eurammon
refrigerants delivered by mother nature

eurammon magazine

Refrigerants by Nature

2018

www.eurammon.com

eurammon

refrigerants delivered by mother nature

eurammon started as an initiative in 1996 and has made great steps in improving awareness and acceptance of natural refrigerants among operators of refrigeration and air conditioning systems – while at the same time contributing substantially towards a more eco-friendly and sustainable refrigeration technology. The European initiative now comprises almost 80 members in 26 countries around the globe – and counting. eurammon always aims to provide their members and all interested parties with information about the latest developments in cooling and refrigeration technologies. By publishing interesting case studies, informative papers, exploratory leaflets we actively promoting the knowledge transfer between all these interest groups and further commit ourselves for the use of natural refrigerants.

Become a member of eurammon now.
Visit our website http://www.eurammon.com
or contact karin.jahn@eurammon.com
We look forward to welcome you.

Dear Readers,

since eurammon was founded in 1996, our international initiative has made considerable progress in contributing towards a more sustainable and eco-friendly approach in refrigeration engineering. We are glad that in the more than 20 years behind us, we have succeeded in creating more awareness as well as largely increasing the acceptance of natural refrigerants. Fulfilling its role as a knowledge pool for the use of natural refrigerants, eurammon provides comprehensive information about all aspects of these compounds to experts, politicians and the general public.
As the importance of natural refrigerants grows, eurammon's work becomes even more important. Achievements such as the Kigali Amendment, that will effectively reduce the manufacturing and use of Hydrofluorocarbons (HFCs), and the Paris climate agreement have increased the significance of natural refrigerants and thus also strengthened the impact of eurammon in the world-wide efforts to reduce the advance of the ongoing climate change. The HFC phase-down that has started in 2015 is bound to achieve the substantial reduction of 79 per cent of these substances by 2030.

On the whole, ecological awareness is growing steadily, and legislation is reacting to this development by enforcing stricter rules when it comes to the use of refrigerants. The EU F-gas regulation is widely regarded as an appropriate step forward in order to impose necessary and reasonable phase-downs to the industry. Along with that, energy efficiency and the preservation of natural resources also gained in importance, which supports our efforts of promoting and spreading the use of natural refrigerants as well.

These are all crucial achievements that clearly motivate us to further continue our efforts to advance the application of natural refrigerants. This becomes even more relevant as the impact of our work is bound to increase in the years ahead. Natural refrigerants will have an important share in providing eco-friendly and sustainable solutions to customers and the industry. Therefore, our mission is clear: Continue to create even more awareness about the necessity to implement natural refrigerants and reduce possible reservations against their use.

The newest edition of the eurammon magazine at hand, is another vital part of these efforts. We therefore hope that you will enjoy and benefit from reading it.

Enjoy your read!

Bernd Kaltenbrunner
Chairman, eurammon

Dr. Karin Jahn
Managing Director, eurammon

GF Piping Systems

Maximum safety and efficiency

COOL-FIT 4.0: pre-insulated piping system – the technology leap for cooling of food and beverage

- 100 % corrosion- and maintenance-free system
- 50 % faster installation through pre-insulation *
- 30 % higher energy efficiency

www.gfps.com/cf4

*All comparisons with piping systems made of metal, which were subsequently isolated with a rubber-based foam.

GFDO_AD_00030_EN (09.18)

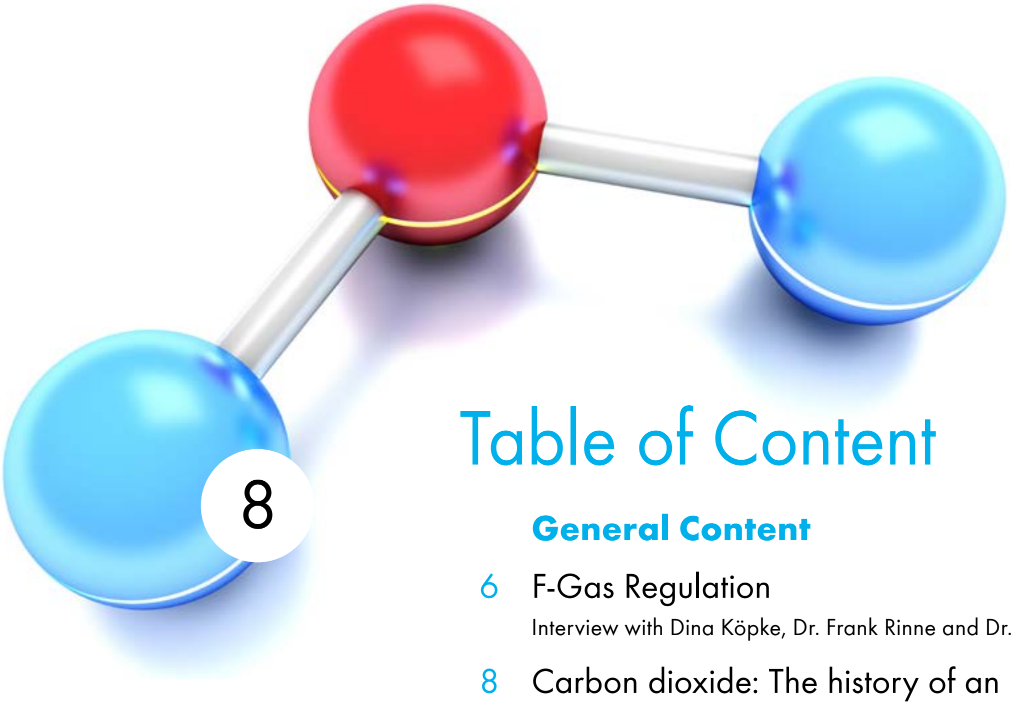


Table of Content

22

Challenges of the F-gas regulation

Dr. Frank Rinne, Director Systems and Solutions Emerson Climate Technologies GmbH

The F-gas regulation already takes effect. What would you deem to be the main success points and what are the main challenges?

Dina Köpke: In terms of success points, the reporting of the European Commission shows that the registered market participants meet their quotas. Substituting R404A by R407A/F or R448A/499A is working, the according components have been qualified.

Regarding challenges we have seen a rise in illegal sales, especially via internet portals, since the first phase-down of the quota to 63 per cent. Also, from a technological point of view, the application of inflammable refrigerants remains a big challenge, especially concerning refrigerants of the groups 2, 2L and 3. For the commercial use of propane there are many components available, but for the group 2L, alternative components still have to be qualified due to the variety of these refrigerants. This also affects the planning of equipment manufacturers and developers if they want to be able to offer a sufficient number of solutions with adequately low GWPs.

Dr. Jürgen Zöller: Seen from our perspective the main success of the F-gas regulation is that it managed to create awareness about the impact of fluorinated gases on the greenhouse effect. But apart from that, I mostly see challenges. The complex system with phase-down quotas and GWPs is way too complicated and asks too much of the market participants. As a result, the market is in chaos and some products are just not available at all. Yet, the effect within the first two years was largely weakened by inventory sourcing. In 2017, the situation escalated and made prices explode. This year, we see the market flooded by illegal imports[1], which sent prices plummeting again. So, the regulation shows little effect but made the industrial gas market highly speculative. The question is now what will happen in the near future. If illegal imports will be sealed off, this will make prices surge again. If not, it is hard to forecast the effects.

The Kigali amendment to the Montreal Protocol aims for a further phase-down of HFCs until 2050. But considering

[1] Cooling Post Ltd (2018): Amazon in court over illegal F-gas sales. https://www.coolingpost.com/world-news/amazon-in-court-over-illegal-f-gas-sales/

INTERVIEW • eurammon member Dr. Frank Rinne, Director Systems & Solutions and Dina Köpke, Director Governmental Affairs of Emerson Climate Technologies GmbH and Dr. Jürgen Zöller, Managing Director of Technische Gase und Gasetechnik GmbH, talk about their experiences and the effects of the European fluorinated gas regulation.

the effects that the F-gas regulation achieved or did not achieve up to now – does an amendment like this or the planned Review 2022 to the European regulation make sense at all?
Dina Köpke: This is really hard to anticipate at this moment. I think, it would be very important to conduct a comprehensive study in order to get a more complete picture and then eventually take the right measures concerning amendments at the right point in time.

Dr. Jürgen Zöller: From my point of view, it would be reasonable to establish clearly defined quota prices for HFC gases instead of leaving them to the market forces. This would facilitate better planning opportunities for the users. Currently, commercial users can't keep up with testing all the different alternatives and substitutes. So it is hardly a surprise that they stash away tons of supplies to be on the safe side. However, as I see the EU commission constricted in this respect, I expect amendments in this direction to be fairly unlikely.

Wouldn't it be wise for stakeholders in the climate and refrigeration sector to successively abstain from F-gases and substitute them with natural refrigerants already before the particular phase-down stages become effective?
Dina Köpke: It is essential for each market participant to utilize refrigerants with a lower GWP as soon as possible. Natural refrigerants are definitively future-proof – therefore they are the most reasonable solution if technically and legally feasible. In Germany and some other EU member states, public support programs additionally promote the use of natural refrigerants.

Dr. Jürgen Zöller: As a vendor, we both offer HFC gases as well as natural refrigerants. If a manufacturer can build competitive products today, they should definitely not wait for the according phase-down steps. But as I mentioned before, the volatile market caused by illegal imports ruins any chance to plan and control even near-future developments.

How complex is the transition to alternative refrigerants for the industry? Do you assess manufacturers and craftspeople to be sufficiently prepared and trained?
Dr. Frank Rinne: I think manufacturers are well prepared, trained and equipped. However, for the crafts and trades the situation is quite different. But this has distinct reasons. Being located at the end of the value and communications chain, there is not much pressure on craftspeople yet – as alternative refrigerants have not been around for long. Also, we are talking about small enterprises that find it difficult to free up their personnel for the amount of training time that would be necessary to reach a quick and profound penetration of alternative solutions.

Dr. Jürgen Zöller: In several workshops held to inform service technicians on flammables we experienced that alternative refrigerants are not prevalent at all when it comes to smaller crafts and trades. For larger OEMs, the situation is different to some extent – but repair people need training courses for the handling of flammable refrigerants.

