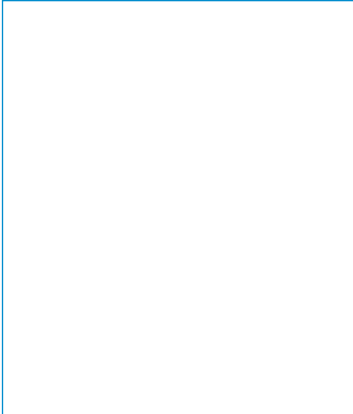
With headquarters in Nordborg, Danfoss is Denmark's largest industrial group and a world leader in research, development and production of mechanical and electronic products and controls. Founded in 1933, Danfoss now has 17 000 employees and produces ca. 500 000 products per day in 55 factories in 21 countries. Electronic frequency converters, intelligent refrigeration controls, radiator thermostats, compressors and thermostats for refrigerators and freezers are some of the products in the Danfoss range. According to Danfoss, the company is committed to global sustainable refrigerations solutions to reduce CO₂ emissions and particularly promotes development of safe hydrocarbon, CO₂ and ammonia systems with proven reduction of CO₂ emissions as alternatives to HFC refrigerants.

Throughout the McDonald's restaurant in Vejle a range of Danfoss products for both carbon dioxide and hydrocarbon refrigeration systems is incorporated. They are installed in the two heat pump units, the walk-in freezer-cooler unit, ice dispensers, meat freezers, post-mix soft drink machine, wall freezer and salad display merchandiser. The Danfoss products include compressors, expansion valves, solenoid valves and controls, both mechanical and electronic.

Danfoss supplied standard products incorporating current and proven technology to hydrocarbon applications. It also retrofitted the post-mix soft drink machine, converting it from R404A, a blend of HFC refrigerants, to propane refrigerant.

For the carbon dioxide refrigeration systems the company developed custom-made products since standard CO₂ products for transcritical applications such as these are not yet available. While the carbon dioxide refrigerant is simple to use in a sub-critical cycle, typically the low temperature circuit in a cascade system such as in a freezer, in a transcritical refrigerations cycle it reaches very high pressures up and above 100 bars where liquid and gas become indistinguishable. The transcritical cycle is used in applications such as water heaters or as an alternative to HFCs and hydrocarbons in vending machines. The operating conditions are so extreme that a completely new approach must be taken in design of both compressors and control equipment and systems.

For transcritical CO₂ applications Danfoss has therefore performed a feasibility study of a low capacity hermetic type compressor, based on an existing Danfoss HFC compressor platform. It has assembled and tested a number of these compressors in various running conditions. The compressors demonstrated acceptable compression performance as well as noise and vibration levels with no critical wear detected for any compressor parts. The CO₂ systems in the McDonald's restaurant should be regarded as working prototypes installed and approved on the basis of technology evaluation.



Danfoss believes CO₂ will have an important role to play alongside the other natural refrigerants, but “we are also acutely aware of the tasks involved in implementing this exciting new technology”, Henning Kaasen of Danfoss says. The group will continue its development of new controls and compressors for CO₂ systems and plans to supply standard approved CO₂ products as soon as possible. The HFC-free McDonald's restaurant project Danfoss regards as “a good example of how a client can influence development in natural refrigeration by a “pull effect”.

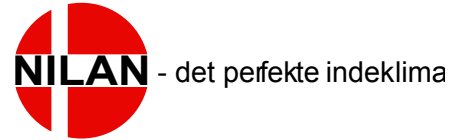
Schematic diagram of a hermetic compressor for CO₂ applications



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A chilling breeze from the North: HVAC with CO₂ technology by Nilan A/S

Nilan is Denmark's largest producer of reversible heat recovery aggregates for both private and commercial use. For the last decades the company has delivered approximately 275.000 units worldwide.

Commercial heat recovery aggregates from Nilan are found in many banks in Denmark as well as in McDonald's restaurants in Scandinavia. As refrigerants those HVAC units use R407C or other HFC-gas. For the McDonald's restaurant in Vejle, however, Nilan was asked to supply two units for heating, cooling and ventilation of lobby and kitchen that use natural refrigerants while keeping the energy consumption neutral compared to optimised HFC systems available.

