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Dear Readers,

The international industrial refrigeration and air-conditioning branch is going through upheaval. In light of global climate change and the phase-out of HCFCs with their harmful impact on the ozone layer and on the climate, many operators are occupied with upgrading or completely replacing their existing systems. A growing number in both industrial countries and in the emerging markets are increasingly opting for natural refrigerants such as ammonia, carbon dioxide or hydrocarbons to enhance the environment-friendliness and sustainability of their systems.

In the USA for example there are signs of a development towards ammonia solutions or ammonia-CO_2 cascades in an increasing number of industrial refrigeration systems. This trend to natural refrigerants receives additional support from public and private environment initiatives for promoting energy efficiency in constructing new systems or upgrading existing facilities. The environment rating of these projects is improved simply by using natural refrigerants. Furthermore, natural refrigerants stand out not only by being environment-friendly – the global warming potential of ammonia is zero and that of carbon dioxide and hydrocarbons is negligibly small – but above all by being energy efficient. Systems with natural refrigerants need around 30% less energy than conventional solutions.

One positive trend in terms of using natural refrigerants can also be detected in emerging markets such as Brazil for example. Similarly to the situation in Europe, here too ammonia has been used for industrial refrigeration for many years, and operators in the sector of supermarket refrigeration also show a positive attitude to using natural refrigerants in the light of the climate discussions. Furthermore, the Brazilian government has spoken in favour of long-term solutions in the framework of climate protection and advocates the preferential use of natural refrigerants wherever possible.

By contrast, the situation for natural refrigerants in developing countries is still rather difficult. Reasons for the still small number of systems using natural refrigerants result primarily from inadequate experience and a lack of information regarding new technologies. It must be presumed that it will take a long time for developing countries to change to natural refrigerants in view of their poor economic situation and their low technical standards, in a process that can only become successful with intensive education work and technical support.

Our magazine "Refrigerants by Nature" aims to show that solutions with natural refrigerants are meanwhile available for practically every application. The magazine presents outstanding projects from a wide range of different branches, while the list of manufacturers and suppliers gives an overview of components and equipment for systems with natural refrigerants. Furthermore, it includes reports on international developments and trends in natural refrigerants and also features an interview with Dr. Lambert Kuijpers from the Technical University Eindhoven and Georges Hoetericx, member of the eurammon Board, about the impacts of the Copenhagen Climate Conference on the European refrigeration and air-conditioning industry.

We hope you enjoy reading the magazine and remain,

Yours sincerely,

Monika Witt
CEO, eurammon

Dr. Karin Jahn
Managing Director, eurammon

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Natural refrigerants: current developments and trends

The decision as to which refrigerant should be used in a refrigerating or air-conditioning system is based on the major criteria of safety, costs and environment protection. But against the background of constantly increasing energy prices, the energy consumption of a system also plays an increasingly important role. Ideally, the chosen refrigerant should have excellent thermodynamic properties, high chemical stability and good physical characteristics. Furthermore, it should have no or only a negligible impact on the environment, while also being inexpensive and available worldwide.

However, there is no one refrigerant that fulfils all these requirements. And so in practice, the decision for the most suitable refrigerant depends on a series of different factors. Here the operating area and the operator's requirements are taken into account, together with the installation site and environmental aspects. But it is above all the actual rating of the overall refrigerating system while taking account of part load conditions that has a crucial influence on energy consumption, as the overall concept of a refrigerating system has a greater influence on efficiency than the choice of refrigerant. However, a number of current projects show that systems operating with natural refrigerants are particularly efficient and environment-friendly.

Ammonia refrigeration convinces with top energy efficiency

Ammonia is the refrigerant with the demonstrably best thermodynamic properties. It is the only natural refrigerant that industry never wanted to dispense with on account of its high efficiency. Ammonia is also unbeatable in ecological terms: it has no ozone depletion potential and no global

Refrigerating and air-conditioning systems operating with natural refrigerants are particularly efficient and environment-friendly

warming potential (ODP and GWP = 0), with a favourable TEWI balance thanks to the high COP of ammonia systems.

In industrial systems with capacities exceeding 500 kW, ammonia is simply unsurpassed in terms of energy and cost efficiency. And it is also finding increasing use on a smaller scale, for example in systems with a capacity of less than 500 kW where the quantity of ammonia can be reduced when choosing a suitable secondary refrigerant. At present, intensive research is in progress here in particular in the range of small-capacity systems, with the objective among others of developing small, semi-hermetic and hermetic compressors with output below 100 kW. Reduced quantity heat exchangers are also being developed along the same lines. Furthermore, various research projects are also looking at simplified oil management with soluble oils to facilitate DX systems as well.

Moreover, today ammonia is also being used increasingly in areas that used to be dominated by synthetic refrigerants. For example, all large exhibition buildings in Germany have been equipped with ammonia liquid chillers for air-conditioning. Banks, insurance companies and office buildings also increasingly use ammonia liquid chillers for energy-saving air-conditioning. Even modern airports make increasing use of ammonia systems, in the light of risk analysis results indicating no greater hazard potential for the general public or airport employees than systems using synthetic refrigerants. And so ammonia systems have been installed not only in Düsseldorf's refurbished airport but also in London Heathrow's new Terminal 5 and in Zurich airport. The freight hub in New Zealand's Christchurch airport also saves energy by using ammonia for cooling systems.

Using carbon dioxide to save energy and money

The last ten years have brought about a constant increase in the interest shown in CO_2 refrigerating systems. This is due for example to the fact that the global player Nestlé has constantly forged ahead with the development of NH_3/CO_2 cascade refrigeration plants, demonstrating their energy efficiency with installations in Europe, the USA and Japan. Other companies have followed suit. In addition, this trend has been encouraged by state incentives in some countries. For instance, the Netherlands grant considerable tax relief for CO_2 systems, while taxation on synthetic refrigerants has been increased in Scandinavia. CO_2 is also particularly suitable for heat recovery or heat pump systems. Applications of this kind are already widespread in Asia and other countries can be expected to follow.

How much energy can actually be saved by using CO_2 as refrigerant depends above all on the ambient temperature. The efficiency of a CO_2 system is clearly superior to a plant operating with synthetic refrigerants when used in the subcritical range. But in the supercritical range too, success is also being achieved in optimising system efficiency. This has been confirmed among others by the Coca Cola Company which uses both CO_2 and R134a for its 550-litre refrigerators, with the result that the systems operating with CO_2 consume 20 to 30% less energy.

In the trans- or supercritical mode (temperatures > 31.2 °C), CO_2 systems are in principle less efficient than those using synthetic refrigerants. Even so, when viewed over the whole year, CO_2 refrigerating systems are frequently more energy-efficient than those with synthetic refrigerants, as most systems operate in the subcritical range most of the time, particularly in latitudes with moderate weather.

Climate-neutral cooling with hydrocarbons

Hydrocarbons such as butane, propane and propene are ideal refrigerants. Butane for example is very successful in the more than 300 million domestic refrigerators currently being used. Furthermore, butane can also increasingly be found in smaller commercial refrigerating systems. The beverages company Pepsi for example compared the efficiency of small drinks chillers with up to 150 g coolant and found that units operating with butane consumed up to 27% less energy than those using R134a. Since then, the beverages manufacturer has given preference to butane in these chillers – and is not the only one. Ben & Jerry used butane for their ice-cream freezers for the first time in the USA, with most satisfactory results.

Propane has very similar thermodynamic properties to R22. Some Asian countries have therefore replaced R22 with propane in central air-conditioning systems and report cut-backs in energy consumption between 10 and 30% with only minimum modifications necessary to the systems. Unilever has also recognised the advantages of propane as a refrigerant: already during the 2000 Olympic Games in Brisbane and Sydney the company performed a field study with 360-litre ice-cream freezers, comparing operation with propane to operation with R404A. On average, the propane freezers permitted energy savings of about 9%.

Hydrocarbons have excellent thermodynamic properties, which is why refrigerating and air-conditioning systems operating with these substances are particularly energy-efficient. They are well miscible with conventional refrigerating oils and have a relatively high critical temperature. While the flammability of hydrocarbons requires hermetically sealed systems with explosion protection for electrical components, all components are easily available and current technology copes well with the demands of safe operation. Given the high energy saving potential of systems with hydrocarbons, a number of companies have announced their intentions of operating new refrigerating systems with hydrocarbons.

In light of climate change, energy efficiency and reducing emissions of greenhouse gases are becoming ever more important

Natural refrigerants are inexpensive, available in abundance and can cover nearly every refrigeration application already today

Up to now, Europe has imposed a 150 gram filling restriction of hydrocarbons. However, this value was determined arbitrarily, so that it would be preferable to make the filling restriction dependent on the prevailing conditions in each case. Recommendations for such site-dependent limit values could be compiled and developed for example in the framework of a scientific research project. Larger filling quantities could probably be permitted if the propane filling is located up high on the roof of a building, or in large, well ventilated rooms.

In the USA there seems to be a willingness to rethink the situation: while the use of hydrocarbons was restricted hitherto to industrial applications, this restriction may possibly be lifted in future. For the first time, the US Environmental Protection Agency (EPA) with its highly critical stance on substances that pose a safety risk on account of the product liability laws, has approved of a field study that will test up to 2000 chest freezers operating with flammable refrigerants. This could lead to a real breakthrough.

Water refrigeration with up to 25% potential savings

The evaporation of water has always been used as a means of cooling. But this method that functions quite naturally in the human body through perspiration presents a challenge on an industrial scale. A huge flow of water vapour is needed to achieve an adequate cooling effect, which in turn requires the use of turbo-compressors. Suitable machines here consist either of axial compressors with a relatively small base area and many stages, or radial compressors connected in series. However, these are sensitive to load fluctuations and need operation to be as constant as possible. The situation is further complicated by the fact that operation takes place in a deep vacuum which requires a system that is absolutely tight. Even so, these stringent technical requirements are offset by huge energy saving potential of about 25% compared to currently available R134a liquid chilling units. This is why research is currently in progress in France and Dresden/Germany on prototypes for both radial and axial compressors.

Air: fast refrigeration at low energy costs

Air is interesting as a refrigerant for temperatures below -50°C. Systems with a closed air circuit are convincing above all on account of their particularly rapid cooling at low energy costs. But air has not become widely accepted as a refrigerant because of the comparatively high costs for the overall system. To achieve the necessary mass flow density, expensive turbo-compressor/expander systems are necessary together with special shaft seals to minimise leakage. However, at the same time air-cooled systems are also very compact. This is why today they are primarily used for gas liquefaction on tankers, where the high costs are justified in view of the confined space available.

Double advantage for the environment and corporate balance sheets

Natural refrigerants are inexpensive, available in abundance and can cover nearly every refrigeration application already today. Furthermore, they have a very low global warming potential (GWP) compared to synthetic refrigerants. This alone is reason enough to recommend their use. However, it is just as important that they are highly energy-efficient: after all, more than 80% of the global warming potential posed by refrigerating and air-conditioning systems results from system energy consumption and not from refrigerant leaks. At present, around 15% of global electricity consumption is used to generate refrigeration – resulting in huge savings potential. Measures to save energy throughout the entire service life of refrigerating systems are therefore acquiring increasing significance and can help considerably to relieve the burden on the environment. Here the use of natural refrigerants offers a double incentive for companies: by reducing their energy consumption, they not only cut back on costs but also help to protect the environment. And so in future, everything points towards the use of natural refrigerants in both ecological and economical terms, in order to safeguard both capital expenditure and the environment in the long term!