What can be done to intensify retrofits of existing facilities?
Dr. Frank Rinne: Retrofitting at existing facilities is limited to non-combustible refrigerants. Here, especially R448A/R449A are used, as they work with only slight adaptations. For R134a, the non-combustible alternatives R450A and R513A are available which can further reduce the global warming potential. However, when inflammable refrigerants have to be used, this requires a complete reassessment and must be approved by the authorities, as combustibility effectuates a substantial change in the operation. In many cases this leads to a change of the PED class of a component. And a retroactive certification is not possible.

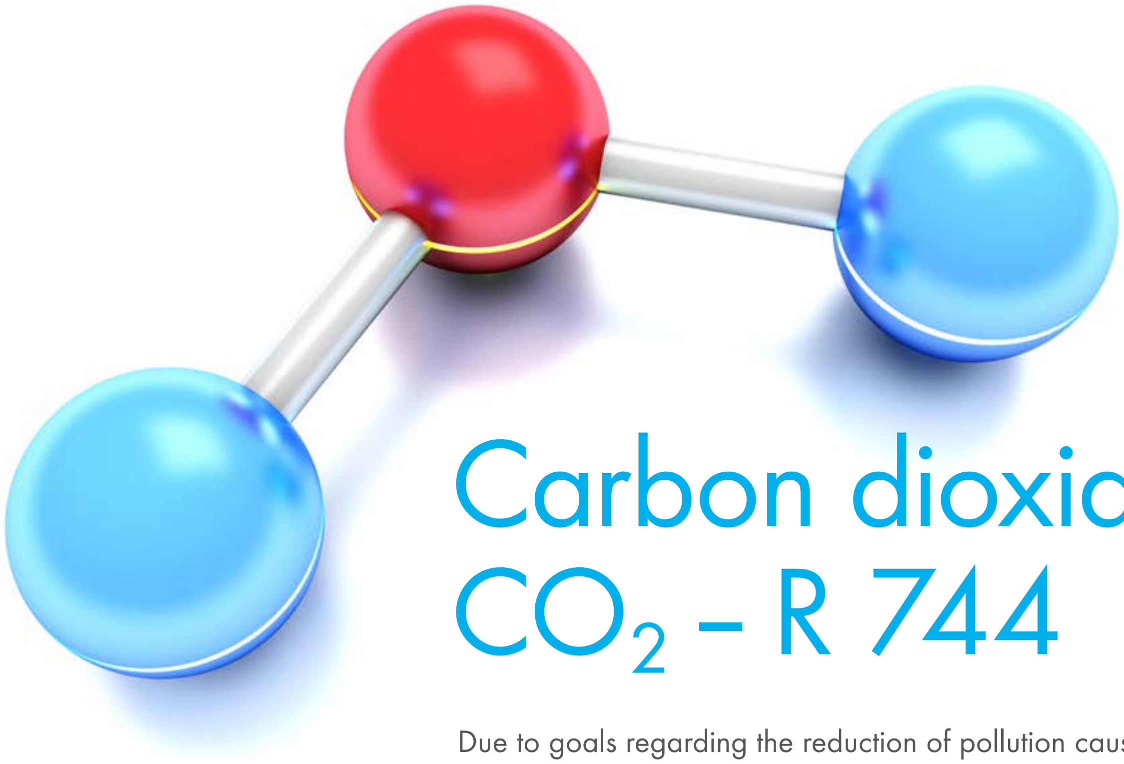
Dr. Jürgen Zöller: This is a huge problem, as retrofits are only viable within the same safety category. So, in practice, only retrofits from refrigerants with a very high GWP to an alternative with a somewhat lower GWP are feasible. But the GWP targets for 2030 can only be met with flammable refrigerants, which demand a redesign and a new certification. So, in the long run and for certain applications there will be hardly any alternative to using natural refrigerants.

Dina Köpke, Director Governmental Affairs at Emerson Climate Technologies GmbH

"Natural refrigerants are definitively future-proof – therefore they are the most reasonable solution"

Dina Köpke

The history of an interesting substance



Carbon dioxide – CO_2 – R 744

Due to goals regarding the reduction of pollution caused by greenhouse gases, natural refrigerants have again become a focal point of scientists, users and politicians. Apart from ammonia, these natural fluids include water, hydrocarbons and carbon dioxide. The latter, with ISO code R 744 and chemical formula CO_2, has witnessed a renaissance in recent years.

CO_2 was used successfully in marine and industrial refrigeration systems in the early 1890s

We are surrounded by CO_2 in the atmosphere, albeit in a lower concentration in comparison to nitrogen (N_2) and oxygen (O_2), but potentially with a great impact on this atmosphere. Atmospheric CO_2 is released from various natural and man made sources, such as volcanoes, oceans (acting as sink/storage), carbonic acid from natural springs, exhaust fumes from chemical production and processing of natural gas and crude oil. Even human beings and animals emit CO_2 with their exhaled air.

Under the name "carbonic acid" we encounter CO_2 in soft drinks and in many other fields, e.g. fire-extinguishing technology, food packaging, food refrigeration, in deep-freezing and cold-milling, in medical applications and as main and secondary refrigerant in refrigeration systems. These versatile industrial applications result from the special properties of CO_2. As a gas, carbon dioxide is neutral in colour, smell and taste, and has a high density (standard state about 2 kg/m^3), roughly 1.5 times the density of air. Furthermore, the chemical compound CO_2 is very stable, as it requires temperatures of over 2000°C to split CO and O_2 – at least without special catalytic agents.

In 1780 the French physicist Lavoisier came up with the term "acide-carbonique" after he had detected the composition of the gas consisting of one part of carbon and two parts of oxygen. In 1823 the physicist Faraday (1791–1867) was the first to produce liquid CO_2 in small laboratory quantities. CO_2 in solid form as snow was first produced by Thilorier in 1834 by expansion of liquid CO_2 to atmospheric pressure. He reported "that the snow could be compressed easily, had a temperature of –78.5°C at atmospheric pressure and changed directly from the solid into the vaporous state without melting first" (sublimation). This solid CO_2 is called "dry ice". It is used even today in considerable quantities, chiefly for transport refrigeration of food. In Germany it was Dr. Wilhelm Carl Raydt, who started the liquefaction and industrial application of CO_2 (1877). He liquefied CO_2 by means of a reciprocating compressor at ambient temperature by hydrocooling.

In 1880 Raydt took out a patent on "A procedure and apparatuses to impregnate, lift and cast water by means of droppable liquid carbonic acid". This is the basis for the production of carbonated beverages. Heinrich Dräger (founder of the Dräger-Werke, Lübeck) realised that liquid carbonic acid was the ideal pressurising agent for beer. He developed and perfected the pressurising apparatuses (CO_2 pressure reducers) for dispensing draught beer. A licence agreement between Dr. Raydt and the Chemische Fabrik Kuhnheim & Co. in 1882 was the first industrial production of liquid CO_2 in Germany.

The gas industry and the use of its liquefied gases accelerated with the invention of light and safe pressurised gas cylinders. In 1886, the brothers Max and Reinhard Mannesmann in Germany presented their cold-rolling process for the manufacture of weldless pipes, which was soon introduced into the manufacture of thin-walled pressurised gas cylinders. An empty steel bottle forged out of one block weighed about 52 kg for a charge of 8 kg of CO_2. Today, an empty pressurised gas cylinder for a capacity of 10 kg made of steel weighs about 16.5 kg and made of aluminium about 12 kg.

As a refrigerant, CO_2 was first proposed by Alexander Twinning in his British patent of 1850. In America, Thaddeus S. C. Lowe experimented with CO_2 for military balloons in the 1860s and made the discovery to use CO_2 as refrigerant. Lowe started to develop refrigeration systems and in 1867 took out the British patent No. 952. The first CO_2 compression cycle refrigeration system in Europe was built by C. Linde in 1881 (Plank) (according to Göttsche in 1883), manufactured by the Maschinenfabrik in Augsburg and put into operation at Krupp in Essen in 1882. From 1893 to 1894, Linde tested such a CO_2 machine in Munich in order to prove the inferiority of the CO_2 machines of his competitors Riedinger and Hall. He also wanted to prove that CO_2 machines could not achieve the efficiency of NH_3 machines.

CO_2

The critical point is at	+31.0 °C and 73.83 bar
the triple point is at	−56.6 °C and 5.18 bar
the sublimation point is at	−79.2 °C and 0.95 bar

An essential contribution to the breakthrough of CO_2 machines was the work of Franz Windhausen in Berlin (1886). The first CO_2 ship refrigeration systems in Germany were built according to his patent DRP 37214 by the companies Riedinger in Augsburg and Haubold in Chemnitz. In 1886 Windhausen took out the British patent No. 2864 for his CO_2 compressor. In accordance with this patent the company J. & E. Hall in England started to build ship refrigeration machines. At the same time the development and manufacture of CO_2 machines and plants started in the USA. The company Kroeschell Bros. Ice Machine Company manufactured CO_2 refrigeration machines according to a patent (1898) by the Hungarian Julius Sedlacek and called his compressor series "North Pole compressors".

Onshore, air-conditioning systems and the food industry were equipped with CO_2 refrigeration systems and cold air and ammonia machines in ships were replaced by CO_2 machines. According to Bäckström, 60% of ship refrigeration plants and 10% of land refrigeration plants were still operated with CO_2 in 1950.

Small refrigeration machines had a performance of between 1.86 and 2.67 kW. Conventional series had a capacity range of 2.33 to 162.82 kW at a brine cooling from −2 °C to −5 °C. So-called plunger condensers or spray condensers served as liquefiers. According to Pohlmann (1935), refrigerant losses due to leakages in the range of 600 kg a year in a CO_2 brine system with a capacity of 80,000 kcal/hr (93 kW) and a charge of 420 kg CO_2 were regarded as a normal.

The development of CO_2 refrigeration systems in Europe was similar to that in the USA where CO_2 was used successfully in marine and industrial refrigeration systems in the early 1890s and for air-conditioning purposes from around 1900. Due to their non-toxicity and non-flammability, CO_2 refrigeration systems were used in food markets, large kitchens, hospitals, hotels, restaurants etc. At the start of the 1930s, CO_2 in industrial refrigeration plants was being replaced by ammonia, which had been used in parallel since the last quarter of the 19th century. In air-conditioning applications, the replacement of CO_2 by the new "safety refrigerant" R 12 (e.g. Freon 12, Frigen 12) started in the mid-1930s.