Nilan converted the heat recovery aggregate VPM 600 with a cooling/ heating capacity of 25/30 kW respectively to use CO₂, because it is a natural refrigerant, neutral to the greenhouse effect and the ozone layer, nonflammable, nontoxic, heavier than air, has high volumetric capacity, low pressure loss and good heat transfer as well as high compressor efficiencies.

The system is constructed with two-stage expansion (i.e. a high and a low pressure valve) so that it is possible to operate both transcritical and subcritical. Due to CO₂'s high pressure up to 120 bar, all components have been redesigned compared to the current HVAC unit using R407C as refrigerant. The compressor is a newly developed piston compressor, the pipe system, valves and fittings are made of stainless steel and also the heat pipe is redesigned to withstand the high pressures.

"The construction and operation of these prototypes has and will give us a wealth of experience in carbon dioxide technology. Now we know how to build and operate a carbon dioxide HVAC system and since the launch of the McDonald's project we have had many enquiries from potential customers", explains Torben Andersen of Nilan A/S.

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Refreshing idea: HFC-free cooler by Vestfrost

Behind the counter of the McDonald's restaurant in Vejle sits a cooler with fresh salad and milk. It works without the HFC gas R134a, and is manufactured by Vestfrost, a company headquartered in Esbjerg, Denmark. Founded in 1963 the group now employs approximately 1400 people and sells about 800 000 refrigerators and freezers annually throughout the world.

Following an intensive development project in the late 1980s Vestfrost was one of the first companies to produce HFC-free coolers and has since then assumed the role of a pioneer in developing environmentally friendly coolers without greenhouse gas. Since 1994 Vestfrost has phased out the use of HFC as an isolating material, using a kind of vacuum soap with hydrocarbon instead.

For years the company also abstained from using HFC-gas as a coolant in products for private households. A novelty is the increasing phase-out of HFC-gas as a coolant in coolers for the commercial market.

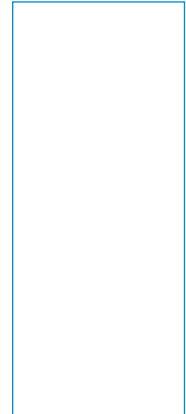
Vestfrost replaced the HFC-gas R134a with isobutane, R600a, for the following reasons: The environmental impact from one kilo isobutane is 760 times less than for one kilo R134a. The GWP (General Warming Potential) for coolers with isobutane is 20 percent less than for coolers with HFC because less coolant is used and the energy consumption is lower. HFC free compressors are in some cases cheaper than HFC compressors and energy consumption is significantly better. Therefore from the environmental as well as economic perspective isobutane is the better solution.

"It is impossible to pinpoint any advantage to products using HFC", Key Account Manager Torben Lauridsen of Vestfrost says. "At Vestfrost, there is no doubt that the coolers of the future will be without HFC".

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**Ice, Ice Baby:
Propane refrigerated ice machines by Scotsman**

Established in 1964, Frimont S.p.A. became Scotsman Europe in 1969 and is now part of the Enodis Group. The company's head office as well as one of the two European plants are situated near Milan. As a group Scotsman Ice Systems is the world leader in the Ice Makers industry with six production plants worldwide and 130.000 units produced a year.

"When asked by McDonald's to develop a prototype ice machine", Segment Manager Andrea Dellacà of Scotsman Europ says, "we undertook the challenge, because it is our philosophy to be a partner in our customer's growth and not a mere supplier."

The ice maker at the restaurant in Vejle is the MV21-HC, a modular air condensed ice machine that produces 22 kilos of ice in 24 hours. It is a modified version of the standard MV21-R404A using propane (R290) as a refrigerant. Among HC refrigerant gas, Scotsman found,

propane is the one whose thermodynamic characteristic suits the working temperature of this kind of application best. In fact, the prototype's performance is very similar to machines using an HFC refrigerant. Scotsman Europe then developed the TC180-HC ice dispenser by modifying the standard TC180-R134a.