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Going green with natural refrigerants

The Bella Center in Copenhagen

Over the last years, the influence of sustainability as a design issue and the principles of green building have been gaining momentum. Builders and developers arround the world have to comply with internationally recognised eco-friendly specifications provided by the US Green Building Council's (USGBC) 'Leadership in Energy and Environmental Design' (LEED) rating system – the international benchmark for the design, construction and operation of high performance green buildings. Amongst other things, the LEED rating system demands zero use of CFC-based refrigerants in base building air conditioning systems. New buildings can improve their ratings by using refrigerants and air conditioning equipment that minimize or eliminate the emission of compounds which contribute to ozone depletion and global warming. In this context, natural refrigerants are a sustainable alternative. These refrigerants are climate neutral, as they have zero ozone depletion potential, and either do not contribute to the greenhouse effect at all – like ammonia – or only do so to a negligible extent, like carbon dioxide or hydrocarbons. Apart from this, they are very energy efficient. Due to their excellent properties, the use of natural refrigerants for building air conditioning is spreading in European countries already. Particularly ammonia is the refrigerant of choice in an increasing number of cases.

Economy as the deciding factor

The Baden-Württembergische Landesbank in Stuttgart, Germany has been continually upgrading its air-conditioning system since the late 1990s. At this point, eight liquid ammonia chillers by Grasso Refrigeration Technology supply cold water at specific temperatures: 6 °C in summer and 12 °C in winter. The water is used to air-condition the office space and cool the mainframe computers. The refrigeration machines are located on the top floor of the main building, while the Evapco evaporative condensers are mounted on the roof of the technology center. Cold water is extensively distributed to the bank and adjacent office buildings via a pipe network. Compact construction limits the ammonia charge per chiller to approx. 300 kg. One special feature of this cooling facility is free cooling: As soon as the outside temperature drops to 5 °C or below, cold water can be produced without involving the refrigeration compressors, thereby minimising the energy consump-

tion. Those parts of the facility containing ammonia are housed in gas-tight cubicles and are monitored by sensors. The facility has a total refrigeration output of over 15 MW.

Cooling Office Buildings

Roche Products, a global health care corporation, relies on a combination of ammonia and hydrocarbons. Its pharmaceuticals division, where products used in the prevention, diagnosis and treatment of disease are produced, is located at its British headquarters in Welwyn Garden City north of London. Roche has had a modern office building constructed here on nearly 22,000 m^2. To cool the rooms, the group wanted an energy-saving, sustainable solution, which was eventually planned and installed by Star Refrigeration. Two 930 kW ammonia chillers mounted on the roof of the building provide air-conditioning for the offices. In the summer the ammonia chillers can offset part of their heat rejection load by using borehole water pumped through an ancillary heat exchanger. This reduces the discharge pressure of the condensers and effectively increases the facility's efficiency. Three additional chillers run on hydrocarbons and cool the computer server rooms, with refrigeration output of 130 kW each. All five chillers are equipped with sensors to monitor their leak-proofness and an alarm system. A computer-based monitoring system guarantees the facility's reliability and operational readiness.

Baden-Württembergische Landesbank in Stuttgart

Heat pumps for the recource conserving use of energy

The 2009 United Nations Climate Change Conference, commonly known as the Copenhagen Summit, was held at the Bella Center in Copenhagen, Denmark, between 7 December and 18 December. The conference included the 15th Conference of the Parties (COP 15) to the United Nations Framework Convention on Climate Change and the 5th Meeting of the Parties (COP/MOP 5) to the Kyoto Protocol. As an example for the recource conserving use of energy in the city of Copenhagen GEA has installed an "Aquifer Thermal Energy Storage" (hereafter abbreviated ATES) with heat

Due to their excellent properties, the use of natural refrigerants for building air conditioning is spreading in European countries already

Ammonia (NH_3)

Ammonia has been successfully used as a refrigerant in industrial refrigeration plants for over 130 years. It is a colourless gas, liquefies under pressure, and has a pungent odour. Ammonia has no ozone depletion potential (ODP = 0) and no direct global warming potential (GWP = 0). Thanks to its high energy efficiency, its contribution to the indirect global warming potential is also low. Ammonia is flammable and is toxic to skin and mucous membranes. However, its ignition energy is 50 times higher than that of natural gas and ammonia will not burn without a supporting flame. Due to the high affinity of ammonia for atmospheric humidity it is rated as "hardly flammable". Ammonia is toxic, but has a characteristic, sharp smell which gives a warning below concentrations of 3 mg/m^3 ammonia in air possible. This means that ammonia is evident at levels far below those which endanger health. Furthermore ammonia is lighter than air and therefore rises quickly.

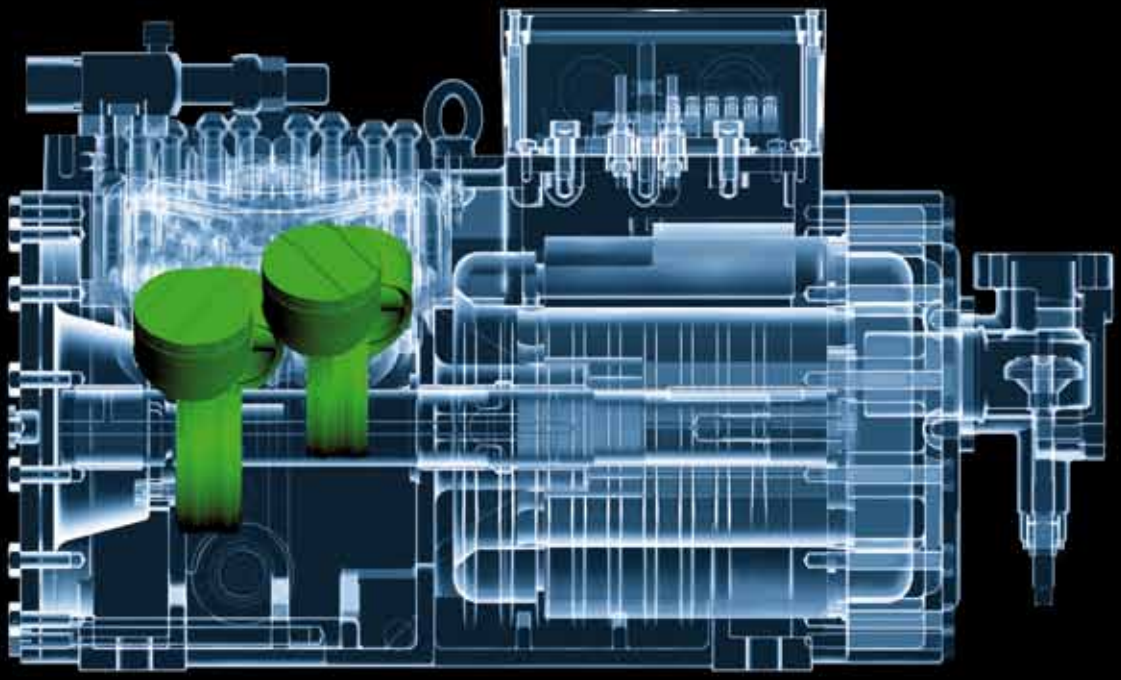
pumps for combined cooling and heating for a 58.000 m² building used as hotel and conference centre in Denmark. The system provides 4.1 MW of cooling and 2.9 MW of heating. During the summer, the system uses deep level groundwater from "cold" wells to provide cooling to the buildings. The heated groundwater is re-injected into "warm" wells and stored underground. During winter, the cycle is reversed and the water is pumped from the warm well and cooled down by the ammonia heat pumps. The chilled water is stored in the "cold" well to be used the next summer. The heat recovered by the heat pumps is used for the heating systems for the buildings. The system reduces the total energy consumption of heating and cooling for the buildings by 70%. It's also expected that the entire heating capacity will be provided by the heat pumps, totally eliminating emissions by gas- or oil fired boilers. In order to maximise energy savings, achieve high heating temperatures and prevent emissions of chemical refrigerants, the ammonia heat pumps are of an optimised design with screw compressors, cascade coolers and frequency controllers. The project is the first installation of its type in Denmark.

top: Machine room with heat pumps for combined-cooling and heating

below: Gree air-conditioners using propane

Making air-conditioning systems environment-friendly

The Chinese air-conditioning system manufacturer Gree Electric Appliances is one of the companies using propane to replace R22 and R410A in new systems. The company is one of the world's largest manufacturers of room air-conditioners with a production output of more than 70 million units a year. The Chinese use HCFC R22 as a standard refrigerant, but these refrigerants make a considerable contribution to global warming as well as destroying the ozone layer. Altogether, China's air-conditioning systems generate annual HCFC emissions amounting to 260 million t of carbon dioxide equivalent, thus constituting one of China's largest source of emissions. This is why in late 2009, Gree, assisted by the implementing agency GTZ Proklima, started pilot production of room air-conditioning systems based on propane. The quantity of refrigerant ranges from 200 to 350 g for rated cooling capacities of 2 to 4 kW, depending upon the model. Significantly, the air-conditioners have a higher efficiency than both R22 and R410A models, whilst requiring a smaller mass of system materials. In addition to the reduced charge size, GTZ Proklima with UK-based consultant Daniel Colbourne, assisted with the safe design of the air-conditioners. A production line will turn out 180,000 systems per year. The change-over in refrigerant will save 560,000 t of carbon dioxide equivalents in direct emissions over the entire service life of the air-conditioning systems. To this should be added a further 320,000 t of carbon dioxide equivalents in indirect emissions saved by the improved energy efficiency of the systems. For the final consumer, this benefits in terms of lower electricity bills.



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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 kg 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. So refrigeration specialists Knudsen Křling designed a refrigeration system that uses two refrigeration circuits linked 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 dissipation.

The first temperature level is needed in frozen food cabinets and the deep freeze chambers in the cellar. At an evaporating temperature of -28 °C, the carbon dioxide is used to maintain an ambient temperature of -20 °C. The second temperature level is used for refrigerators and cold stores requiring an air temperature of a few degrees above 0 °C. This is achieved by supplying the evaporators with carbon dioxide at an evaporating temperature of

-10 °C. The third and highest level ensures reliable heat dissipation by condensation or gas cooling, depending on the ambient temperature. Overall the cascade system has a refrigeration capacity of 150 kW.

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 high noise-control 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 5.600 m^2 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 good 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 cools 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 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-

Carbon dioxide (CO_2)

Carbon dioxide is known in refrigeration technology as R 744 and has a long history extending back to the mid 19th century. It is a colourless gas that liquefies under pressure, with a slightly acidic odour and taste. Carbon dioxide has no ozone depletion potential (ODP = 0) and negligible direct global warming potential (GWP = 1) when used as a refrigerant in closed cycles. It is non-flammable, chemically inert and heavier than air. Carbon dioxide has a narcotic and asphyxiating effect only in high concentrations. Carbon dioxide occurs naturally in abundance.