The discussion about CO_2 as a refrigerant was revived by a patent of Professor Gustav Lorentzen from 1990, "Trans-critical vapor compression cycle device", patent WO 90/07683. Other drivers came from the works about CO_2 as a refrigerant for automotive air-conditioning systems by G. Lorentzen and J. Pettersen in 1993/94. CO_2 refrigeration systems have become common practice in recent years. CO_2 is used as a primary and secondary refrigerant, both in freezers for food products, also in supermarkets, cold stores and ice rinks. Usually, the cooling and re-condensation of the secondary refrigerant CO_2 in larger plants is done by single-stage or two-stage NH_3 refrigeration systems. CO_2 is used in CO_2/NH_3 cascade plants with CO_2 compressors on the low-temperature side, while the high-temperature side often uses NH_3. Systems for automotive air-conditioning systems and heat pumps with CO_2 as refrigerant have been developed, and are designed to operate at transcritical conditions.

In addition to being ecologically benign, there are also solid economic advantages with using CO_2. It results in better product quality, constant secondary refrigerant temperatures, better heat transfer coefficients, smaller low-pressure compressors, smaller pipe dimensioning and optimisation of energy consumption.

INTERVIEW • eurammon member Michael Freiherr, Chief Technical Officer at Güntner GmbH & Co. KG, talks about various influencing factors on the energy efficiency of defrosting systems and looks at the special requirements when using natural refrigerants.

"Energy efficiency in defrosting systems"

One of the most frequent causes of operational problems with both freezer and normal chilling temperature refrigeration systems is ice build up on air coolers and evaporators. Ice formation on the evaporator's fins for example is detrimental to the heat transfer and results in a temperature increase in the cold room. To minimise the energy consumption as far as possible, an effective and efficient defrosting system is required. This will help to keep the whole refrigerating system running efficiently in the long term.

eurammon member **Michael Freiherr**, Chief Technical Officer at Güntner GmbH & Co. KG

How can the energy efficiency of a defrosting system be calculated?

Michael Freiherr: The energy efficiency of a defrosting system is the sum of the latent and sensible heat necessary to convert the ice build up on the evaporators to water just above 0 °C, divided by the energy actually consumed by the system during defrosting. Well rated systems reach a defrosting efficiency of approx. 0.5 in real operation, however the efficiency of many systems is far lower.

What aspects influence the energy efficiency of a defrosting system in practice?

Michael Freiherr: The energy demand of the defrosting system depends primarily on the defrosting method, for example, air defrost, water, electric or hot gas. The efficiency also depends on equipment layout and fine tuning during commissioning by the engineer on site. Important aspects here include good positioning of the defrost sensor as well as a correct calculation of defrosting times and intervals. Defrost-on-demand is particularly efficient, as this is only activated when a sensor fitted on the evaporator or cooler detects the corresponding demand.

Another possibility of minimising defrost energy consumption is to use the waste heat already present in the system rather than consuming additional defrosting energy. Possibilities include hot glycol/brine/Thermobank, hot gas defrosting and Bäckström defrosting method in particular.

Energy can also be saved by keeping as much of the heat inside the evaporator/cooler during the defrost process. If less heat escapes into the cold room, this reduces the refrigerating capacity necessary to maintain the room set-point temperature after a defrost. Smart solutions include the use of a hood on the backside of the cooler and socks or dampers on the air outlet side impeding hot air heat circulation, or an insulated cooler preventing it entirely.

Which special aspects apply to defrosting methods in NH_3 systems?

Michael Freiherr: Basically, every established defrosting method can be used in systems with natural refrigerants, taking account of all safety aspects that apply to normal chilling operation. Hot-gas defrosting is widely used for NH_3 pump systems on a very broad global scale. One of the reasons is that in NH_3 systems, it is particularly easy for the refrigerant condensate generated in the evaporator during defrosting to flow back into the wet return pipe or to the separator. Ammonia also has a relatively high evaporation enthalpy compared to other >

> "Systems with natural refrigerants fundamentally offer operators a high degree of future viability"
>
> Michael Freiherr

> refrigerants which makes it possible to achieve shorter defrost times than with other refrigerants.

One characteristic of NH_3 systems are the relatively high discharge temperatures. If this is not taken into consideration during the system design, defrosting could cause unwanted vapour formation and result in ice formation in the cold room. Another advantage of hot gas defrosting , regardless of the specific refrigerant used is the very uniform heat supply from the inside. This removes frost and ice very quickly with shorter defrosting cycles and as such enhanced efficiency.

Which special aspects apply to defrosting methods in CO_2 refrigerating systems?

Michael Freiherr: If CO_2 is used for hot gas defrosting, it would require the air cooler and the hot gas piping to be rated to the same pressures as the CO_2 gas cooler / condenser. However, CO_2 air coolers are usually designed for far lower pressure levels. In terms of efficiency, hot brine defrosting would therefore appear to be a better alternative when compared to electric defrosting in CO_2 cascade systems.

How can energy efficiency be evaluated in general for defrosting systems with natural refrigerants?

Michael Freiherr: It is not possible to generalise here. The efficiency of the defrosting system depends on many different individual parameters so that it is relatively difficult to make comparisons. However, when deciding which refrigerant to use, it is far more important to note that systems with natural refrigerants fundamentally offer operators a high degree of future viability. Ammonia and CO_2 are not affected by current and future restrictions imposed by the F-Gases Regulation or other environmental requirements and are therefore suitable for long-term planning.

POLAIRIS
Evaporative condenser

The Polairis™ Evaporative Condenser incorporates highly efficient radial fans with EC motors and the patent pending DiamondClear™ Design.

It offers a long and trouble-free energy efficient operation in combination with an unmatched accessibility and minimal need for maintenance.

PEACE OF MIND

AT HALF

THE ENERGY COST

Reliability

With more than 80 years of experience, we have over 200.000 units reliable operating worldwide, all locally supported throughout the product life-cycle.

Sustainability

We integrate sustainability not only into what we do but also into how we do it. For more than 80 years BAC has been helping its customers achieve their sustainability goals.

Innovation

Ongoing investment in research, combined with the most advanced R&D laboratory facility in the industry, enables BAC to consistently offer the most technologically advanced products to exceed both industry standards and the needs of our customers.

NEXUS™
MODULAR HYBRID COOLER

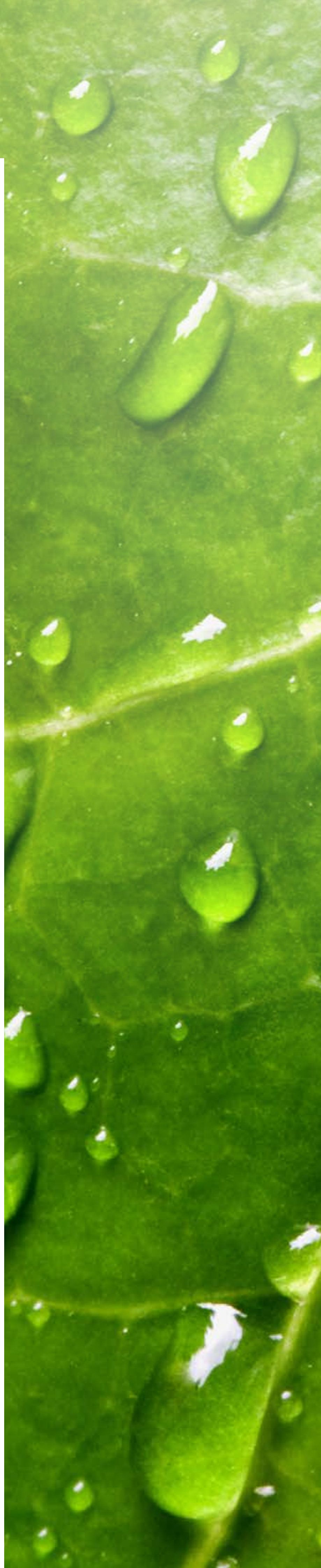
BALTIMORE AIRCOIL COMPANY

www.BaltimoreAircoil.eu
info@baltimoreaircoil.be

The Nexus™ Modular Hybrid Cooler is the world's first intelligent, plug-and-play, modular hybrid fluid cooling system for HVAC and light industrial applications.

It automatically optimizes water and energy savings while delivering the lowest installation and operating costs, lowest environmental impact, maximum uptime and lowest maintenance in a simplified, compact and lightweight design.

THE MOST COMPACT AND RELIABLE COOLER ON THE MARKET



"Natural refrigerants are a popular topic: growing demand for initial and further training courses"

Protecting the ozone layer, reducing greenhouse gases and F-gases phase-down: the current environmental policy framework conditions are boosting the demand for climate-friendly solutions in the refrigeration sector. However, the planning, installation and operation of systems with natural refrigerants demands special legal expertise and safety-engineering know-how. Dr. Ralf Catanescu, Principal at the Federal College of Refrigeration and Air Conditioning Technology (BFS) in Maintal and Prof. Dr. Alexander Krimmel, Director of the European Academy (ESaK) in Maintal explain how the changing market situation is influencing initial and further training courses.

> "Corresponding know-how will belong to the basic skills in future, given the growing practical relevance"
>
> Dr. Ralf Catanescu

What is your opinion: is there a growing need for training courses when it comes to natural refrigerants?

Prof. Krimmel (ESaK): Yes, there certainly is. Recent environmental policy developments such as the European F-Gases Regulation or the Kigali Amendment to the Montreal Protocol have triggered a lively discussion on the market about the use of various refrigerants. Although this development had been foreseeable for quite some time, a great degree of uncertainty still prevails. We receive many enquiries particularly from installers and workers with regard to converting existing refrigeration systems and the future viability of new systems that are to be installed. >

DOUBLE INTERVIEW • Prof. Dr. Alexander Krimmel, Director of the European Academy (ESaK) in Maintal, and Dr. Ralf Catanescu, Principal at the Federal College of Refrigeration and Air Conditioning Technology (BFS) in Maintal talk about the growing demand for training courses on Natural Refrigerants.