Safety requirements for such compressor-type appliances with unprotected cooling system and flammable refrigerants ask for the electrical apparatus to be prevented from causing ignition of a surrounding explosive atmosphere. Therefore, Scotsman used components specifically produced for propane application, co-operating especially with Danfoss. While the MVH21 ice machine is now under test in Vejle, the TC180 is ready to start the test.

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**A smooth choice:
Combo-Softserve ice cream and shake machine
by Taylor (Carrier)**

The combination soft serve and shake freezer at the restaurant in Vejle is a prototype manufactured by the US supplier Taylor (Carrier). It was developed in collaboration with Taylor's Danish distributor and service representative Inter-Gastro, its compressor supplier Tecumseh, and technical and safety personnel from Carrier Corporation.

After careful consideration of the required performance of the freezer, the performance curves of the available alternatives to HFC refrigerants, and the mission timeline and objectives, Taylor chose to use propane (R290) as replacement for the HFC-gas R404A currently used in the combination soft serve and shake freezer.

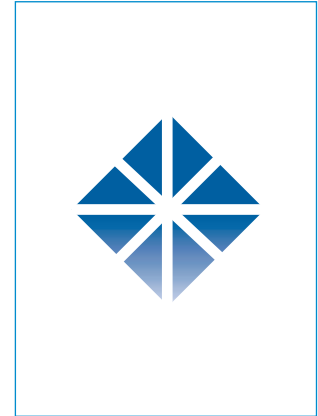
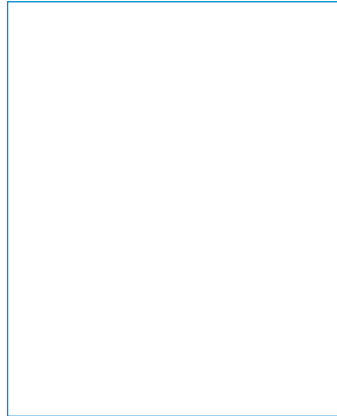
Taylor found the most time consuming and costly part of the conversion from R404A to R290 was due to the flammability of R290. The overall depth of the freezer had to be increased by 150mm to accommodate isolation of certain electrical components and a cabinet-ventilating fan had to be installed. These changes to the freezer as well as the installation of a propane detector in the restaurant were required in order to be compliant with all of the relevant EU safety directives.

"We believe the choice of refrigerant must be evaluated on an application-by-application basis, considering all relevant factors such as environmental protection, health and safety, energy efficiency, life cycle cost and local codes", Jack Esformes of Taylor explains. "There is no one refrigerant solution for multiple applications, but there can be multiple refrigerant solutions for the same application." Taylor will continue to invest in optimized HFC systems to deliver maximum energy efficiency while simultaneously pursuing alternative refrigerants. In addition to HFCs, Taylor believes Carbon Dioxide for soft serve and shake freezer applications can meet market demands for maximum performance, minimum equipment size, and minimum environmental impact.

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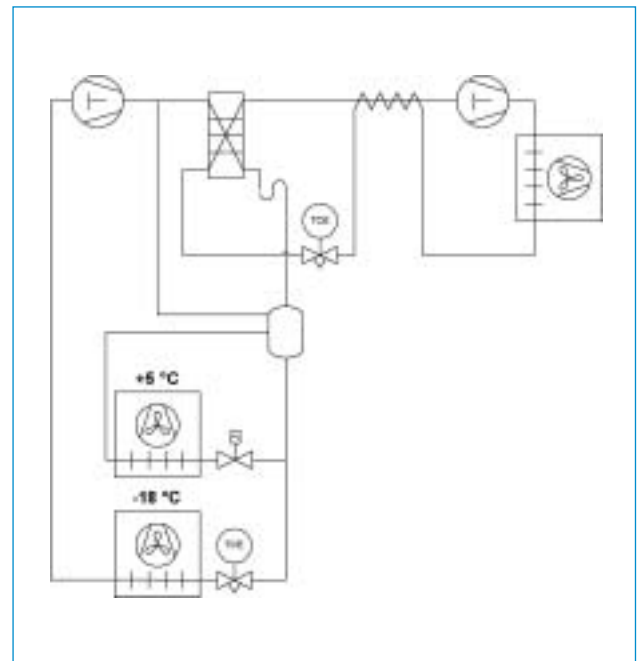


Step into the cold:
Walk-In Box by Fin-Dan

Situated in Allingåbro/ Denmark Fin-Dan supplies refrigeration systems for the Danish market since 1970. For three years the company is building refrigeration equipment using CO₂ and propane for supermarkets.