Supermarket refrigeration can be environmentally friendly too. Intensive research and development in recent years has made the use of carbon dioxide feasible in a wide range of applications

High temperature R1270 compressors

top: Green cooling with a transcritical carbon dioxide refrigeration system

middle: Refrigeration system operating on carbon dioxide and R1270

below: The evaporator by Güntner function as a gas cooler

The use of carbon dioxide makes for energy-efficient refrigeration plants and only makes a negligible contribution to the greenhouse effect

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. 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.

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Whether you're dealing with cheese, meat or fruit – when it comes to perishable products, freshness is the top priority. To meet the high quality standards associated with such products, impeccable refrigeration must be ensured throughout the supply chain – beginning with production and intermediate storage and ending with the point of sale. To achieve this the food and beverages industry depends on the industrial production of cold energy. The use of natural refrigerants offers potential for saving energy by up to 30%, thanks to their high energy efficiency. Ammonia for example is acknowledged to be the most efficient refrigerant, which also has a positive effect on the carbon balance. In addition, the industrial production of ammonia, carbon dioxide & co. is less energy-intensive and therefore less costly than that of synthetic refrigerants – advantages that operators, refrigeration system engineers and planners are showing signs of appreciating to an increasing extent.

Fresh fruits and vegetables from farm to store to consumer

The international logistics services company Gartner KG, headquartered in Lambach, Austria, has recently begun operating a modern distribution center for fruits and vegetables in Kehl, Germany. A long-lasting and dependable refrigeration plant with low energy consumption and environmentally friendly with a sustainable refrigeration concept were the key specification requirements. The cold store has been designed by KWN Enginieering GmbH according to state-of-the-art technology using the natural refrigerant Ammonia (NH_3) R717 in the chillers and complies with the requirement of the customer for a long-term environmentally friendly refrigeration concept. The system uses a secondary loop to distribute the energy to the cooling points, the food-safe coolant propylene glycol is the secondary refrigerant fluid. The chillers generate cold using two separate liquid cooling units from Grasso in flooded operation – two NH_3-reciprocating compressors with 220 kW and two NH_3-reciprocating compressors with 640 kW. Heat is removed via an evaporative condenser from Evapco that is situated directly above the chiller units. In designing the plant, special consideration was given to the very low partial loads which can occur in a food storage facility. The air coolers from Güntner used in the stock area are speed-controlled and can be regulated individually. The plant designers made sure that air distribution was constant and with no blockages, even though high humidity is possible. In selecting a suitable piping system for the refrigerant, several criteria were decisive, namely; long lifetime, efficiency, light weight and ease of installation. Due to its excellent price and performance ratio the pre-insulated plastic piping system Cool-fit from Georg Fischer was chosen. The system consists of fittings and pipes, pre-insulated by the manufacturer, which can be installed easily with a simple reliable pipe jointing technique. The piping systems was installed in the mechanical equipment room without pre-insulation. These ABS fittings, pipes and valves (butterfly valves, filters, compensators) were postinsulated using a rubber based insulation. With this new distribution centre, the

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ammonia evaporators manufactured by Güntner

single-stage screw compressors made by Grasso

Gartner company has constructed a state-of-the-art cold store with lowest possible carbon foot- print cost effectively.

Consistent refrigeration for guaranteed freshness

For meat-processing companies, it is particularly vital to maintain the cold chain throughout all phases of production. In order to fulfil this demand, KÄLTETECHNIK Dresen + Bremen planned and produced a modern refrigeration system for the new building under construction for Großmetzgerei Gruninger [industrial butcher], thus providing provide optimum temperatures in all production areas. The refrigeration supply system for the entire production area was successfully commissioned in April 2010, consisting of a complex NH_3/glycol refrigeration system with total refrigerating capacity of 1,800 kW. The condensation energy generated by operation of the refrigeration system is recovered for the most part and used for heating purposes and for producing hot water. Speed-controlled screw compressors in a combined system ensure maximum operational reliability. One special feature includes equipping the production rooms with a system for intensive dehumidification after wet cleaning. The refrigeration system is fitted with a process control unit with network link and remote data transmission for simple, clearly structured operation and monitoring. Altogether the refrigeration system with 69 air coolers is responsible for the production rooms together with the chilled, deep-freeze and storage rooms with a total surface area of 6,000 m^2. Corresponding distribution takes place through a ramified glycol cooling and heating circuit in the technical mezzanine with a total volume of approx. 25,000 l. Actual refrigeration takes place in the central machine room using the economical natural refrigerant ammonia (NH_3) with a filling of 2,500 kg.

Fruit Storage delaying the ripening of fruit The British fruit grower Mansfields stores apples and cherries in a controlled atmosphere so that they will be available in top quality all year round regardless of when they were picked. State-of-the-art measuring, control and refrigerating systems monitor temperature, humidity, oxygen and carbon dioxide levels, keeping them at the required level to delay the ripening of fruit and vegetables. Mansfields wanted an efficient, HFC-free refrigeration system for the warehouse in Chartham near Canterbury. The refrigeration experts International Controlled Atmosphere Storage and SRS Frigadon designed a propane secondary refrigerant system completed in 2008 with an output of 1,150 kW. Five air-cooled factory-assembled packages charged with altogether 90 kg propene provide refrigerating energy for the secondary circuit at a temperature of -9 °C. The special safe design of these chillers and a detailed safety analysis was provided by Re-phridge. A brine mixture of water and salt is used as the secondary refrigerant. The circuit is filled with 30,000 l and works at an operating pressure of only 1.5 bar to cool the heat transfer fluid down to -3 °C. The brine is pumped to the 36 controlled atmosphere cold storage rooms which are kept at a constant air temperature of -0.5 °C and 1.5 °C. The secondary refrigerant also cools the preparation and loading areas. The evaporators in the warehouses are defrosted by Off Cycle Defrost. This entails interrupting the refrigeration process so that the brine absorbs heat from the ambient air which is used for defrosting. This method prevents the products being cooled from absorbing unnecessary heat and saves energy. The system design minimises the quantity of refrigerant and guarantees an ESEER (European Seasonal Energy Efficiency Ratio) of more than 4.2, although based on local conditions the real seasonal cooling COP (coefficient of performance) is around 6.

Energy-efficient milk processing

The milk factory Sitnikov in Siberia is a major processing company in East Russia. To replace the previously used synthetic refrigerants, refrigeration is now to be converted to an environment-friendly, economically efficient solution. The operator defined the technical capability in precise terms, specifying the need for a refrigeration system that cools 80 m³ of water from 8 to 2°C every hour for the processing and storage of dairy products.

The core of the new refrigerating system consists of two screw compressors by Bitzer, installed as a twin pack on a joint rack. The 586 kW ammonia plant has a charge of 300 kg and it's design operating conditions are an evaporation temperature of -2°C and a condensing temperature of +35°C. Use of the highly efficient refrigerant ammonia has cut power consumption by 30% compared to systems with synthetic refrigerants. The operator deliberately chose two small screws compressors instead of one large machine so that production can be maintained if one of the two compressors be out of operation. The twin compressor solution also facilitates more precise capacity control, reaching the full COP (Coefficient of Performance) of 4.46 even for a utilisation rate of only 50%. Other important components in the system include an economiser, a flooded evaporator with pumped refrigerant circulation, condenser and programmable control. The compressor oil is cooled using a water cooled heat exchanger. The new refrigerating system has been running free of any interference since mid 2008.

top: Machine room with NH_3/glycol refrigeration system

below: distribution center for fruits and vegetables

Natural refrigeration of meat and sausages

The Volkovysk combine is one of the 10 largest meat processing factories in Belarus. Every year around 60,000 t of meat are processed here to make products such as mincemeat, sausages and meatballs. More than 300 meat and sausage products are cooled with the natural

refrigerant ammonia. The original factory (founded in 1964) was to be modernised and extended during on-going production. To fulfil the high demands resulting from correct storage of the products, the operators instructed Güntner to equip the deep-freeze rooms. To this end, Güntner supplied 14 ammonia evaporators mounted under the ceiling on stainless steel frames. The evaporators hold the room temperatures in the various deep-freeze storage areas at a constant -5, -10, -30 and -40 °C. The total capacity of the evaporators is 8,700 kW. 50 t of ammonia circulate through the central refrigeration system, while the secondary refrigerant circuit operates with 600 kg of refrigerant. Volkovysk completed the extensive modernisation work in 2008. A similar solution with ammonia evaporators by Güntner has also been implemented for the Belarus meat combine Vitebsk.

Meat production with natural refrigerant

CHI Pharmaceuticals Limited as a member of Tropical General Investment (TGI) has a very strong presence in vital sectors of Nigeria's economy like Fruit Juices, Dairy products, Food processes, Pharmaceuticals and Health care.

It has built a new meat production factory in Lagos to supply food retailers in the regional market. For reasons of energy efficiency and sustainability this new plant has been built with ammonia as natural refrigerant. GEA Grasso as a strong partner installed for cooling the deep cold storages of approx. 870 m^2 and the production area of approx. 834 m^2 a two-stage cooling plant. The low stage side has a cooling capacity of 112 kW and supplies the cold rooms with direct ammonia. For the production area was used a glycol system with 130 kW. To provide the needed capacity four GEA Grasso piston compressors were installed. For safety reasons one high stage compressor can be used also for the low temperature circuit. A heat exchanger manufactured by GEA Ecoflex produces cold glycol for the glycol circuit. Furthermore the heat is rejected by an evaporative condenser. Although there are no strict regulations in Africa for cooling plants the new plant fulfills the high European standards.

The use of natural refrigerants offers potential for saving energy by up to 30%, thanks to their high energy efficiency

Cheese and Power Drinks cooled naturaly

Kraft Foods is one of the companies that have opted for natural refrigerants. The international food and beverage company, well known for its brands such as Philadelphia cheese, Miracle Whip mayonnaise and Jacobs coffee, has built a new production plant for cheese products and powdered drinks in Bahrain, from where it will supply food retailers throughout the Middle East with Kraft Foods products. Since the operator places great importance on economical and sustainable refrigeration, Johnson Controls installed an ammonia refrigeration system. At the heart of the facility is a machine room with ammonia refrigeration units that chill cold water to a temperature of just 2 °C by cooling the ammonia, which has a total refrigerating capacity of 8,000 kW, and evaporates at 0 °C. The coolant is distributed to the various users via a network of pipes, where it absorbs the heat generated by the manufacturing processes. Other components of the system include four screw compressors, some of which are speed-regulated, two plate heat exchangers, one gravity-driven separator and three evaporative condensers. The refrigeration plant for the approx. 60,000 m^2 production plant was put into operation in late 2007.