Prof. Dr. Alexander Krimmel, Director of the European Academy (ESaK) in Maintal

"The new regulations and standards are indeed a challenge for our training and teaching"

Prof. Dr. Alexander Krimmel

Dr. Ralf Catanescu, Principal at the Federal College of Refrigeration and Air Conditioning Technology (BFS) in Maintal

> Another sign of the increased interest in natural refrigerants are the topics stipulated by companies for course assignments and Bachelor's theses in the framework of cooperative degree courses, with one in four (20 to 25%) meanwhile looking at natural refrigerants.

Dr. Catanescu (BFS): In general, those attending our courses show great interest in this topic. After all, corresponding know-how will belong to the basic skills in future, given the growing practical relevance. The market already has by nature a fundamental level of information. In principle, the training program we provide is so broad that our graduates are familiar with all established refrigerant alternatives, whether natural refrigerants, synthetic refrigerants or blends, and are able to pursue respective developments in refrigeration and air-conditioning companies. Even so, there is currently still a high demand for special seminars and courses.

Status quo – which qualifications can be obtained with regard to natural refrigerants?

Prof. Krimmel (ESaK): The European Academy (EsaK) in Maintal is the only University of Cooperative Education to be specialised in the field of refrigeration and air-conditioning in German-speaking countries. The state-recognised academy offers two internationally accredited Bachelor degrees in „Refrigeration Engineering" and „Air-conditioning Engineering" in the framework of a cooperative programme (dual curriculum). Both 6-semester courses have a modular structure in line with current standards. The combination of theory and practice gives our graduates outstanding qualifications so that they can start working straightaway as skilled workers, regardless of whether the cooperating companies are actively involved with natural refrigerants or not. At the moment there is no special module for „Natural Refrigerants". However, since 2014 we have been offering an annual lecture event that looks at the challenges posed by natural refrigerants and how to handle them safely. The special lecture event – known as the „eurammon Day" – is one of the semester highlights for many students. Members of the initiative for natural refrigerants provide the audience with practical first-hand information about the current technical development of concepts, components and systems operating with natural refrigerants. Initially lasting just one day, the lecture event has meanwhile been extended to two days in view of the great echo and demand.

Dr. Catanescu (BFS): The Federal College of Refrigeration and Air Conditioning Technology has been providing a comprehensive range of initial and further training for skilled workers for more than 50 years, and offers a broad programme of modules and seminars to keep them up to date with the latest legislation and engineering developments. All courses give due consideration to natural refrigerants. In 1994 for example, our seminar programme already featured seminars on R290 (propane) in refrigeration systems. Furthermore, we currently offer additional seminars and special courses e.g. on CO_2 and NH_3.

How do the changed framework conditions influence the initial and further training courses – where do you see a need for action?

Dr. Catanescu (BFS): Basically, teaching of all kinds has to adapt constantly to the latest political and legislative requirements and to newest technical developments. However, the current changes coming with the F-Gases Regulation go way beyond the usual scope, generating additional complexity in both technical and legal respects. Something has to be done here. The modular structure of our courses lets us react quickly to corresponding developments with a swift, straightforward process for adapting the contents of our courses to the changed framework conditions and growing demand. This ensures that course participants acquire the necessary new specialized know-how for this specific purpose.

Prof. Krimmel (ESaK): The new regulations and standards are indeed a challenge for our training and teaching. They are key aspects in the planning and sizing of new systems and also in the maintenance and/or conversion of existing refrigeration systems. Time-consuming familiarisation is needed just for correct documentation. Integrating these new contents in the existing syllabus therefore puts a extra load on both time and human resources. But there is no alternative. A conceivable and appropriate solution would be to introduce a separate module on natural refrigerants. Corresponding changes to the syllabus would have to wait until the current accreditation expires, and become part of reaccreditation in September 2021.

Role model or latecomer – how does German training on natural refrigerants rank in an international comparison?

Dr. Catanescu (BFS): The fundamentally high standard of training systems in Germany puts us in a very good position also in respect when compared with other countries. This is also revealed by the demand from neighbouring countries for our training courses. Furthermore, for quite some time now we have been offering several courses each year for GIZ (German Society for International Cooperation) with natural refrigerants as one of the main topics. Our seminars enable the participants to respond to the new environmental policy framework conditions in their countries and to develop viable solutions for the future – although the time frame stipulated by the political authorities for certain refrigerant prohibitions is extremely tight so operators are facing great problems in some cases. The great interest and positive international echo shows that the range we offer is very successful.

Prof. Krimmel (ESaK): Various international programmes e.g. by the UN (UNEP, UNIDO) are currently trying to promote the German training standards for refrigeration and air-conditioning engineering with special courses in order to establish the corresponding qualifications and standards abroad. This also includes countries with larger markets such as China and India. As far as Europe is concerned, the European Commission has ascertained significant deficits for using and handling natural refrigerants, both in terms of equipment and with regard to qualified personnel. In Germany, specific efforts are being made to redress these deficits, e.g. by setting up new institutes and holding special courses with corresponding systems. Many young people are also attracted to possibilities for gaining experience abroad, which is possible through the international approach adopted by the institutes.

On an international scale, the ESaK works together with three official cooperation partners: the Norwegian University of Science and Technology in Trondheim, Norway, the Purdue University in West Lafayette, USA, and the Universidade Federal in Florianopolis, Brazil. ESaK students have the possibility of doing their Bachelor's thesis at one of the partner universities. These periods spent abroad are eligible for financial support from the BFS/ESaK Foundation and are an important aspect of international transfer of know-how where both the students and the companies are involved.

“The competitive disadvantage of natural refrigerants is diminishing”

INTERVIEW • Stephan Sicars (UNIDO) talks about the market situation for plants using natural refrigerants in emerging and developing countries.

Within the framework of the Kigali Amendment to the Montreal Protocol, altogether 150 countries have undertaken the commitment to gradually dispense with using HFCs that impact on the climate. The rate of implementing the phase-down process depends on the development status of each particular country. While industrial countries such as the USA want to implement 85% decrease in HFCs by 2036, much longer periods apply for emerging and developing countries. eurammon member Stephan Sicars from the UNIDO, United Nations Industrial Development Organization, looks at trends and tendencies covering all aspects of equipment with natural refrigerants in emerging and developing countries.

What role do industrial countries play when it comes to implementing the Montreal Protocol in emerging and developing countries?

Stephan Sicars: The industrial countries are currently providing about US $160 million each year for implementing the Montreal Protocol in the developing and emerging countries. But a lot has changed since the Montreal Protocol came into force more than 25 years ago. Back then, both the know-how and many products came from the industrial countries and were consumed in developing countries. Today, many developments come from the emerging countries. Frequently they are just as good as or even better than solutions produced by the industrial countries when it comes to simplicity, value for money and robustness.

How is the market for natural refrigerants developing in the emerging and developing countries?

Stephan Sicars: Numerous more recent applications with natural refrigerants are currently doing well in the market, without any additional legal interference such as prohibitions, subsidies or taxation. Systems with natural refrigerants are said to be easy to implement, but only under certain conditions. CO_2-based systems are preferably used in larger countries where refrigeration system installers have a network of technical representatives, with

>

eurammon member **Stephan Sicars** from the UNIDO, United Nations Industrial Development Organization.

"Higher costs are difficult to compensate in the purely market economy environment prevailing in developing countries"

Stephan Sicars

> “Plants that run on refrigerants with a higher GWP will certainly have to meet far stricter requirements in terms of equipment tightness and monitoring in future”
>
> Stephan Sicars

> training and maintenance provided by the local dealerships. Ammonia is mainly used as a refrigerant in countries that already have many years of experience with ammonia. However, the ability to plan more complex ammonia systems including the safety aspects and to steer such systems through the corresponding approval processes is currently declining. This refers to both system installing firms and also to the authorities in some medium-sized countries.

Are there limits for applications with natural refrigerants?

Stephan Sicars: In technical terms, a large share of refrigerating tasks can be solved well or very well with equipment that uses natural refrigerants. However, development work is still necessary for systems in the medium capacity range between 5 and 100 kW, particularly for commercial air-conditioning. Due to safety precautions the medium capacity range of typical direct evaporation air-conditioners would exceed the allowed charge limits for hydrocarbons. On the other hand this range has too low capacity for efficient water chilling units. Intensive work is currently in progress worldwide on corresponding solutions.

Which application areas have the greatest need for action?

Stephan Sicars: Refrigerants are responsible for about 1.5% of the anthropogenic greenhouse effect. Most of the global emissions come from small air-conditioning units (mini-splits) and car air-conditioning systems. It looks as if car air-conditioning systems at least are moving towards refrigerants with a low greenhouse effect. That cannot be said for split air-conditioning units. Although the developing countries have a number of manufacturers for split refrigeration systems with hydrocarbons as refrigerants, with most major manufacturers offering a capacity for producing several million units a year, it is almost impossible to sell the units at the moment for competitive reasons. Now that the units reach the same safety levels as the current standard units, the key remaining barrier posed by hydrocarbon systems consists in the higher installation costs. However, higher costs are difficult to compensate in the purely market economy environment prevailing in developing countries.

How can we get people willing to invest more in climate-friendly technologies?

Stephan Sicars: With a unit operating on natural refrigerants, the customer has to take on a very high share of the direct and indirect costs. With equipment operating on fluorinated hydrocarbons, these costs are paid by society at large because in the long term it is society at large that has to cover the consequences of the far higher environmental pollution. However, this competitive disadvantage would appear to be diminishing – not by sharing out the environment costs but by implementing stricter emission prevention requirements. With the costs resulting from the climate relevance of refrigerants increasingly being shared out between the equipment, and similarly with the requirements made by the governments in terms of operation and leakage scenarios getting stricter all the time, solutions with natural refrigerants will sell better on the market. On the other hand, it is, for example, also relatively probable that China will play a greater role in steering the market in future. That way new technologies would become increasingly competitive on China's huge market and could then be exported to other countries.

First Montreal, then Kigali: can we expect even tighter regulations for refrigerants in future?