While current walk-in refrigerators use R134a and walk-in freezers R404A for refrigerants, Fin-Dan developed and provided a 40 bar CO₂/ propane unit for the "Fisher" +5/-18o C room. As shown in the diagram the propane system cools the CO₂ circuit, which cools the room.

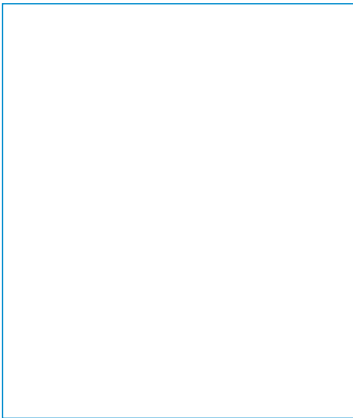
The company went for this solution because "it has a well tested layout and the components are available". For Fin-Dan transcritical CO₂ units "could be an alternative".



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Cold juice, cool choice:
Post-mix drink system and orange
juice dispenser by IMI Cornelius

IMI Cornelius is the world's leading supplier of complete solutions to the drinks dispense and food service markets. As a division of a UK-based international engineering solutions group, IMI plc, Cornelius forms an integral part of a global organisation that has a £1.6 billion turnover, 96 manufacturing and support locations worldwide, and 19,000 employees in 30 countries. The infrastructure of IMI Cornelius alone stretches across Europe, the Americas and Asia, with over 4,500 employees in 20 countries and 13 manufacturing locations in the US, UK, Germany, Spain, China and Mexico.

IMI Cornelius offers draught beverage dispensing and cooling solutions for soft and alcoholic drinks, food service equipment systems and point of purchase merchandising displays.

To the McDonald's restaurant in Vejle IMI Cornelius supplied the Apexx 6, Postmix Beverage Cooler/Soda Circuit System and the QLT-180, an Postmix Orange Juice Dispenser, both using propane as cooling agents and CFC free foaming agents.

IMI Cornelius have applied hydrocarbon gases because hydrocarbons have a minimal global warming potential and zero ozone-depleting potential. According to IMI Cornelius the technology also puts lower stresses on operating parts, allows cooler running temperatures on key components and targeted reductions in down time and all outs.

The selection of replacement refrigerants for specific applications, IMI Cornelius found, is usually based on matching vapour pressures, which will result in similar operating characteristics such as refrigerating effect and shaft power. The HC's have similar vapour pressures to those they replace, and do not require redesign or severe modifications to the above listed beverage cooling equipment.

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**Go for cold:
Meat and wall freezer by H&K International**

Established in 1930 Toronto, Canada, H&K International is now one of the world's leading international suppliers of commercial kitchen equipment, including food preparation lines, air extraction systems, refrigerated storage units and counter lines. H&K has manufacturing plants located in Europe, the USA, Mexico and Indonesia, with sales in excess of US\$200 million and over 800 employees. McDonald's, TGI Fridays, Subway, IKEA, IFS and other leading international foodservice brands and supermarkets all use H&K's services.

In 1998 H&K were instructed by McDonald's to provide mobile meat freezers plus wall mounted chillers and freezers for the Millennium Dome in the UK. This was later followed with the same instruction for the Olympic stadium in Australia.

At the time of the Dome, no major manufactures of compressors had purpose built units available for (system integrated) industrial use. To overcome this, H&K studied the international regulations and then converting standard Danfoss R404A systems to suit Propylene (R1270). This hydrocarbon was chosen as the hydrocarbon gas least likely to cause problem whilst moving into this partially unknown territory. An independent test authority to ensure conformity to international standards examined the H&K specials. These units have only recently been de-commissioned after 3 years of trouble free operation.