Storing fruit at controlled temperatures

The fruit and vegetable wholesaler Iran Dubai Co. operates numerous cold stores and distribution centres throughout the Middle East. At its site in Bushehr, an Iranian port on the Persian Gulf, the existing warehouse needed to be enlarged and converted into a cold store. For the conversion 33 ammonia evaporators manufactured by Güntner, specially designed for high-pressure operation and no more than 4.5 m long, were used. The reason for this was that the units needed to be fitted on brackets at a specific height on the walls, which meant that the wholesaler was particularly interested in a compact yet high-performance solution. The warehouse, which covers an area of 3,700 m^2, consists of several cold storage chambers, each at a different temperature, ranging from -25 °C to 0 °C up to 15 °C The evaporation temperatures thus range from -33 °C to 5 °C, with a refrigerating capacity of about 50 kW per unit. There is a separate storeroom for bananas that is kept at a temperature of 13.5 °C. Here, the evaporation temperature is 7.5 °C at a refrigerating capacity of 123 kW. Any parts of the system that are iced up are defrosted using hot ammonia gas.

Freshness Wins

Del Monte, a leading international fruit producer and beverages company, has built a new fresh fruit, juice and salad production facility in Dubai. The facility, which covers some 30,000 m^2, consists of several air-conditioned production lines, a cold store and a cooling chamber, where 4,500 t of fruit and vegetables – including the sweet Gold Pineapple – ripen each year. The refrigeration for the facility is provided by an indirect ammonia refrigeration system with a refrigerant circuit, which serves to further maximise the high efficiency of this natural refrigerant. The system's circuit is charged with 4,000 kg of ammonia. The heated gas is condensed at 40 °C by an evaporative condenser. Water is used as the coolant for the high-temperature reactor, and glycol for the low-temperature zone. The cooling is provided by two plate heat exchangers. At the high-temperature level there are three single-stage screw compressors made by Grasso, each with a refrigerating capacity of 630 kW and an evaporation temperature of 1 °C. This circuit provides water chilled to 6 °C, which is used to cool the higher-temperature cold stores, corridors and for the air-conditioning system as well as to pre-cool the glycol coolant for the low-temperature zone, which also uses three single-stage screw compressors made by Grasso. Its evaporation temperature is -16 °C and the refrigerating capacity of the compressors is slightly lower, at 600 kW per compressor. The low-temperature level supplies glycol chilled to -10 °C to the processing rooms and cold stores. A seventh screw compressor can also be activated in the event of mechanical failure, to ensure that production continues uninterrupted.

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Winter sports fun all year round, thanks to natural refrigerants

indoor snow park "Ski Dubai"

Ice skating, ice hockey or skiing: winter sports are extremely popular with young and old. And fans don't have to wait for the winter to enjoy their favourite sports. Ice rinks and indoor skiing slopes offer winter sports fun every day of the year. But the operators of sporting facilities in need of refrigeration are facing new challenges. According to the EU regulation on substances that cause degradation of the ozone layer, since January 2010, only reconditioned HCFCs may be used in refrigerating and air-conditioning systems. This period then ends in 2015. From then on, all HCFCs are prohibited in refrigerating and air-conditioning systems. One possible solution for modernizing the systems consists of natural refrigerants, such as ammonia, carbon dioxide or hydrocarbons, with convincing properties such as sustainability and economic efficiency. Ammonia for example is acknowledged to be the most efficient refrigerant, as reflected in the low operating costs for users. In addition, ammonia systems relieve the pressure on the environment, as the refrigerant does not make any contribution to the greenhouse effect.

Making intelligent use of waste heat

The "Curl Aberdeen" ice rink in Summerhill, Aberdeen, is one of the centres for Scotland's traditional winter sport of curling, and is an example of how such facilities can benefit from the advantages of the natural refrigerant ammonia. The ice rink has a total ice surface of around 1,350 m^2 and is also used for public ice skating. In order to cut back on the increased operating and maintenance costs, the operator instructed the company Star Refrigeration to plan and install an efficient system running on natural refrigerants. With close to 40 years experience, Star has provided high efficiency cooling solutions to around 70% of the UK's ice and curling rinks. For "Curl Aberdeen", Star Refrigeration designed a refrigerating system to provide cooling to the rink floor. This includes a critical charged refrigeration plant with a mere 80 kg of ammonia and a glycol circuit which is connected to the refrigerant circuit by means of an evaporator. The system has a refrigerating capacity of 253 kW to cool the secondary refrigerant glycol to -10 °C before it is pumped through a network of pipes integrated in the floor of the rink. In this way, the cooling system fulfils the high demands made of the ice surface in terms of constant quality, hardness and temperature. The main components of the refrigerating machine that is

pre-assembled in the factory include two reciprocating compressors, an accumulator on the intake side, two glycol pumps, two drive motors and an electronic control panel. A desuperheater on the high-pressure side makes thermal use of the compression heat of the refrigerant. The energy recovered in this way is used for the underfloor heating of the remaining facilities apart from the ice rink itself. The refrigerating system is also equipped with an external evaporative condenser which condenses the refrigerant; this unit is accommodated on separate grounds next to the main building.

Skiing in the desert

A similarly designed system has been installed in the world's third largest indoor snow park "Ski Dubai". As the main attraction of the Mall of the Emirates shopping centre in Dubai, "Ski Dubai" offers a wide range of winter sporting activities for up to 1,500 visitors on premises covering 22,500 m². The snow park offers five skiing slopes, covered with more than 6,000 t of snow. Energy-efficient cooling of the snow is provided by an ammonia refrigerating machine with a capacity of 2,600 kW. The snow is cooled by a glycol circuit which is connected to the refrigerant circulation of the machine by two Alfa Laval plate heat exchangers. At an evaporation temperature of -22 °C, the ammonia cools the secondary refrigerant to -15 °C. The glycol is then transported through a piping system 100 km in length that runs through the building floor under the layer of snow which is one metre thick. This ensures that the snow foundation remains frozen. In addition, the glycol circuit feeds the 29 air coolers in the ceiling of the building, which keep the temperature in the snow park at a level of -1 to -2 °C during opening hours. After midnight, the air temperature is lowered to -8 °C for production of 30 t of new snow, which happens every night. Water is cooled down to 1 °C in a water chiller and then pumped to the snow canons. These inject the water into the cold air in the building, where it crystallizes and forms snowflakes. The heart of the refrigerating machine consists of three Grasso screw compressors. A computer control system adjusts the output of the compressors exactly to the refrigerating demand, thus reducing their energy consumption. Further potential for saving energy is offered by the insulation which turns the snow park into a giant cool box. Walls that are five metres thick warrant that the generated cold remains in the building, keeping the snow park at low cost at temperatures below freezing point. In this way, energy accounts for less than 10% of the total operating costs. The whole refrigeration process also benefits the adjoining Mall of the Emirates: the 30 to 40 t of "old snow" which are replaced by new snow every night in "Ski Dubai" are recycled to water in a melting pit. The cold water is then used for air-conditioning in the shopping centre and for irrigation of the adjoining gardens.

One-stage screw compressors by Bitzer

left: Glycol with -10 °C is pumped through a network of pipes integrated in the floor of the "Curl Aberdeen" ice rink

right: Main components of the ammonia refrigerating machine

Environment-friendly modernization of the ice stadium

Tingvalla Ice Stadium in Karlstad, Sweden, is Europe's largest open air stadium with an ice rink measuring 65 x 180 m. It is used for bandy, a version of ice hockey that is popular in Scandinavia and Russia. The stadium's refrigerating system has been completely renewed to safeguard the refrigeration concept for the years to come. Francks Kylindustri was instructed to plan and carry out the work. The task facing the contractor consisted in safeguarding operation at outside temperatures of 12 °C, keeping the ice temperature at a constant -4 °C. Further demands made of the refrigerating machine included high energy efficiency and low operating costs, together with minimum maintenance. The Swedish solution was designed with a cascade system using 1.3 t of ammonia as refrigerant and 16 t of carbon dioxide as secondary refrigerant with partial evaporation. The refrigerant cools the carbon dioxide at an evaporation temperature of -12 °C. The carbon dioxide is stored in four accumulators which are connected with the ammonia system by heat exchangers. This condenses the secondary refrigerant which comes back partially evaporated from the four separately switched cooling circuits measuring 65 x 45 m, installed underneath the ice surface. Cold production on the ammonia side is generated by three one-stage screw compressor combined sets with a total refrigerating capacity of around 2,300 kW and a pumping volume of 4,100 m^3 per hour. Altogether, ten open screw compressors by Bitzer are used: two of the combined sets have three compressors each, the third set has four. Each compressor is directly coupled to a drive motor with a rated output of 110 kW. The motors are in the highest energy efficiency class. Each set is equipped with a multi-stage oil separator with a separating volume of 700 dm^3. To cool the oil, each set is connected to a joint ethylene glycol circuit by means of a plate heat exchanger. The ethylene glycol is pumped to a central recooler on the roof of the machine house where it cools down against air. The combined sets drain the ammonia evaporator through a central intake pipe; the evaporator works in flooded mode for the highest possible thermodynamic efficiency. Three wet cooling towers connected in parallel positioned outside next to the machine house are responsible for condensing the ammonia.

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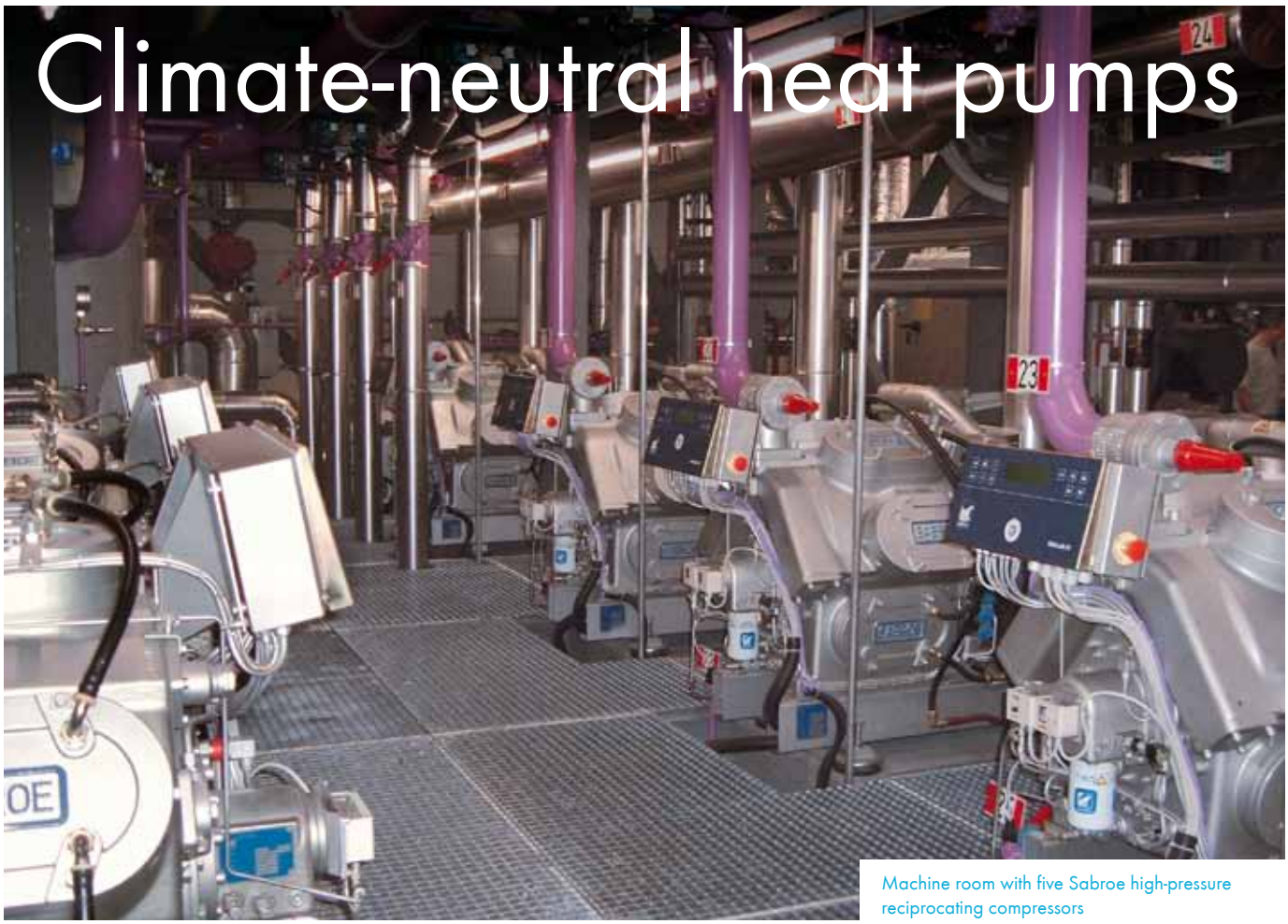
Climate-neutral heat pumps