Stephan Sicars: I believe so. In my opinion, it is improbable that refrigerants with a GWP> about 100 will see broad use in the medium term. While apart from prohibiting refrigerants that impact on the climate, there are also other ways of mitigating climate change, for example by enhancing the energy efficiency of refrigerating systems. After all, the use of fossil energies is one of the main causes of CO_2 emissions. But in global terms, for the individual states it is far cheaper and easier to enforce a refrigerant prohibition than to specify energy efficiency measures for plants and equipment. In other words, plants that run on refrigerants with a higher GWP will certainly have to meet far stricter requirements in terms of equipment tightness and monitoring in future. This makes the use of such refrigerants increasingly unattractive because of the expense involved, thus diminishing the competitive disadvantage for machines with natural refrigerants.

Mark Bulmer, Head of Global Market Development at GF Piping Systems

Ákos Murin, CEO QPLAN Kft.

Refrigeration and air conditioning systems with secondary cooling circuits are booming. – Mark Bulmer (Georg Fischer Piping Systems), Ákos Murin (QPLAN Kft.), Stina Forsberg (Temper Technology AB) and Monika Witt (TH. WITT Kältemaschinenfabrik GmbH) – explain the advantages of the system, typical error sources and the direction in which the market is developing.

Secondary loops are already used in countless systems and applications. Why is this such a hot topic in refrigeration and air conditioning technology?
Stina Forsberg: New legislation with increasingly tight restrictions on synthetic refrigerants is forcing the industry to look for alternatives. Secondary loops have proven themselves as an outstanding solution for many years and are now also on the agenda for the first time in many new application areas.

Monika Witt: Also, many operators fear the additional safety requirements when exceeding certain refrigerant quantities. Secondary loops are an elegant solution here: The refrigerant charge can be reduced or limited to the machine room and the secondary refrigerant (i.e. water, glycol, temper) is pumped to the cold rooms.

What advantages are offered by refrigerating systems with secondary loops?
Ákos Murin: Secondary systems offer greater safety compared to systems that are cooled directly using refrigerants. Although the secondary loop increases installation costs and reduces efficiency due to a second heat exchanger, in many cases these factors are outweighed by the advantages regarding safety and flexibility.

Stina Forsberg: On top of that, extensions and modifications of the secondary loop are considerably easier and more cost-effective than changing refrigerant filled pipe systems – thereby offering operators far greater flexibility.

INTERVIEW • Four eurammon experts – Mark Bulmer (Georg Fischer Piping Systems), Ákos Murin (QPLAN Kft.), Stina Forsberg (Temper Technology AB) and Monika Witt (TH. WITT Kältemaschinenfabrik GmbH) talk about a solution with secondary loops.

In which areas of application or specific plants are secondary loops used?

Monika Witt: Secondary loops avoid employees or goods coming into contact with harmful refrigerants in the event of a leak. This makes them the preferred solution for areas in which a large number of employees work, for example, in goods delivery or food packaging. Furthermore, when the customer does not want the refrigerant being able to get in contact with sensitive or open refrigerated goods in the food processing industry, such as in slaughterhouses and meat processing, but also for dairies, juice production, fruit cooling and banana ripening.

What are the special characteristics of secondary loops (sub-zero) compared to conventional 7/12°C air conditioning systems?

Mark Bulmer: Cooling systems with fluid temperatures below 0°C use special, frost-resistant secondary refrigerants, which often have a higher viscosity than water. A great deal of specialist knowledge is required to select the right liquid and concentration, while all the other system components, such as pumps or heat exchangers, have to be adapted to the selected secondary refrigerant.

Ákos Murin: In sub-zero systems, a professionally planned and implemented heat insulation system is also of vital importance in order to prevent condensation and the formation of ice on surfaces. In addition, the importance of corrosion protection cannot be stressed enough. It is not just a matter of "let's paint the pipe", but is a whole scientific field in itself.

What are the most common or typical error sources in practical operation?

Mark Bulmer: Secondary loops often have an extensive piping system with lengths of between 2 and 20 km. As a general rule, the pipework has to be laid out particularly carefully for such large-scale systems; for example, it must be able to compensate for expansions and contractions. The correct positioning of all shutoff valves for any maintenance or modification work is of similar importance. In order to guarantee the efficiency of the system, correct venting is also essential during commissioning and operation.

Monika Witt: One of the most common errors is the use of system components that are not matched to the particular properties of the secondary refrigerant. If the hydraulic balancing of the system (even distribution to the consumers) is not executed properly, the refrigerant capacity is poorly distributed. Other typical error sources include incorrectly selected or installed pumps which can cause hydraulic shocks upon startup, as well as quick-acting valves such as solenoid valves, which can cause damaging pressure fluctuations.

Stina Forsberg: Most errors are caused by a lack of knowledge. Indeed, it happens every now and then that systems are charged with unsuitable secondary refrigerants. Moreover, it is not uncommon that smaller leaks are not repaired, simply because the required knowledge is lacking. That is why eurammon has begun compiling a handbook on secondary systems, which comprises the most important information and make it available to the market.

How would you assess the market potential of sub-zero secondary loops?

Mark Bulmer: Refrigeration systems with secondary loops will make a disproportionate contribution to the market growth of systems with natural refrigerants over the next 20 years. One reason for this is that a large number of national environmental regulations are set to come into effect – which will raise costs for synthetic refrigerants and any leaks that occur.

Monika Witt: Systems with secondary loops do not initially seem to be the most cost-effective solution, but they are becoming more attractive with regard to costs, because expert knowledge is then only required for the machine room with the primary refrigerant loop. This expertise can be obtained with shop-fabricated "plug & play" systems with various refrigerants. Expertise required for the secondary loop is normally already existing at contractors for air-conditioning or heating and plumbers.

Ákos Murin: Thanks to the more stringent requirements relating to environmental protection and the energy efficiency of refrigeration systems, those systems with natural refrigerants will become ever more attractive for the market. However, the market is also facing stricter safety requirements and restricted fill levels. Systems with natural refrigerants and a secondary loop often strike the right balance between the raised requirements in relation to environmental protection, efficiency and safety.

Stina Forsberg, Managing Director at Temper Technology AB

Monika Witt, Managing Director (Technology and Sales) at TH. WITT Kältemaschinenfabrik GmbH

Advantages and challenges of low charge ammonia systems

Many reasons for small quantities of refrigerant

Ammonia is an environmentally benign, cost efficient and future proof refrigerant. It has been traditionally used in industrial applications for cooling capacities of several megawatts using tonnes of refrigerant charge. However, the flammability and toxicity of ammonia impose comparatively high safety requirements in terms of system design when compared to synthetic refrigerants, and traditionally has not always been suitable for every application. System and component development has resulted in the wider adoption of low-charge ammonia systems as an attractive alternative to conventional systems, across an increase range of applications. Ammonia is non-harmful to the environment and isn't included in the F-Gases Regulation and pending phase-down programme. Smaller charges reduce safety risks and the regulatory stipulations that have to be heeded when devising the system. With a combination of low Total Cost of Ownership (TCO) and low operating costs, low charge systems are often the best solution for the long term, in both economic and ecological terms.

"Small quantities reduce health and safety risks in the event of a leak, and simplify the official approval procedures"

Dr. Rob Lamb

Traditional, pump based ammonia refrigeration systems typically contain a charge of 2 to 3 kg per kW cooling capacity. By contrast, low-charge systems contain far less ammonia, typically less than 1.3 kg per kW, and applications are even possible with just 0.06 kg per kW. These small quantities reduce health and safety risks in the event of a leak, and simplify the official approval procedures, as systems with smaller charges have to heed far fewer requirements and regulations. The planning, operation and maintenance of some low charge system designs is also easier as there are fewer components and many systems are manufactured as a single factory built package. In many cases there will be no need for pumps to move the refrigerant around the system and both pipework and vessels are smaller.

Systems with 95% less ammonia charge

Low charge systems can achieve the same capacity levels as conventional pump-based systems but with a fraction of the refrigerant inventory. Traditional refrigeration systems circulate more liquid than is required for extracting heat in the evaporators. The overfeed rate i.e. the ratio of liquid to gaseous ammonia is typically 2:1 to 8:1 depending on the application. In other words, only one of the two to eight kilograms of refrigerant pumped through the system is actually evaporated into the gas phase. In low charge systems, the ratio is usually less than 1.2:1. "Suitable system designs can reduce the ammonia charge in the overall system by 75% and even 95% in the evaporator, with no appreciable drop in capacity", explains Dr. Rob Lamb, Marketing Director at eurammon member Star Refrigeration Ltd.

These low circulation rates are possible through recent developments in evaporator design for temperature controlled storage applications using aluminium piping. Traditional air coolers use stainless or galvanised steel pipe which require 4:1 recirculation rates to achieve the design cooling capacity. Aluminium pipe has twice the thermal conductivity of galvanised steel and 12.6 times the conductivity of stainless steel (304L). The result is improved heat transfer between the room air and the refrigerant without the need for liquid pumps, leading to

Thanks to the intelligent system design of the Azanefreezer by Star Refrigeration Ltd., it was possible to reduce the ammonia charge at Farmfoods to 0.1 kg per kW.

more efficient operation than pumped recirculation for the same operating conditions.

Prerequisites – precise calculation and clean working

When design low charge systems, attention is needed in terms of charging and installation cleanliness. "Optimum efficiency and permanently safe operation depends crucially on accurate calculation of the required ammonia charge. It must be large enough to permit stable, efficient operation across the entire operating range of the system, and also take account of changing ambient temperatures and system loads", says Lamb. If the charge is too small, it will jeopardise the long-term performance capability and reliability of the overall system, for example if a leak causes small quantities of refrigerant to escape which would reduce the cooling capacity and efficiency of the system. Cleanliness during the installation process is also important. "The small circulation rates required for low charge systems means that small orifice expansion devices can easily clog due to remnants of dirt from the installation process." On the other hand, the refrigeration systems are simple in design, reducing requirements for ongoing maintenance which makes them cheaper to operate.