By the time of the Olympic Stadium in Sydney, Danfoss had developed their purpose built units for propane (R290) but did not have a matching condenser. The Freezers and chillers were shipped to Australia and subjected to rigorous independent tests to international standards by an independent test laboratory selected by the Australian Government. H&K were awarded certification of suitability by the Department of Fair Trading in New South Wales Australia.

The same type of equipment, mobile freezers and wall mounted units has since been supplied to the Danish restaurant in Vejle (In addition to the ozone friendly refrigeration gas, H&K introduced new insulation foam, which does not contain CFC or HCFC. It has an ODP (ozone depletion) of zero).

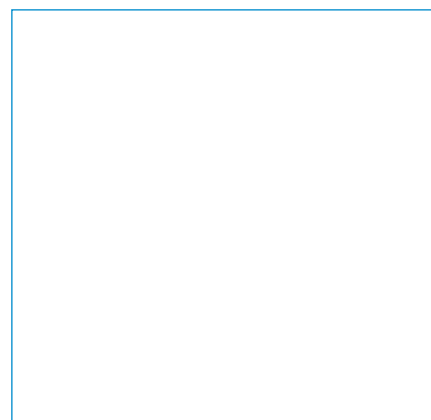
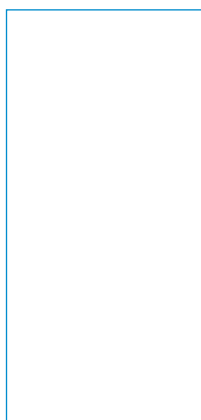
H&K consider that the most likely hydrocarbon gas that will be used where condenser assemblies are integrated in the equipment (non remote) and where the regulations state the charge must not exceed 150 grams per circuit (applies to McDonald's) will be propane because of compressor availability.

Using the H&K Mobile Meat Freezer (MF1) as an example:
Using standard R404A refrigerant gas = 270 gram charge
Using hydrocarbon R290 refrigerant gas = 100 gram charge

The hydrocarbon has a lower density, which means although the volume is the same the weight is considerably reduced. Hydrocarbon has a lower viscosity, which means it flows easier giving improved cooling efficiency assisting reduction in electrical power use of approximately 18%.

Contact:

sales@hki.com



A taste of things to come

The Future

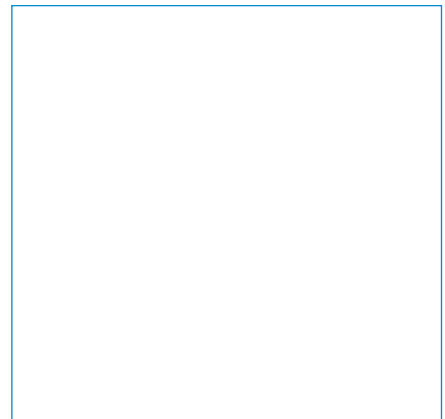
With McDonald's first HFC-free restaurant an exciting start has been made to finding viable alternatives to HFC-equipment and improving the overall impacts. The pilot project has also demonstrated what working together with all stakeholders can achieve on moving a common global issue forward. McDonald's has therefore decided to continue working on a HFC-free future, together with our worldwide suppliers, governments and NGOs.

McDonald's will focus on improving the pieces of equipment from the pilot program with the highest environmental and greatest energy-saving impact, i.e. the HVAC system, walk-in cooler/freezer and the Shake/Sundae machines. The research and development process with McDonald's suppliers is well-underway with a goal to find commercially viable alternatives. This R&D phase will take between 2 – 4 years, depending on production components availability, service network training, system optimization, laboratory test verification and the ability to meet pricing targets.

McDonald's will also continue to work with suppliers and partners to push for development of total alternate refrigerant solutions for all other equipment, which may be on the market even sooner.

It is not McDonald's immediate goal to open a second totally HFC-free restaurant, but to use the findings of this pilot test as a stepping stone to continue optimizing the individual equipment technology and introducing equipment items as they become viable. The next test phase will also include newer refrigeration technologies like CO₂, since there are market limitations for HC. This will be done on local, regional, and global levels depending on readiness of equipment and markets.

In summary, the results of the test have been very encouraging and has strengthened our commitment towards a HFC-free future.



Glossary

Carbon dioxide (CO₂)

A gaseous compound formed by, for example, combustion of carbon. Carbon dioxide contributes to the greenhouse effect.