Machine room with five Sabroe high-pressure reciprocating compressors

Heat pumps in the private sector normally use geothermal energy or the ambient air as energy source. By contrast, large heat pumps in industry, retail and trade can revert to sources such as waste heat from refrigeration and air-conditioning, discharged process waste air or wastewater with a higher temperature level. It is therefore possible to achieve using heat pumps far higher water outlet temperatures with the same energy input, thus expanding the range of possible applications and avoiding increased carbon emissions. Given the growing significance being attributed to energy efficiency and to protecting resources, the heat pump sector is now also making increasing use of the potential offered by natural refrigerants such as ammonia, carbon dioxide or water as working substances.

The energy supply system for Mülligen letter sorting centre was planned and installed by ewz (Zurich municipal utility company). The system is owned and run by ewz. Mülligen letter sorting centre is part of Energieverbund Schlieren (Schlieren energy consortium) and therefore provided with heat and refrigeration by ewz as energy contractor. On behalf of ewz, Johnson Controls has designed and produced one of Europe's largest ammonia heat pumps, while SSP Kälteplaner AG was responsible for detailed planning of the ammonia-related heat/ refrigeration production system. The Mülligen letter sorting centre to the north west of Zurich handles up to 4.5 million letters every day. The largest building in Switzerland needs lots of energy for heating and cooling. This is taken from the wastewater of a nearby sewage plant, constituting an energy source with a potential of 266 million kWh low temperature waste heat per year. The refrigerating capacity of the heat pumps is 4.3 MW, with a heating capacity of 5.6 MW at 62 °C hot water outlet temperature. Around 50% of the heat energy is taken from the treated wastewater from the sewage plant, with another 30% from the waste heat rejected by the building air-conditioning system. If no room heat is needed, the combined heating/refrigerating machine uses the wastewater to cool the rejected heat from the refrigeration system. This applies particularly in the summer, when

Given the growing significance being attributed to energy efficiency and to protecting resources, the heat pump sector is making increasing use of the potential offered by natural refrigerants

the many automated letter sorting systems demand an increased cooling load of 4.9 MW. The whole ammonia system is installed in a plant room of around 70 m^2. Three Sabroe reciprocating compressors are used for first-stage refrigeration at an evaporation temperature of 5 °C and a condensation temperature of 30 °C. These compressors can also be used as a pure refrigerating system without using waste heat. In heat pump mode, the ammonia is compressed by five Sabroe high-pressure reciprocating compressors from 30 °C to 65 °C saturation temperature. The high-pressure liquid is supercooled and expanded in two stages via the intermediate pressure vessel. The coefficient of performance (COP) in the heating phase was calculated at 3.97 without supercooler. The system which was commissioned in 2007 covers around 70% of the heat demand over the year. Annual savings in fossil fuels amounts to approx. 6100 MWh, corresponding to a reduction in carbon emissions of 1200 t per year.

CO_2 for refrigeration and heating

A water/water heat pump working with trans-critical carbon dioxide has been developed by Star Refrigeration. 'Envitherm' provides high efficiency cooling and uses the waste heat to generate hot water. As a refrigerating machine, the heat pump cools water from 12 °C to 6 °C at a capacity of 41 kW. The plate heat exchanger gas cooler uses the waste heat produced by the reciprocating compressor and heats mains water from 10 °C to 70 °C, with a capacity of 50 kW. The COP is more than 3 for cooling and more than 4 for heating. Ideal for installing in new or existing facilities, the package is connected to both the chilled water/glycol and hot water circuits within a facility. On-board water pumps are included on the package to overcome the hydraulic pressure loss through the evaporator and gas cooler. Multiple units can be connected in parallel or series for higher capacities. The complete factory tested heat pump package operates with a 25 kg carbon dioxide charge and requires only water connections and an electrical supply. It is ideal for generating hot water either for storage or instant use in applications such as food production, hotels, office buildings and hospitals.

Heat pump with natural refrigerant R723

Since 2009, Frigopol has been offering an air/water heat pump for industrial use that works with the natural refrigerant R723 – a refrigerant blend consisting of ammonia and dimethyl ether. Working at a capacity of 24 kW, the system provides hot water at a temperature of up to 45 °C for room heat and at a temperature of up to 65 °C for process water. The main component of the heat pump filled with 3.5 kg R723 is a semi-open compressor with frequency control to allow variable capacity adjustment between 50 and 100%. An overriding control ensures that the water flow temperature remains on a constant level by changing the speed of the compressor when the need arises. The control works according to a heat curve that depends on the outside temperature. The heat pump achieves a COP of 4.2 (A7/W35) and works very efficiently. For example, the electric motor is cooled with water that then flows directly into the hot water circuit. This electric motor is a water cooled stator which is a special construction with a piping around the motor. To defrost the evaporator, high pressure hot gas is taken through the evaporator so that no energy has to be taken from the hot water circuit. The compact heat pump is soundproofed and installed outside the building. Typical customers include housing associations and smaller businesses.

Heat pump by Frigopol works with the natural refrigerant R723

Hydrocarbons

Refrigeration plants using hydrocarbons like propane (C_3H_8) or butane (C_4H_{10}) have been in operation all over the world for many years. Hydrocarbons are colourless and nearly odourless gases that liquefy under pressure, and have neither ozone depletion potential (ODP = 0) nor significant direct global warming potential (GWP = 3). Thanks to their outstanding thermodynamic characteristics, hydrocarbons make particularly energy efficient refrigerants. They are heavier than air and have an anaesthetic and asphyxiating effect in high concentrations. Hydrocarbons are flammable and are capable of forming explosive compounds with air. However, with current safety regulations, refrigerant losses are near zero. Hydrocarbons are available cheaply all over the world; thanks to their ideal refrigerant characteristics they are commonly used in small plants with low refrigerant charges.

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Adding Quality to People's Lives

Copenhagen – and now?

Interview with Dr. Lambert Kuijpers, Technical University Eindhoven, and Georges Hoetierickx, member of the eurammon Board

"Copenhagen Accord" instead of a new global climate treaty – has Copenhagen been a success or disaster?

Hoeterickx: We certainly cannot say it was a success, neither was it a disaster. The expectations of many parties were too high, the commitments of others doubtful. I can understand some people feel disappointed but one has to be realistic: Real conclusions or action plans can hardly be achieved in such a meeting with so many participants and different interests.

Kuijpers: Given the pre-negotiations it was already virtually decided that this meeting would not be able to deliver a new treaty. What was hoped for was that Copenhagen could do ground-laying work for negotiations in 2010 to reach a legally binding agreement for dealing with climate change via reductions of emissions, capacity building in developing countries, the establishment funding modalities etc.

The challenge for Copenhagen was enormous, because of fundamental economic and political realities, reaching out to all kinds of activities in the world of trade, to the historic responsibilities of developed countries. Loaded with these huge expectations, attended by more than 35,000 delegates, observers and NGO members, it became very soon clear that this summit would only be able to confirm a status quo.

If one goes back to the history of the last twenty years, the first landmark climate deal, Rio in 1992, was easy, the second, the Kyoto Protocol in 1997, was achievable, because it included moderate reduction targets, a variety of flexible mechanisms and a limited participation. As a third step, Copenhagen, became an insurmountable hurdle. The major reason: In Kyoto, Parties were divided into Annex I (industrialised countries) and non-Annex I Parties (developing countries), with common but differentiated responsibilities. Over the years, this divide has become a politically very inflexible issue.

The final Copenhagen Accord provides guidance how to go forward

After the Bali 2007 conference it has been tried to get out of this impasse via two streams of negotiations: (1) one stream on long term commitments aiming at a different kind of legally binding treaty and (2) another stream on shorter term amendments to the Kyoto Protocol for the 2012–2020 period. It was hoped that these two streams could be merged at some point to deliver a new kind of global treaty. However, Copenhagen made clear that the developing countries did not want to go further than an amended Kyoto Protocol for the reduction commitments. The final Copenhagen Accord is now something that provides (non-politically binding) guidance how to go forward.

Although there is no mandatory action for the HVACR sector, it seems logical that the European HVACR industry will target at least a 20% reduction in emissions

Europe has itself committed to reduce greenhouse gas emissions by 20 per cent or more until 2020. What does this mean to the HVACR industry?

Kuijpers: Although there is no mandatory action for the HVACR sector, it seems logical that the European HVACR industry will target at least a 20% reduction in emissions. To a certain degree this could be done by converting away from using (and emitting) HFCs and to go to low GWP alternatives, such as natural refrigerants. Further reductions will have to be achieved by energy saving and increasing energy efficiency. The first implies prudent use of refrigeration and air conditioning, the second is targeted for example at better operation strategies and higher quality components.

Hoeterickx: Europe should take its own actions to reduce CO_2 emissions and energy consumption like many North European countries like Denmark and Sweden have already done. For example, the energy needed to warm offices and houses in Sweden is less than 50% of what is needed in Belgium by much higher standards for insulation, heat recovery systems etc. Europe could take a leading role here.

Which further arrangements of the Copenhagen Accord have an effect on the HVACR industry?

Hoeterickx: By reviewing all processes having an impact on our environment, European authorities will for many applications in the HVACR industry appreciate the advantages of natural refrigerants such as ammonia, carbon dioxide and hydrocarbons. It will be their task to establish guide lines and rules which make the use of these refrigerants easier without compromising safety aspects.

Kuijpers: It is up to the HVACR industry to show the way to sustainability, and high energy efficiency, via sophisticated design, manufacturing and operation of

equipment. It is difficult to judge how far there will be advantages or disadvantages for natural refrigerants in the future global HVACR market. But it can be stated that natural refrigerants should be investigated and selected whenever and wherever they have advantages.