New applications – from process cooling to HVAC

Low charge technology with its high system capacity opens up new applications where classic ammonia systems or refrigeration plants with synthetic refrigerants have been used. This includes refrigeration plants for deep-freeze and cold storage facilities as well as the food industry, process cooling, data centre cooling systems and the HVAC sector. The new refrigeration system installed for the British food and frozen food specialist Farmfoods is a good example for the efficiency and flexibility of low charge systems. The company has around 300 food stores throughout the UK and was looking for an energy efficient refrigeration system with natural refrigerants for its new distribution centre in Bristol to supply the company's stores in the south of England. Farmfoods opted for two Azanefreezers by Star Refrigeration Ltd. with ammonia as refrigerant. These operate with a total cooling capacity of 530 kW to keep temperatures permanently and reliably at -22 °C in the freezer rooms. The chilled areas are cooled to +2 °C by an Azanechiller which uses ammonia to cool a secondary glycol circuit and has a capacity of 120 kW. The intelligent system design reduced the ammonia charge in both systems to 0.25 kg per kW and 0.1 kg per kW, respectively. The new systems are not just far more efficient than standard HFC refrigeration systems. Use of the natural refrigerant ammonia also reduces the company's carbon footprint – something that final consumers find increasingly important.

For eurammon member Rob Lamb from Star Refrigeration Ltd., the project clearly demonstrates the potential and growing significance of low charge refrigeration systems. "It combines high efficiency with a comparatively simple system design, relatively minimum regulatory requirements and high environmental compatibility that makes low-charge ammonia systems an attractive alternative in almost every application segment, also including the high capacity range", says Lamb.

Cascade systems with more than one natural refrigerant

Combined applications of natural refrigerants

Natural refrigerants such as ammonia (NH_3), carbon dioxide (CO_2) and hydrocarbons each have their own strengths and advantages. We take a look at how combining these refrigerants in cascade systems can provide further benefits including efficiency and reduced component size.

Combined Carbon Dioxide and Ammonia plant for pet food processing

The Prosper De Mulder Group (now Saria) uses an environmentally friendly and highly efficient plate freezer system for the processing of pet food in a facility in Doncaster, England. The freezers use carbon dioxide as refrigerant in the plate freezers which enables the plant to run at lower temperatures and lower power consumption than could be achieved with ammonia alone or with synthetic (HFC or HFO) refrigerants. This performance improvement results partly from greatly improved heat transfer within the plates of the freezer and partly from the reduced pressure drop in the flexible hoses and suction line of the freezer. A core temperature of –18°C in the 75mm blocks of meat is reached in 60 minutes – in plants with Ammonia or synthetic refrigerants a time of over 2 hours would be required.

The plant comprises a low temperature carbon dioxide circuit of two screw compressors and a surge drum/pump set serving 16 plate freezers, each with 26 stations. The high temperature circuit uses ammonia to condense the carbon dioxide in two plate and shell heat exchangers. The ammonia system is also used to serve a cold store and scraped surface heat exchangers. Heat is rejected from two evaporative condensers.

Consideration was given to designing an integrated carbon dioxide system; delivering cooling not only to the plate freezers but also to the cold store and the scraped surface heat exchangers. To use carbon dioxide alone for the cold store would have required operating the high-pressure side of the carbon dioxide system at lower conditions than was acceptable for optimised operation of the low temperature freezing plant.

The main environmental benefit is the low energy consumption of this system. Due to the systems design it is not necessary to run the ammonia compressors at high pressure in order to achieve a defrost. The CO_2 plant configuration also allows the cold store and process load to be run from the ammonia plant. If a two stage ammonia plant had been used for the freezers, the additional loads would require their own plants, as the intermediate condition of the ammonia freezer plant would have been too high for the cold store.

In comparison to the size of a compressor required to run ammonia at –40°C, the CO_2 compressors are significantly smaller and cheaper. By running CO_2 at –50°C there are also fewer plate freezers in the hall, and thanks to narrower plate profiles, each CO_2 freezer station contains two more stations than could be fitted into an ammonia station. The defrost system is more complex than for ammonia, but this is more than compensated for by the savings in the other areas. The CO_2 / NH_3 cascade system results in a 10 to 15 per cent saving for the refrigeration plant and a 5 per cent saving in energy costs.

Two supermarket distribution centres among the biggest temperature controlled buildings in the UK

When the supermarket chain Asda built two new distribution centres in Skelmersdale and Falkirk, the buildings were among the biggest temperature controlled structures in the UK, with a total combined internal volume of 412,000 m^3.
Both installations utilise the natural refrigerants carbon dioxide and ammonia. Each site has a cold store and a series of large chill rooms, operating just above 0 °C. The refrigeration plant for the -25 °C cold store operates as a cascade system, with CO_2 serving as the low temperature fluid in a standard vapour compression cycle and rejecting its heat to the ammonia (NH_3) system. CO_2 is then used as a volatile secondary refrigerant for the chill areas, being pumped out at –5 °C, the condensing temperature for the cold store circuit, and returning as a vapour at the same condition, for condensing by the NH_3 system.

The CO_2 systems utilise components suitable for operation at higher pressures required for this fluid. Oil injected screw compressors are used for the low temperature CO_2 circuit, alongside a highly efficient oil recovery system operating a 3-stage separation process. Their swept volume is a 10th of what would have been required if ammonia had been used as the low temperature refrigerant. Plate and shell heat exchangers are used for the CO_2 condensers, delivering a compact, efficient and reliable package. The air coolers used in both the cold and chill stores were designed with circuiting that had been optimised for use with CO_2, delivering higher performance than comparable coolers using either NH_3 or synthetic (HFC) refrigerants. The energy efficiency of the new Carbon Dioxide coolers is substantially better than had been achieved on previous sites. Further environmental benefits have also been achieved. The previous standard system would have used four evaporative condensers, with associated chemical water treatment. But for this system, the whole plant heat rejection is achieved with only two condensers, making the water treatment simpler and cheaper.
In addition to these benefits, the use of CO_2 for both the cold and chill stores has allowed much smaller pipework to be used for distribution of CO_2 to the air coolers which also resulted in cost savings during construction.

These two examples prove that the combination of CO_2 and NH_3 can be applied across a wide range of temperatures and applications – for example for low temperature freezing, cold storage, chill applications, air-conditioning and hot gas defrosting. The use of this versatile combination in industrial installations will certainly be repeated many times in the coming years.

The winners of the Natural Refrigeration Award 2017. From left to right: Peng Gao, Stefan Brinkmöller, Marco Cefarin.

Award winners honoured at the eurammon Symposium in Schaffhausen

Natural Refrigeration Award 2017

Every two years, eurammon, the initiative for natural refrigerants, rewards young scientists for pioneering research in the field of natural refrigerants. This year, the Natural Refrigeration Award prize of € 5,000 was awarded with support from the Technical University Braunschweig and the Czech trade journal Chlazení. The prizes were awarded to the three winners on 22 June 2017 during the eurammon Symposium, where they were also able to present and discuss their research work and results relating to the use of natural refrigerants such as ammonia and CO_2 with the international expert audience at the symposium.

The first prize was won this year by Peng Gao from Shanghai Jiao Tong University (China). His dissertation related to the development of an innovative solid sorption freezing system for refrigerated trucks. The system uses the exhaust gas generated by combustion of the fuel in the truck engine at temperatures between 200°C and 500°C for refrigeration in a two-stage solid sorption freezing cycle operated with the natural refrigerant ammonia. The innovative system is superior to the mechanical vapour compression refrigeration system usually to be found in refrigerated trucks in terms of both costs and environmental protection: the operating costs and the related CO_2 emissions for the refrigeration system are close to zero. The system is also suitable for refrigerated lorries carrying frozen goods, even in ambient temperatures of up to +30°C. The research results convinced the international jury and triggered great interest among those attending the eurammon Symposium. „The dissertation clearly shows the potential of research in the field of natural refrigerants, also indicating the economical and ecological advantages that can be achieved with innovative applications“, explained Monika Witt, Vice-chair of eurammon.

The second prize went to the students Dennis Lerch and Stefan Brinkmöller for their project assignment as part of their engineering course at HsKA Karlsruhe University of Applied Sciences (Germany). They developed the „Bavarian Breakfast

More information about the Natural Refrigeration Award together with the dissertations and projects of the prizewinners is available on the eurammon homepage **http://www.eurammon.com**

Maker Green Line". The mobile high-temperature heat pump has a cold and a hot water basin for cooling 35 bottles of wheat bear from 20°C to 5°C, while at the same time heating 70 Bavarian „Weisswurst" sausages from 20°C to 80°C. The unit uses the natural refrigerant isobutane (R 600a). With view to the high pressure ratio required a semi hermetic piston compressor was selected. The beer is cooled by a self-designed tube coil evaporator with medium-high finned tubes, which absorbs the thermal energy effectively through the circulating pump. The condenser was constructed as a plate heat exchanger that transfers the heat to the hot water basin keeping the refrigerant charge as low as possible. A thermostatic expansion valve was also developed especially for the project. The BFBGL is a prime example how natural refrigerants can be used in environmentally friendly refrigeration technology, impressively and practically underlining the efficiency.

The third prize was awarded to the dissertation by Marco Cefarin from the Universitŕ degli Studi di Udine (Italy). The aim of the parametric study was to design an NH_3-H_2O absorption refrigeration system that is also capable of making maximum use of industrial waste heat at low temperatures. A mathematical reference model with a pre-condenser heat exchange dephlegmator reached a COP level of 0.471. While maintaining constant condensating and evaporating temperatures, there was a drop in efficiency at low generator temperatures. The optimum minimum generator temperature was also influenced by different system parameters, such as the size of the heat exchanger and the fluid flow rate. The concentration gradient of ammonia between rich and lean solution was identified as being a central criterion for possibly using a heat recovery concept. The data predicted in the theoretical model were then verified and confirmed in a reference system.

Peng Gao won the first prize of the Natural Refrigeration Award 2017.

Planning for the future: long-term investment security as a driver for natural refrigerant

DOUBLE INTERVIEW • eurammon chairman Bernd Kaltenbrunner and IIAR President Dave Rule talk about future developments in the natural refrigeration branch.

eurammon is an industry initiative and centre of excellence which has dedicated itself to the use of natural refrigerants in Europe for more than 20 years. The International Institute of Ammonia Refrigeration (IIAR), eurammon's long-standing partner in the US, celebrated its 45th anniversary in 2016, representing decades full of changes and political developments in Europe and the US. Bernd Kaltenbrunner, Chairman of the eurammon Executive Board, and Dave Rule, President of IIAR, take a look back, analyse the current situation and reveal new trends and developments that will help make refrigeration technology more sustainable.