Chlorofluorocarbons (CFCs)

A family of organic chemicals composed of chlorine, fluorine and carbon atoms, usually characterized by high stability contributing to a high ODP. These fully halogenated substances are commonly used in refrigeration, foam blowing, aerosols, sterilants, solvent cleaning, and a variety of other applications. CFCs have the potential to destroy ozone in the stratosphere.

Energy Efficiency – Coefficient of Performance (COP)

The energy efficiency or Coefficient of Performance (COP) of a refrigerating system is defined as the ratio between the refrigerating capacity of the plant, Q₀ (cooling/freezing capacity, kW) and the power/electricity consumption, p (kW) of the compressors and pumps. The COP is primarily depending on the working cycle and the temperature levels (evaporating/ condensing temperature) but also the properties of the refrigerant and system design and size. $COP = (Q_0/P)$

Global warming

The warming of the earth due to the heat-trapping action of natural and manmade greenhouse gases. Greenhouse gases emitted by human activities including CFCs and HCFCs, are believed to warm the Earth's atmosphere, leading to climate change.

Global warming potential (GWP)

The relative contribution of certain substances (greenhouse gases), e.g. carbon dioxide, methane, CFCs, HCFCs and halons, to the global warming effect when the substances are released to the atmosphere by combustion of oil, gas and coal (CO₂), direct emission, leakage from refrigerating plants etc. The standard measure of GWP is relative to carbon dioxide (GWP=1.0), which is consistent with the Intergovernmental Panel on Climate Change (IPCC) indexing approach. The GWP can be given with 20, 100 or 500 years integration time horizon. There is not a complete agreement within the scientific community on what is the proper time horizon, but 100 years is most commonly used.

Greenhouse gas

A gas, such as water vapour, carbon dioxide, methane, CFCs and HCFCs, that absorbs and re-emits infrared radiation, warming the earth's surface and contributing to climate change.

Hydrocarbon (HC)

A chemical compound consisting of one or more carbon atoms surrounded only by hydrogen atoms. Examples of hydrocarbons are propane, propylene and butane. HCs are commonly used as a substitute for CFCs in aerosol propellants and refrigerant blends. The hydrocarbons have an ODP of zero. Hydrocarbons are volatile organic compounds, and their use may be restricted or prohibited in some areas. Although they are used as refrigerants, their highly flammable properties normally restrict their use as low concentration components in refrigerant blends.

Hydrochlorofluorocarbons (HCFCs)

A family of chemicals related to CFCs which contains hydrogen, chlorine, fluorine, and carbon atoms. HCFCs are partly halogenated and have much lower ODP than the CFCs.

Hydrofluorocarbons (HFCs)

A family of chemicals related to CFCs which contains one or more carbon atoms surrounded by fluorine and hydrogen atoms. Since no chlorine or bromine is present, HFCs do not deplete the ozone layer. HFCs are widely used as refrigerants.

Liquefied petroleum gas (LPG)

Gas that occurs naturally as a constituent of wet natural gas or crude oil or produced as a by-product of petroleum refining.

Montreal Protocol

The Montreal Protocol, developed under the management of the United States Environment Programme in 1987, is an international environmental agreement that came into force on 1 January 1989. The protocol defines measures that Governments ("Parties") must introduce to limit production and consumption of substances that deplete the ozone layer. The Montreal Protocol and the Vienna Convention – the framework agreement from which the Protocol was born – were the first global agreements to protect the Earth's atmosphere.



Natural refrigerants

Naturally existing substances which are already circulating in the biosphere which can be used as refrigerants. Examples of natural refrigerants are ammonia, hydrocarbons (e.g. propane), carbon dioxide (CO₂), air and water.

Ozone

A reactive gas consisting of three oxygen atoms, formed naturally in the atmosphere by the association of molecular oxygen (O₂) and atomic oxygen (O). It has the property of blocking the passage of dangerous wavelengths of ultraviolet radiation in the upper atmosphere. Whereas it is a desirable gas in the stratosphere, it is toxic to living organisms in the troposphere.