Which role play natural refrigerants in reaching the 2-degree-target?

Hoeterickx: The impact of natural refrigerants might not be the most important factor but it is one of the many needed to finally reach the 2-degree-goal. In fact, every energy consuming process should be evaluated on its environmental merits and adjusted if certain sound criteria are not reached.

Kuijpers: If they are used as replacements for HCFCs and HFCs they could play a certain role, in particular if they have better energy efficiency, leading to lower carbon dioxide emissions. On the other hand, one should realise that the 2-degree-target is a long term goal (2050 or beyond) where one could expect that HFCs have already been succeeded by a next generation of low GWP synthetic refrigerants, with which natural refrigerants will have to compete.

What comes after Copenhagen?

Kuijpers: The Accord suggests a bottom up approach whereby developed and developing countries submit their reduction pledges for information to the UNFCCC. The next meetings are planned for Bonn (June 2010) and Mexico (December 2010). It is, however, totally unclear what these meetings will try to accomplish. One will need a re-thinking of the process and find new modules for a framework to talk. It seems as if the world will have a fragmented approach to addressing climate change (particularly emissions) during the next decade.

The impact of natural refrigerants might not be the most important factor but it is one of the many needed to finally reach the 2-degree-goal

Natural refrigerants should be investigated and selected whenever and wherever they have advantages

Given the fact that further negotiations need not be directly related to the UNFCCC as a facilitator, discussions could also be taken up to plan further negotiations in different settings, such as the MEF (Major Economies Forum on Energy and Climate Change) or in a body under the G-8 or G-20.

During 2010–2011, the Montreal Protocol Parties could also revert to a discussion on globally regulating production and consumption of HFCs, being replacements for ozone depleting substances. This discussion was started in 2009 and failed lacking input from the Kyoto Protocol process. The chance that this issue could now result in a more positive approach is not negligible. This in particular given the fact that the post Kyoto negotiations have to find different modalities for continuation.

In summary, lacking a politically binding agreement in Copenhagen, lacking a new starting point that has to be found for discussions towards a new binding climate agreement under whatever facilitating body, 2010 will hopefully reveal how all the nations of the world plan to go forward towards a more integrated approach.

About Georges Hoetierickx

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. Hoetierickx 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 Hoetierickx gained experience in all kinds of heat rejection and refrigeration systems, applied in Europe and the Middle East.

About Dr. Lambert Kuijpers

Dr. Lambert Kuijpers has a part time assignment at the Eindhoven Center for Sustainability, Technical University Eindhoven, Netherlands. Kuijpers has a MsC and a PhD from this University on nuclear physics, has been working on these issues in research centres in the Netherlands, Italy and the UK. He has been a section leader for thermodynamics (with R&D on refrigeration and AC topics) at Philips Research Labs Eindhoven. Since 1992, Kuijpers has been co-chair of the UNEP Technology and Economic Assessment Panel (TEAP) under the Montreal Protocol. He has been guiding and also been very instrumental in the drafting of many reports related to all relevant Montreal Protocol issues. He has been actively involved in several IPCC reports, lastly in the IPCC AR4; he was an advisor to the UNFCCC on gases and several metric issues in the negotiations for a successor to the Kyoto Protocol during 2008-2009.

Carbon dioxide(CO_2)

Carbon dioxide has a long history in refrigeration, extending back to the mid-19th century. It is a colourless gas that liquefies under pressure, with a slightly sour odour and taste. Carbon dioxide has no ozone depletion potential (ODP = 0) and negligible direct global warming potential (GWP = 1) when used as a refrigerant in closed cycles. It is non-flammable, chemically inert and heavier than air. Carbon dioxide is narcotic and harmful to human health at moderately high concentrations. Because carbon dioxide has a lower critical temperature than other refrigerants, recent research has focused particularly on optimizing system design, and more and more effective refrigeration plants are being developed to close this gap. Carbon dioxide is available in abundance, and there is no need for recycling or waste disposal.

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The world is committed to climate protection

Aiming for two degrees

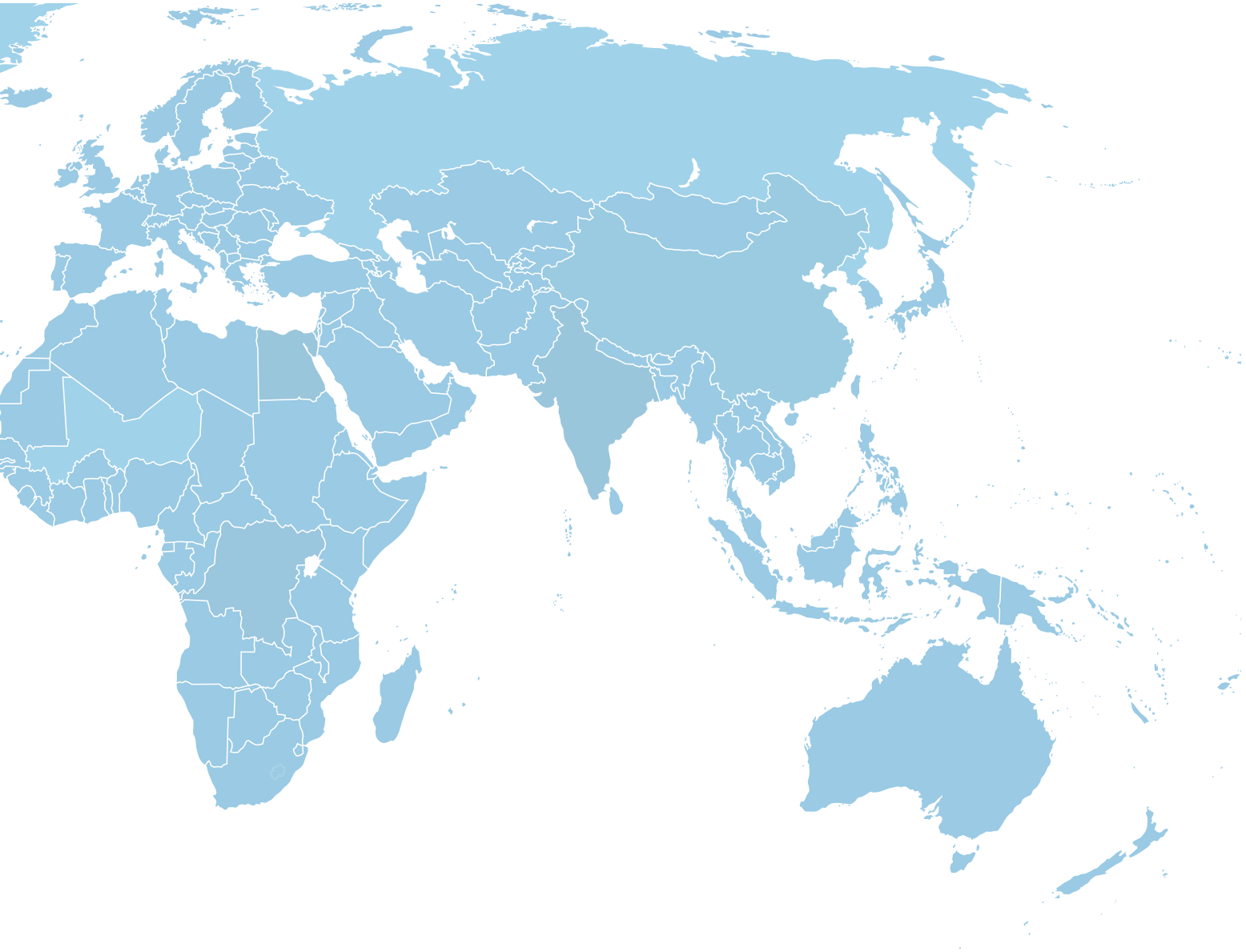
At the UN climate conference in Copenhagen, leading nations including the USA, the EU member states and China – agreed to drastically reduce worldwide emissions of greenhouse gases in order to limit global warming to two degrees Celsius. The EU, for instance, has specifically committed to reducing its carbon dioxide emissions to at least 20% below 1990 levels by the year 2020. The industrialised nations will also provide funds to help protect developing countries from the effects of climate change. The Copenhagen Accord was acknowledged by all the participating nations and forms the basis for future climate summits with the aim of extending the Kyoto Protocol, which is due to expire in 2012.

Kyoto Protocol limits greenhouse gases

The Kyoto Protocol was adopted in 1997 as an amendment to the UN Framework Convention on Climate Change. It came into force in 2005, by which time it had been ratified by 55 nations which together accounted more than 55% of total carbon dioxide emissions in 1990. This protocol was the first ever binding agreement under international law to specify fixed emission targets for greenhouse gases,which are the main culprit behind global warming. The greenhouse gases specified include carbon dioxide, methane, dinitrous oxide, HFCs, perfluorinated carbons (PFCs) and sulphur hexafluoride. The Kyoto Protocol stipulates that industrialised nations reduce their greenhouse gas emissions by an average 5.2% from 1990 levels during the first commitment period, which runs from 2008 to 2012.

Prospects for natural refrigerants

The international community's joint efforts to protect the climate, open up new prospects for natural refrigerants. As environmentally friendly refrigerants, ammonia, carbon dioxide and hydrocarbons are not threatened with any restrictions or prohibition and are therefore a sustainable solution for use in refrigeration and air-conditioning.



	Ozone Depletion Potential (ODP)	Global Warming Potential (GWP)
Ammonia (NH_3)	0	0
Carbon dioxide (CO_2)	0	1
Hydrocarbons (Propane C_3H_8, Propene C_3H_6, Iso-Butane C_4H_{10})	0	<3
Water (H_2O)	0	0
Chlorofluorocarbons (CFCs)	1	4680–10720
Partially halogenated chlorofluorocarbons (HCFCs)	0.02–0.06	76–12100
Perfluorocarbons (PFCs)	0	5820–12010
Partially halogenated fluorinated carbons (HFCs)	0	122–14310

Product directory

Refrigerating plants with NH3 for
01 building industry
02 brewery
03 chemical industry
04 beverage industry
05 indirect systems
06 industry
07 chilled water production
08 cold storage
09 food industry
10 pharmaceutical industry
11 special applications
12 sports

Refrigerating plants with CO2 for
13 building industry
14 gas condensation
15 beverage industry
16 industry
17 cold storage
18 food industry

Refrigerating plants with flammable refrigerants of the group 3* for
19 chemical industry
20 gas condensation
21 special applications

Refrigerating plants with R723 for
22 indirect systems
23 chilled water production
24 special applications

Refrigerating plants with water for
25 air conditioning
26 heat pumps

27 Packaged water chiller

Kälteanlagen mit NH3 für
01 Bauindustrie
02 Brauereien
03 chemische Industrie
04 Getränkeindustrie
05 indirekte Systeme
06 Industrie
07 Kaltwassererzeugung
08 Kühllager
09 Lebensmittelindustrie
10 pharmazeutische Industrie
11 Sonderanwendungen
12 Sportstätten