Over 20 years of eurammon and more than 45 years of IIAR – what have the greatest achievements and challenges been during this time?

Bernd Kaltenbrunner: eurammon was established in 1996 with the aim of informing industry, the general public and authorities of ammonia as a safe solution in the refrigeration and air conditioning industry. This is achieved through production of informational material and lectures at conferences, symposiums and workshops. Back then, legislators were in the process of discussing restrictions for ammonia-based refrigeration systems, which were ultimately averted thanks in part to our extensive information sharing efforts. More than ten years ago, in 2006, we made the decision to expand our focus to include all natural refrigerants, as there was also a high demand for information particularly for CO_2 and hydrocarbon systems. We cover these with events such as our symposium in Schaffhausen and lecture series at Chillventa, among other things. Having joined forces to create a joint initiative, we can bring together our expertise on a central platform and generate synergies, for example in our efforts to inform. We make our knowledge available through publications in international papers and launched an extensive online product database on our website. Using an intelligent search facility, anyone who's interested can find specific components and services for systems with natural refrigerants – and obtain a clear list of suppliers, including practical details such as contact information and links to company websites.

> "Companies are once again wondering which refrigerant to invest in. Natural refrigerants offer greater security"
>
> Dave Rule

Dave Rule: Just like eurammon, IIAR was originally founded with a focus on ammonia as a natural refrigerant. In response to new technologies, growing environmental awareness and new legal requirements, we've expanded our work to include all natural refrigerants. We're currently focusing on ammonia and CO_2, but now also see that hydrocarbons will become more and more important in the future due to their environmental benefits. IIAR has also developed into an institution for establishing new standards in the US. For instance, standards in the petrochemical industry have been applied to the refrigerant industry in the past, which has resulted in much too restrictive regulatory hurdles for operators. To improve this situation, we've introduced eight standards so far, ranging from the development of safety features for refrigeration systems to system >

Bernd Kaltenbrunner, Chairman of the eurammon Executive Board, and **Dave Rule**, President of IIAR (from left to right)

installation, operation and shut-down. Intensive interaction with government authorities has allowed us to incorporate institutions into the development of standards – so that they recognise these standards throughout the country. This consistency is extremely important particularly for end consumers and has significantly improved the position of the refrigerant industry.

How is the market for natural refrigerants developing in Europe and the US? What are the similarities and differences?

Bernd Kaltenbrunner: In Europe, requirements and restrictions set out by the government and authorities are the most important drivers for the industry. State funding for systems with natural refrigerants also helps promote and incentivise their use. We're seeing a positive effect from growing environmental awareness in the general public, which is increasingly taken into account when making purchasing decisions. As a consequence, sustainable supply chains are becoming more and more important to companies, which proactively communicate their use of eco-friendly technologies externally – particularly when they manufacture eco-friendly or organic products. For companies which offer organic meat and cheese, for example, refrigeration with natural refrigerants is a part of their corporate identity.

Dave Rule: While environmental factors such as global warming and depletion of the ozone layer do play a role in the current discussion, in the US the transition to natural refrigerants is primarily driven by regulatory authorities. It was ratification of the Montreal Protocol and the associated phase-out of the widespread R22 refrigerant that first motivated industry to search for alternatives which don't have any impact on the ozone layer. However, the conditions for climate-friendly solutions have recently got worse again due to the United States' withdrawal from the Paris Agreement. Financial cuts in environmental protection can also be expected. But it's still unclear to what degree further regulations and their implementation will be affected in the future.

Which other influential factors will promote the success of natural refrigerants?

Bernd Kaltenbrunner: One of the key difficulties for companies is the highly variable life cycle costs of a system. Component manufacturers, refrigeration specialists and operators have different views and concepts, so there's no objectively comparable data available to the market. Just like in the US, we in Europe also view investment security as an important success factor for natural refrigerants. Companies realise that policymakers are serious about the phase-out, which is why the market is searching for refrigerants that will offer security for the next 10 to 15 years and beyond. Systems with natural refrigerants such as ammonia, hydrocarbons and CO_2 are ideal candidates. No new regulatory requirements are currently in the pipeline for them and lots of practical experience has already been gained with the corresponding systems.

Dave Rule: In addition to government regulations, energy costs have also proven to be a strong driver. People and companies are increasingly thinking about the type and amount of energy used. Following the R22 ban, many companies switched to HFCs, which are currently being discussed at great length in the context of global warming. The US Environmental Protection Agency (EPA) is now advising against the use of certain HFCs, which may eventually be affected by a phase-out. As a result, companies are once again wondering which refrigerant to invest in. Natural refrigerants offer greater security.

What experience have you had with the phase-out? To what degree is the industry thinking about new solutions?

Bernd Kaltenbrunner: To put it simply, there are two groups of companies in Europe. One continues to use very cheap, but not very eco-friendly, systems – even though they're fully aware that these systems will have to be updated in the foreseeable future. They predict delays or an easing of the phase-out. But that's unrealistic, as policymakers have always responded with shortened deadlines and more stringent threshold values. For the second group, planning and a robust basis for their cost calculations takes priority. It's owner-managed companies and companies with a strong focus on the environment in particular that place a higher value on long-term, sustainable operations when it comes to system planning and pay closer attention to the period of use.

Dave Rule: In the US, stringent regulatory requirements for ammonia systems with high charges restricted the switch to natural refrigerants at the beginning. That benefited the development of small package systems with low charges – the new systems and technologies require a mere fraction of the ammonia and therefore face much fewer restrictions. A typical cold store can operate with a small package system with around 500 kg of ammonia, rather than the 2,000 to 3,000 kg required by conventional systems in the past.

What are some of the unique characteristics of the European and US markets that we should be looking out for?

Bernd Kaltenbrunner: There's currently a large market for natural refrigerants in the US and most of the key players are pulling together. For instance, IIAR can establish new standards with relative ease, so the industry can move very quickly. In Europe we have the same technical expertise and know in great detail how the systems work but decisions are often very carefully weighed and discussed at great length, which means it can take a long time for new EU standards and regulations to be adopted, some of which then need to be transposed into national law.

But the Montreal Protocol, for example, had immediate impacts on the EU and Germany, and has since been joined by the Kigali Agreement. The result is a commitment to actively and financially support the agreed multiphase reduction of HFCs particularly in emerging countries. The EU and Germany have plenty of experience and a long tradition of using natural refrigerants such as ammonia, carbon dioxide and hydrocarbons. Systems with natural refrigerants are already in operation around the world, built with European expertise and components. Europe can assume a key role in this international market.

Dave Rule: At the beginning, the environmental aspects of refrigeration and air conditioning technology played a much smaller role in the US than in Europe. But that has changed over the last several years. Even if it's still unclear what effects the US government's decision will have in the future, we're already taking on a leading role in many areas, including the reduction of HFCs. In addition, sharing expertise and information is very important in the US market, which is why we've established the Academy of Natural Refrigerants. The institution offers engineers and industry access to extensive specialist knowledge about natural refrigerants, ranging from standards and risk management to special technical know-how for system planning. Anyone who's interested can also take part in online training courses and gain qualifications in the form of certificates and final exams. The format and content that we share through the Academy of Natural Refrigerants are sure to be relevant for users in other countries too.

> "Systems with natural refrigerants are already in operation around the world, built with European expertise and components"
>
> Bernd Kaltenbrunner

Elections of the eurammon Board and Chairman of the Steering Committee

At the end of April 2018, numerous eurammon members gathered for the two-day members' meeting in Madrid. Apart from important networking and many exciting lectures, the election of the new eurammon Board and Steering Committee were also on the agenda.

Bernd Kaltenbrunner, KWN Engineering GmbH, was re-elected as Charmain and Monika Witt, TH. WITT Kältemaschinenfabrik GmbH, was confirmed as Vice Chair. As additional board members, the voters elected Mark Bulmer of Georg Fischer Piping Systems Ltd., Georges Hoeterickx of EVAPCO Europe BVBA and Thomas Spänich, GEA Refrigeration Germany GmbH. The whole board wishes to express their gratitude for the trust that the members have placed in them by their re-elections. Also, the members of the Steering Committee successfully stood for election. As a result, the new Chairman of the Steering Committe is Frank Rinne of Emerson Climate Technologies GmbH. He also would like to thank all members for their trust and commitment.

eurammon symposium on the challenges of the F-gas Regulation and Eco-Design Directive in 2018 and Compelling Solutions with Natural Refrigerants

Natural refrigerants as a future-oriented solution in view of increasing climate regulations

On 28 and 29 June 2018, the eurammon Symposium was once again held in Schaffhausen (Switzerland). In a total of thirteen lectures on the subject of „Challenges of the F-Gas Regulation and Eco Design Directive in 2018 and Compelling Solutions with Natural Refrigerants“, the speakers provided information on current trends and developments in refrigeration and air-conditioning technology. As in previous years, the eurammon lecture event was fully booked with almost 70 participants from 15 countries.

Measures such as the F-Gases Regulation, which provides for a gradual reduction in the total quantity of F-Gases sold in the EU, as well as the start of the ratification phase of the Kigali Agreement at the beginning of 2019 and accession to the Paris Climate Treaty, increase the pressure on industry and users to focus on climate-friendly and energy-saving refrigeration systems. „Refrigeration systems that rely on natural refrigerants already meet the increased climate regulations, often have a more efficient energy balance and are therefore usually cheaper to use. In my view, natural refrigerants are therefore the best alternative for meeting future challenges," said Bernd Kaltenbrunner, chairman of eurammon. The main topic of the symposium showed not only the legal and safety framework conditions but also future-oriented application examples.

Natural refrigerants as future-oriented solutions for increasing legal requirements, tailor-made system design and new standards

The first day focused on international climate agreements, refrigerant regulations and climate-friendly technologies. Arno Kaschl from the European Commission, reported on the status quo of the F-Gases Regulation and gave an outlook on the next steps. Carsten Hoch from TÜV Süd gave an insight into the necessary introduction of a Europe-wide uniform and standardised classification and regulation for flammable refrigerants. Hermann Renz from Bitzer Kühlmaschinenbau GmbH and a long-time member of eurammon, gave the expert audience an overview of the different programs and standards for the energy efficiency of different appliances and systems and their calculation. Lambert Kuijpers, UNEP, pointed out in his lecture on energy efficiency that attention should not only be paid to the use of refrigerants with a low global warming potential, but that the use of energy-efficient systems also makes an important contribution to achieving climate targets. Professor Dr. Michael Kauffeld from the Karlsruhe University of Applied Sciences presented various technologies that already meet the requirements of the F-Gases Regulation and will help achieve climate targets.