OzonAction Programme

UNEP DTIE's OzonAction Programme provides assistance to developing country parties under the Montreal Protocol through information exchange, training, networking, country programmes and institutional strengthening projects.

Ozone depleting substances (ODS)

Any substance with an ODP greater than 0 that can deplete the stratospheric ozone layer. Most of ODS are controlled under the Montreal Protocol and its amendments, and they include CFCs, HCFCs, halons and methyl bromide.

Ozone depletion

Accelerated chemical destruction of the stratospheric ozone layer by the presence of substances produced, for the most part, by human activities. The most depleting species for the ozone layer are the chlorine and bromine free radicals generated from relatively stable chlorinated, fluorinated, and brominated products by ultraviolet radiation.



Ozone depletion potential (ODP)

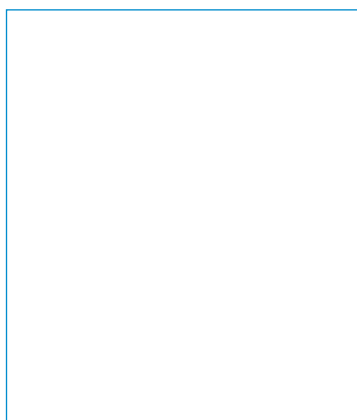
A relative index indicating the extent to which a chemical product may cause ozone depletion. The reference level of 1 is the potential of CFC-11 and CFC-12 to cause ozone depletion. If a product has an ozone depletion potential of 0.5, a given weight of the product in the atmosphere would, in time, deplete half the ozone that the same weight of CFC-11 would deplete. The ozone depletion potentials are calculated from mathematical models which take into account factors such as the stability of the product, the rate of diffusion, the quantity of depleting atoms per molecule, and the effect of ultraviolet light and other radiation on the molecules. The substances implicated generally contain chlorine or bromine.

Ozone layer

An area of the stratosphere, approximately 15 to 60 kilometers (9 to 38 miles) above the earth, where ozone is found as a trace gas (at higher concentrations than other parts of the atmosphere). This relatively high concentration of ozone filters most ultraviolet radiation, preventing it from reaching the earth.

Phase out

The ending of all production and consumption of a chemical controlled under the Montreal Protocol.



Propane

A gaseous hydrocarbon of the alkane series (C₃H₈)

Propylene

A member of the ethylene series (C₃H₆)

Refrigerant

A heat transfer agent, usually liquid, used in equipment such as refrigerators, freezers and air conditioners

Stratosphere

The part of the earth's atmosphere above the troposphere, at about 15 to 60 kilometers (9 to 38 miles). The stratosphere contains the ozone layer.

TEWI

$$\text{TEWI} = (\text{GWP} \cdot L \cdot n) + (\text{GWP} \cdot m \cdot (1 - \alpha_{\text{recovery}})) + (n \cdot E_{\text{annual}} \cdot \beta)$$

TEWI "total equivalent warming impact" [kg]

GWP "global warming potential" of refrigerant relative to CO₂ [kg/kg]

L yearly leakage rate [kg]

n lifetime of the plant [year]

m charge of refrigerant on the plant [kg]

α_{recovery} recovery rate when to plant is scraped [0-1]

E_{annual} annual energy consumption [kWh/year] CO₂ emission per kWh electrical production [kg/kWh] (0.65 in DK)

United Nations Environment Programme (UNEP)

UNEP, established in 1972, is the voice for the environment within the United Nations system. UNEP acts as a catalyst, advocate, educator and facilitator to promote the wise use and sustainable development of the global environment. To accomplish this, UNEP works with a wide range of partners, including United Nations entities, international organizations, national governments, non-governmental organizations, the private sector and civil society. The missions of the United Nations Environment Programme is to provide leadership and encourage partnership in caring for the environment by inspiring, informing, an enabling nations and peoples to improve their quality of life without compromising that of future generations. UNEP is one of the Implementing Agencies of the Multilateral Fund für the Implementation of the Montreal Protocol, along with UNDP, UNIDO and the World Bank.

UNEP TIE

United Nations Environment Programme Division of Technology, Industry and Economics (located in Paris, France) formerly called UNEP Industry and Environment Centre (UNEP IE).

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