Kälteanlagen mit CO2 für
13 Bauindustrie
14 Gaskondensation
15 Getränkeindustrie
16 Industrie
17 Kühllager
18 Lebensmittelindustrie

Kälteanlagen mit brennbaren Kältemitteln der Gruppe 3* für
19 chemische Industrie
20 Gaskondensation
21 Sonderanwendungen

Kälteanlagen mit R723 für
22 indirekte Systeme
23 Kaltwasserproduktion
24 Sonderanwendungen

Kälteanlagen mit Wasser für
25 Klimatechnik
26 Wärmepumpen

27 Kaltwassersätze

Refrigerant compressors for NH3-refrigerating plants
28 reciprocating compressor
29 screw compressor
30 compound systems

Refrigerant compressors for CO2-refrigerating plants
31 reciprocating compressor
32 screw compressor

Refrigerant compressors for refrigerating plants with flammable refrigerants of the group 3*
33 reciprocating compressor
34 multi-stage turbocompressor
35 screw compressor

Refrigerant compressors for R723-refrigerating plants
36 reciprocating compressor
37 screw compressor
38 compound systems

Refrigerant compressors for refrigerating plants with water as refrigerant
39 screw compressor

Condensers for NH3-refrigerating plants
40 refrigerant cooled
41 air cooled
42 aircooled with microchannel
43 brine cooled
44 water cooled
45 hybrid condenser
46 cascade
47 evaporative condenser

Gas cooler for CO2-refrigerating plants
48 air cooled
49 aircooled with microchannel

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
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ALFA LAVAL LUND AB																												
BALTIMORE AIRCOIL International N.V.																												
Bitzer Kühlmaschinenbau GmbH																												●
DANFOSS GmbH																												
EVAPCO Europe GmbH																												
FRIGOPOL – Kälteanlagen GmbH		●	●	●	●	●	●	●	●	●	●	●				●	●	●	●		●	●	●	●			●	●
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Kältemittelverdichter für NH3-Kälteanlagen
28 Hubkolbenverdichter
29 Schraubenverdichter
30 Verbundanlagen

Kältemittelverdichter für CO2-Kälteanlagen
31 Hubkolbenverdichter
32 Schraubenverdichter

Kältemittelverdichter für Kälteanlagen mit brennbaren Kältemitteln der Gruppe 3*
33 Hubkolbenverdichter
34 mehrstufige Turboverdichter
35 Schraubenverdichter

Kältemittelverdichter für R723-Kälteanlagen
36 Hubkolbenverdichter
37 Schraubenverdichter
38 Verbundanlagen

Kältemittelverdichter für Kälteanlagen mit Wasser als Kältemittel
39 Schraubenverdichter

Kältemittelverflüssiger für NH3-Kälteanlagen
40 kältemittelgekühlt
41 luftgekühlt
42 luftgekühlt mit microchannel
43 solegekühlt
44 wassergekühlt
45 Hybridverflüssiger
46 Kaskade
47 Verdunstungsverflüssiger

Gaskühler für CO2-Kälteanlagen
48 luftgekühlt
49 luftgekühlt mit microchannel

Condensers for refrigerating plants with flammable refrigerants of the group 3*
50 refrigerant cooled
51 air cooled
52 brine cooled
53 water cooled

Condensers for R723-refrigerating plants
54 air cooled
55 brine cooled
56 water cooled
57 aircooled with microchannel

Condensers for refrigerating plants with water as refrigerant
58 brine cooled
59 water cooled

Pressure vessels for NH3-refrigerating plants
60 liquid receiver
61 oil separator
62 pump container

63 Pressure vessels for CO2-refrigerating plants

Pressure vessels for refrigerating plants with flammable refrigerants of the group 3*
64 liquid receiver
65 oil separator
66 pump container

Pressure vessels for R723-refrigerating plants
67 liquid receiver
68 oil separator
69 pump container

70 Pressure vessels for refrigerating plants with water as refrigerant

Kältemittelverflüssiger für Kälteanlagen mit brennbaren Kältemitteln der Gruppe 3*
50 kältemittelgekühlt
51 luftgekühlt
52 solegekühlt
53 wassergekühlt

Kältemittelverflüssiger für R723-Kälteanlagen
54 luftgekühlt
55 solegekühlt
56 wassergekühlt
57 luftgekühlt mit microchannel

Kältemittelverflüssiger für Kälteanlagen mit Wasser als Kältemittel
58 solegekühlt
59 wassergekühlt

Druckbehälter für NH3-Kälteanlagen
60 Flüssigkeitssammler
61 Ölabscheider
62 Pumpenbehälter

63 Druckbehälter für CO2-Kälteanlagen

Druckbehälter für Kälteanlagen mit brennbaren Kältemitteln der Gruppe 3*
64 Flüssigkeitssammler
65 Ölabscheider
66 Pumpenbehälter

Druckbehälter für R723-Kälteanlagen
67 Flüssigkeitssammler
68 Ölabscheider
69 Pumpenbehälter

70 Druckbehälter für Kälteanlagen mit Wasser als Kältemittel

29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
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Evaporators for NH3-refrigerating plants
71 plate-type evaporator
72 shell and tube evaporator
73 dry evaporation, electrical type
74 air-subjected with stainless steel pipe
75 air-subjected with steel pipe
76 air-subjected with aluminum pipe

Evaporators for CO2-refrigerating plants
77 plate-type evaporator
78 shell and tube evaporator
79 air-subjected with stainless steel pipe
80 air-subjected with copper pipe
81 air-subjected with steel pipe
82 air-subjected with aluminum pipe

Evaporators for refrigerating plants with flammable refrigerants of the group 3*
83 plate-type evaporator
84 shell and tube evaporator
85 air-subjected with stainless steel pipe
86 air-subjected with copper pipe
87 air-subjected with steel pipe
88 air-subjected with aluminum pipe

Evaporators for R723-refrigerating plants
89 plate-type evaporator
90 air-subjected with stainless steel pipe

91 Evaporators for refrigerating plants with water as refrigerant

92 Ice banks for use with NH3

Kältemittelverdampfer für NH3-Kälteanlagen
71 Plattenwärmeaustauscher
72 Rohrbündelwärmeaustauscher
73 Trockenverdampfer, elektrisch beheizt
74 luftbeaufschlagt mit Edelstahlrohr
75 luftbeaufschlagt mit Stahlrohr
76 luftbeaufschlagt mit Aluminiumrohr

Kältemittelverdampfer für CO2-Kälteanlagen
77 Plattenwärmetauscher
78 Rohrbündelwärmetauscher
79 luftbeaufschlagt mit Edelstahlrohr
80 luftbeaufschlagt mit Kupferrohr
81 luftbeaufschlagt mit Stahlrohr
82 luftbeaufschlagt mit Aluminiumrohr

Kältemittelverdampfer für Kälteanlagen mit brennbaren Kältemitteln der Gruppe 3*
83 Plattenwärmetauscher
84 Rohrbündelwärmetauscher
85 luftbeaufschlagt mit Edelstahlrohr
86 luftbeaufschlagt mit Kupferrohr
87 luftbeaufschlagt mit Stahlrohr
88 luftbeaufschlagt mit Aluminiumrohr

Kältemittelverdampfer für R723-Kälteanlagen
89 Plattenwärmetauscher
90 luftbeaufschlagt mit Edelstahlrohr

91 Kältemittelverdampfer für Kälteanlagen mit Wasser als Kältemittel

92 Eisspeicher für Kältemittelbetrieb mit NH3

Expansion devices
93 high-pressure float controls
94 expansion valve

Accessories for NH3-refrigerating plants
95 valves and fittings
96 regulating devices
97 safety devices
98 controlling devices
99 leak detection spray
100 NH3 area monitoring
101 markers and indicators of flow direction
102 rescue container for leaking emballage
103 compressed gas bottles (2.5–65 kg)
104 container for transportation (max. 500 kg)

Accessories for CO2-refrigerating plants
105 valves and fittings
106 regulating devices
107 safety devices
108 controlling devices

Accessories for refrigerating plants with flammable refrigerants of the group 3*
109 valves and fittings
110 regulating devices
111 safety devices
112 controlling devices

Accessories for R723-refrigerating plants
113 valves and fittings
114 regulating devices
115 safety devices
116 controlling devices
117 compressed gas bottles (2.5–65 kg)
118 container for transportation (max. 500 kg)

	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
ACALOR Technik ww KG																										
ALFA LAVAL LUND AB	●	●	●	●	●	●	●		●	●			●		●	●			●	●						
BALTIMORE AIRCOIL International N.V.																						●				
Bitzer Kühlmaschinenbau GmbH																										
DANFOSS GmbH																							●	●	●	●
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FRIGOPOL – Kälteanlagen GmbH																										
Friotherm AG																										
GEA Grasso GmbH			●	●	●				●	●															●	
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Georg Fischer Piping Systems AG																										
GfKK Gesellschaft für Kältetechnik-Klimatechnik mbH	●	●	●	●	●																		●	●	●	●
Güntner AG & Co. KG				●	●				●	●					●	●				●						
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	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96

Expansionsorgane
93 Hochdruckschwimmerregler
94 Expansionsventile

Kältetechnisches Zubehör für NH3-Kälteanlagen
95 Armaturen
96 Regeleinrichtungen
97 Sicherheitseinrichtungen
98 Steuereinrichtungen
99 Lecksuchspray
100 Gaswarnanlagen
101 Schilder und Fließrichtungsanzeiger
102 Bergungsbehälter für havarierte Gebinde
103 Druckgasflaschen (2,5–65 kg)
104 Transportcontainer (max. 500 kg)

Kältetechnisches Zubehör für CO2-Kälteanlagen
105 Armaturen
106 Regeleinrichtungen
107 Sicherheitseinrichtungen
108 Steuereinrichtungen

Kältetechnisches Zubehör für Kälteanlagen mit brennbaren Kältemitteln der Gruppe 3*
109 Armaturen
110 Regeleinrichtungen
111 Sicherheitseinrichtungen
112 Steuereinrichtungen

Kältetechnisches Zubehör für R723-Kälteanlagen
113 Armaturen
114 Regeleinrichtungen
115 Sicherheitseinrichtungen
116 Steuereinrichtungen
117 Druckgasflaschen (2,5–65 kg)
118 Transportcontainer (max. 500 kg)

Accessories for refrigerating plants with water as refrigerant
119 valves and fittings

Heat pumps with NH3 as refrigerant
120 heat pump with reciprocating compressor
121 heat pump with screw compressor

122 Heat pumps with flammable refrigerants of the group 3*

123 Water cooling towers

124 Refrigerant pump

Refrigerants
125 NH3
126 CO2
127 Alkanes/Alkenes
128 R723
129 Water

130 Safety equipment

Services
131 consultation
132 planning
133 technology transfer
134 return of used NH3

135 Secondary refrigerants

Kältetechnisches Zubehör für Kälteanlagen mit Wasser als Kältemittel
119 Armaturen

Wärmepumpen mit NH3 als Kältemittel
120 Wärmepumpe mit Hubkolbenverdichter
121 Wärmepumpe mit Schraubenverdichter

122 Wärmepumpen mit brennbaren Kältemitteln der Gruppe 3*

123 Kühltürme

124 Kältemittelpumpen

Kältemittel
125 NH3
126 CO2
127 Alkane / Alkene
128 R723
129 Wasser

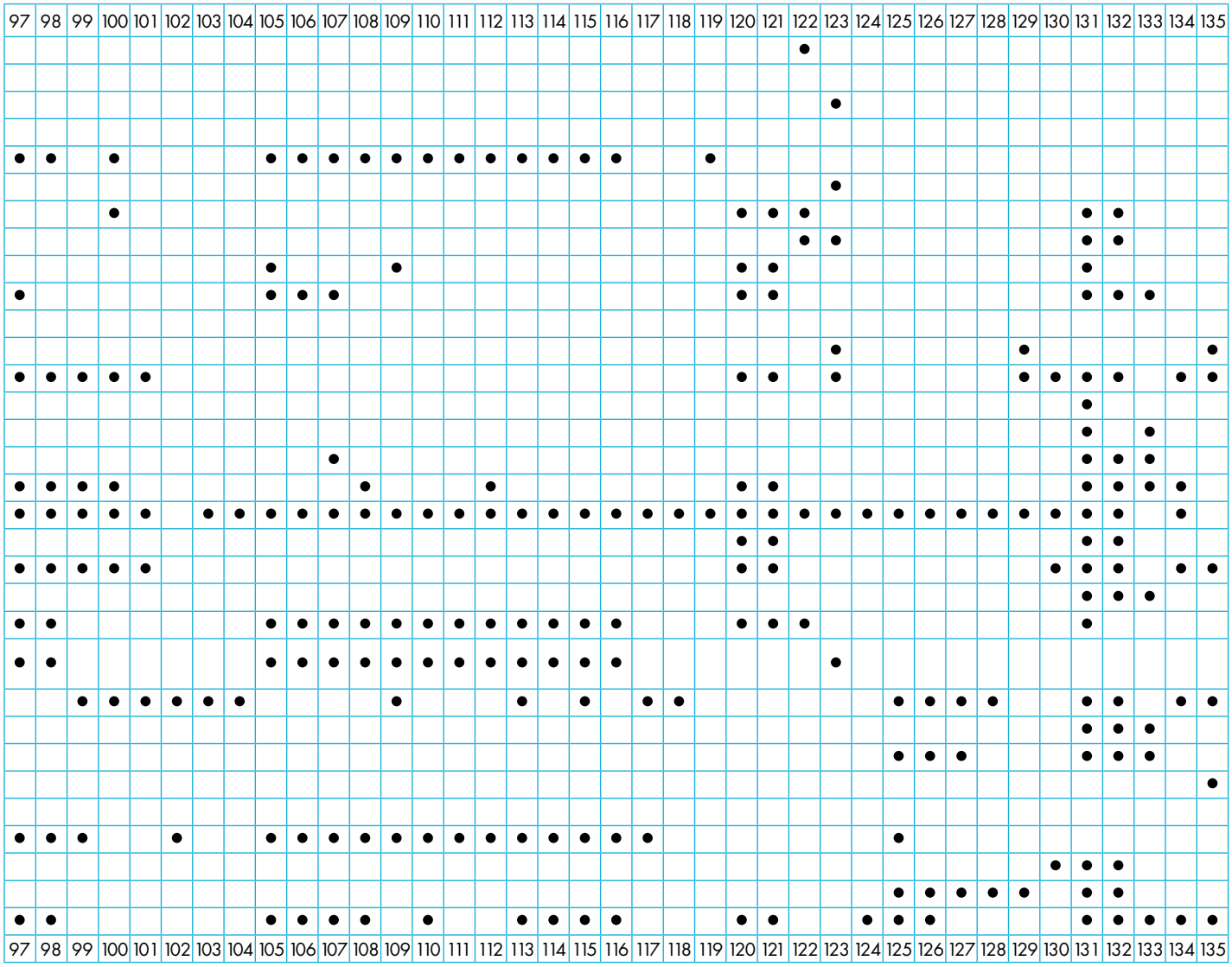
130 Arbeitsschutzmittel

Dienstleistungen
131 Beratung
132 Planung
133 Technologietransfer
134 Rücknahme von gebrauchtem NH3

135 Kälteträger

* DIN EN 378 classification of refrigerants regarding toxicity and flammability; Refrigerants of group 3: Refrigerants which in combination with ambient air and ambient pressure have a minimum explosion level of less than 3.5%.

* Einteilung von Kältemitteln nach DIN EN 378 hinsichtlich Toxizität und Brennbarkeit; Brennbarkeit Gruppe 3: Kältemittel, deren Gemisch mit Luft bei Raumtemperatur und Normaldruck eine untere Explosionsgrenze von weniger als 3,5% v/v hat.



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The European initiative eurammon

Natural refrigerants are environmentally friendly

eurammon is an association of leading, multinational companies in the refrigeration sector, as well as individuals and institutions in natural refrigerants, committed to advocating the increased use of natural refrigerants. eurammon is linked with international associations and institutions around the world through a network of cooperations and memberships. The industry initiative sees itself as a centre of expertise on the use of natural refrigerants and is fuelled by the strong personal commitment of its members.

Hence eurammon shoulders social responsibility in the interest of an eco-industrial policy. The initiative's members develop innovative, future-proof solutions and approaches and push ahead with their implementation. eurammon supports sustainable business practices in refrigeration and the use of energy-efficient systems. The initiative's mission is to promote the use of natural refrigerants across national borders.

Climate protection the natural way

Recent worldwide efforts to step up climate protection have heightened people's interest in natural refrigerants, which have been used successfully in refrigeration technology for over 100 years. In the 1950s and 60s, they were displaced in new plants by synthetic refrigerants, touted by the chemical industry as so-called safety refrigerants. Since that time, numerous regulations were passed that unjustifiably restricted competition. However, thanks to technological innovations and thanks to their effectiveness, natural refrigerants have nevertheless become established as an efficient, safe solution for use in a wide range of industries. The most economically relevant among them are ammonia, carbon dioxide and hydrocarbons.

Natural refrigerants do not deplete the ozone layer (Ozone Depletion Potential, ODP) and either have no global warming potential – like ammonia – or only a negligible GWP. This puts them beyond comparison from a climate perspective. However, using natural refrigerants is worthwhile from an economic standpoint as well. The refrigerants themselves are inexpensive and available in vast quantities. The great efficiency of natural refrigerants and the plants that use them have a positive effect on operating costs. Ammonia, for instance, is acknowledged as the most efficient refrigerant of all. Add to that the inexpensive disposal of natural refrigerants once a plant has reached the end of its life.

Refrigeration in the Future

Whether in the food and beverage industry, in air-conditioning, in sport and recreation facilities, the chemicals and pharmaceuticals industry or in automotives – refrigeration plants using natural refrigerants have proven themselves as an environmentally friendly, economical and reliable solution for producing cold energy. The European initiative eurammon puts its expertise at the service of opening up new areas of application for natural refrigerants and is open to anyone interested in refrigeration, the natural way.

Information papers

No 01 eurammon – Taking the Initiative for Natural Refrigerants

No 02 Ammonia – A Natural Refrigerant

No 03 Evaluation of the Environmentally Friendly Refrigerant Ammonia According to the TEWI Concept

No 04 Assistance in Case of Accidents with Ammonia

No 05 Ecologically Sound Disposal Methods in Ammonia Technology

No 06 Leakage Monitoring at Ammonia Refrigeration Plants

No 07 Technical and Energetic Appraisal of Ammonia Refrigerating Systems for Industrial Use

No 08 Comparison of Liquid Chillers with Screw Compressors for Air-Conditioning Applications with Ammonia and R134a

No 09 Ammonia / Secondary Refrigerant System vs. Direct Evaporation of HCFCs/HFCs

No 10 Aluminium as Construction Material in Ammonia Refrigeration Cycles

No 11 Carbon-dioxide – CO_2 – R744 – (Carbonic Acid). The History of an Interesting Substance

No 12 R 723 – An Azeotrope on the Basis of Ammonia

No 13 Components Used in Carbon Dioxide Refrigeration Systems

All publications can be downloaded at www.eurammon.com.

Kältetechnik Dresen + Bremen GmbH

Kältetechnik Dresen + Bremen GmbH wurde 1987 gegründet und agiert seither erfolgreich als Anbieter von Komplettlösungen auf dem Markt der industriellen Kälteanlagen. Während 1987 vier Mitarbeiter dem Unternehmen angehörten, kümmern sich heute 65 Mitarbeiter um die Belange der Kunden.
Wir sind Spezialisten für die Planung, den Bau und die Installation von Ammoniak-Kälteanlagen mit einem hohen Wirkungsgrad.

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- ❄ Metallveredlung in Galvanikbetrieben

Weitere Informationen zu unseren Leistungen bekommen Sie unter **www.dresen-kaelte.de**.

Unsere Anlagen werden genutzt für Kühl- und Produktionsräume als auch Kühllager, Tiefkühllager und Frosteranlagen.
Außerdem erfüllt die Technik unserer hochmodernen Anlangen die geltenden Bestimmungen zum Schutz der Umwelt.

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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.
www.eurammon.com

eurammon
refrigerants delivered by mother nature

There are plenty of good reasons to join eurammon

For end users, being a eurammon member is well worth it because ...

1. the application of a refrigeration technology using natural refrigerants offering an energy-efficient, ecologically and economically sustainable solution, depends on the concerted action of refrigeration plant users.
2. eurammon is active throughout Europe and provides a platform for coordinated, joint actions.
3. eurammon assists in the long-term implementation of refrigeration strategies using natural refrigerants.

For contractors, being a eurammon member is well worth it because ...

1. eurammon allows sharing experiences about sustainable and environmentally friendly refrigeration technologies in an international network.
2. eurammon members can cultivate personal relations at an international level, free from competitive concerns.
3. eurammon helps to efficiently put into practice today's requirements for a better environment.

For manufacturers and suppliers, being a eurammon member is well worth it because ...

1. eurammon acts as an active lobby above company and country borders to enhance the sharing of information and combined activities to promote the use of natural refrigerants.
2. eurammon provides comprehensive information about the latest developments in the field of natural refrigerants.
3. eurammon widens horizons by promoting and deepening contacts between manufacturers, plant builders and operators.

Visit us at Hall 4,
Stand 318
Chillventa 2010

In Touch with sustainability

GEA Refrigeration Technologies shows that environmentally friendly processes can be creative – but that they need not be expensive. Do you work with the processing, storage, or distribution of food and beverages? Or with oil, gas, chemicals, utilities infrastructure, leisure facilities, or marine applications? If so, we are ready to give you a hand in implementing ecological solutions. As international leader in refrigeration systems, we offer the entire spectrum in our field: development and system design, component manufacturing, installation, after-sales service, and maintenance for facilities around the world. Our cooling and freezing systems primarily employ natural and therefore environmentally friendly substances: especially NH_3 and CO_2. High efficiency and low costs for the supply and disposal of these refrigerants make them attractive for you, too.

Get in touch with us: We look forward to getting to know you personally at stand 318.

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