The opening day of the symposium was rounded off by a panel discussion in which Arno Kaschl, Carsten Hoch, Lambert Kuijpers and Hermann Renz answered questions from the symposium participants. The discussion was moderated by Professor Dr. Kauffeld.

One controversial topic was the insufficient availability of nationwide training centers that train the handling of the increasing number of available refrigerants. Also the problem of a confusing market availability as well as too long delivery times of refrigerants was brought up for discussion. In summary, it was stated that international agreements such as Kigali or the Paris Climate Treaty stimulate public debate and increase the pressure on industry to turn away from synthetic refrigerants and move to natural refrigerants such as ammonia or hydrocarbons and thus also to orientate itself towards sustainable, energy-saving large (>200 kW) and small (<200 kW) refrigeration systems.

Successful practical applications with natural refrigerants

The second symposium day informed the participants about successful and convincing practical applications. Frank Rinne of Emerson Climate Technologies GmbH started the day with a lecture that explained the performance results as well as the comparison results of an Emerson test setup on the basis of different cooling cycles such as the conventional, the by-pass and the mechanical subcooling cycle. Robert Lamb of Star Refrigeration Ltd. demonstrated the successful use of low charge, high efficiency ammonia chiller packages in food factory and indoor ski slope applications. Alexander Pachai of Johnson Controls, who is working in a working group on standardized reporting of accidents involving refrigerants, gave a brief excursion into safety in the handling of refrigerants in order to enable better reporting and thus better accident prevention in the future. Heikki Oksanen of Vahterus Oy presented on how water quality, pressure drop, oil leakage and too low an ammonia level can result in reduced refrigeration plant efficiency. Tommy Angback from Alfa Laval Lund AB then presented his experiences with plate heat exchanger. Roger Rosander from Temper Technology AB gave an overview of heat transfer fluids in his presentation. The symposium was rounded off by the presentation of the refrigeration system design at Zurich Airport by Burkhard Bein. A mix of different cooling systems, different natural refrigerants and an efficient energy management system make this solution sustainable, energy-saving and future-oriented.

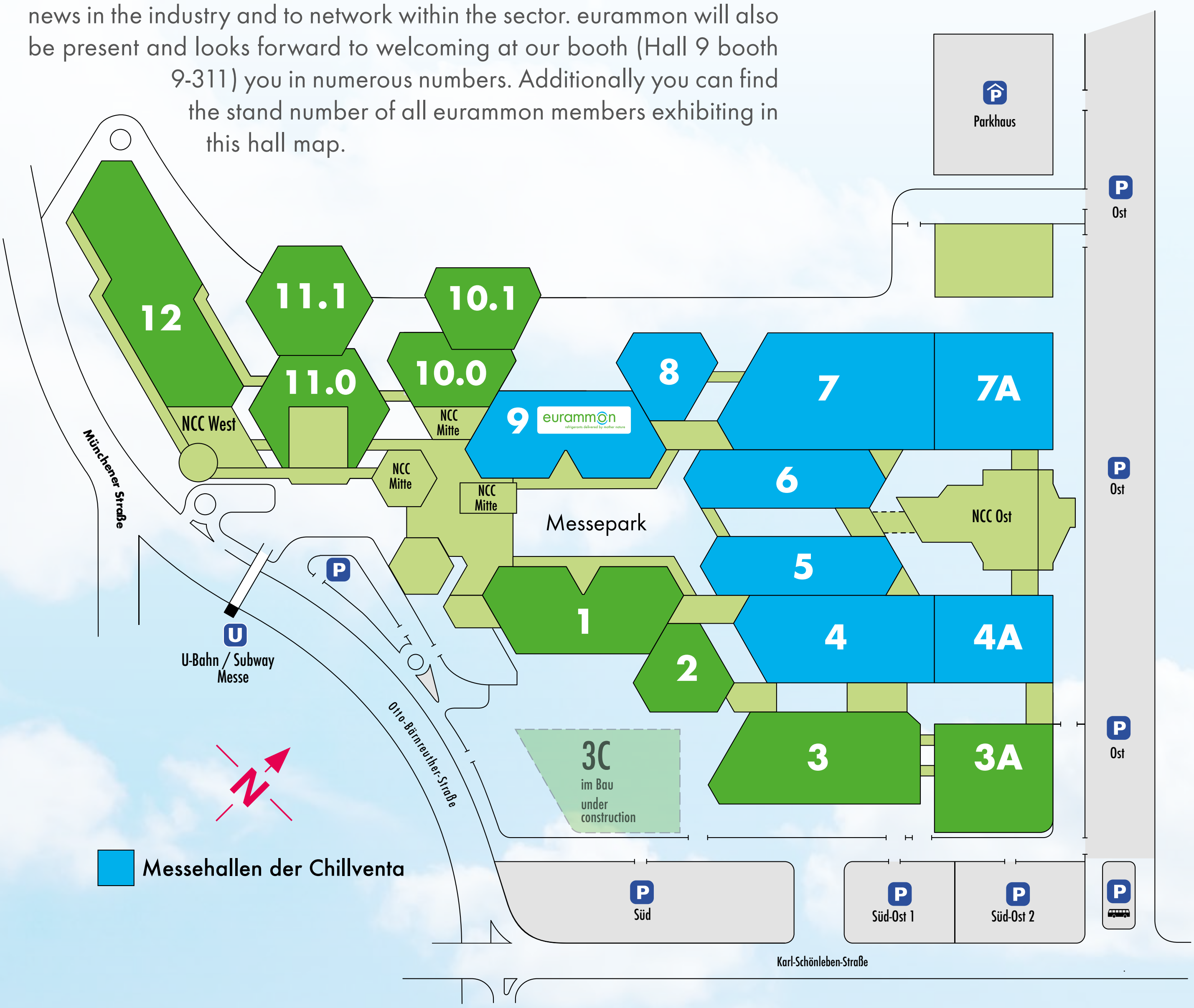
The refrigerant industry is strongly influenced by national and international regulations and restrictions. Challenges such as global warming also play a leading role in the choice of refrigerants. „From my point of view, eurammon and its members are well equipped to meet these challenges. With the use of natural refrigerants we go hand in hand with the goals of climate protection and the reduction of global warming", says Bernd Kaltenbrunner.

Information on the symposium and a selection of presentations by this year's speakers can be found on the eurammon website at **http://www.eurammon.com**

16th to 18th October in Nuremberg

Chillventa 2018

The leading trade fair for refrigeration, ac & ventilation and heat pumps with 981 exhibitors and more than 30.000 visitors in 2016 opens its doors from the 16th to the18th October in Nuremberg. The fair offers experts and interested parties the opportunity to find out about the latest news in the industry and to network within the sector. eurammon will also be present and looks forward to welcoming at our booth (Hall 9 booth 9-311) you in numerous numbers. Additionally you can find the stand number of all eurammon members exhibiting in this hall map.



Company / Institution	Booth No.
Baltimore Aircoil International N. V.	Halle 7 / 7-206
Bundesfachschule Kälte-Klima-Technik	Halle 9 / 9-315
BITZER Kühlmaschinenbau GmbH	Halle 7 / 7-326
BITZER Kühlmaschinenbau GmbH	Halle 7 / 7-626
DANFOSS GmbH	Halle 7 / 7-126
Emerson Climate Technologies GmbH	Halle 6 / 6-318
Emerson Climate Technologies GmbH	Halle 6 / 6-416
ESaK Europäische Studienakademie Kälte-Klima-Lüftung	Halle 9 / 9-315
eurammon	Halle 9 / 9-311
EUROVENT	Halle 9 / 9-410
Evapco Europe GmbH	Halle 7 / 7-406
FRIGOPOL – Kälteanlagen GmbH	Halle 5 / 5-316
Friterm A.S.	Halle 6 / 6-110
GEA Group Aktiengesellschaft	Halle 7 / 7-502
Georg Fischer Piping Systems Ltd.	Halle 4 / 4-107
Güntner GmbH & Co. KG	Halle 7 / 7-124
Güntner GmbH & Co. KG	Halle 7 / 7-127
HKT Huber-Kälte-Technik GmbH	Halle 7A / 7A-422
IIAR International Institute of Ammonia Refrigeration	Halle 9 / 9-311
JAEGGI Hybridtechnologie AG	Halle 7 / 7-124
Mayekawa Europe NV/SA	Halle 7A / 7A-110
Next Lubricants BV	Halle 7 / 7-107
Parker Hannifin Manufacturing Germany GmbH & Co. KG	Halle 7 / 7-106
Skopje University, Faculty of Mechanical Engineering	Halle 9 / 9-114
Temper Technology AB	Halle 7 / 7-510
Th. Witt Kältemaschinenfabrik GmbH	Halle 6 / 6-403
thermofin GmbH	Halle 8 / 8-421
TÜV Süd Industrie Service GmbH	Halle 9 / 9-325
VAHTERUS Oy	Halle 6 / 6-130

eurammon video case
on the advantages of ammonia

Ammonia proves its advantages in various industrial use

Industrial refrigeration is an important part of our developed society. We depend on it to make our modern lifestyle possible. Ammonia, as a natural refrigerant, has proven its reliability in industrial refrigeration for over 120 years. It is also an ideal refrigerant from a climate protection point of view, as it contributes neither to ozone depletion nor to global warming. These advantages are the reasons why Ammonia is used in a wide range of different areas on an international level everywhere around us. Below, we present four versatile use cases which illustrate Ammonia's capabilities and strengths.

Swedish manufacturer of heat exchangers uses Ammonia-based heat pump for its own requirements

Alfa Laval is one of the world's largest manufacturers of heat exchangers. At its production site in Lund, Sweden, the company has been using an innovative Ammonia-based heat pump system since 2013. Waste heat from the component production process is used as the source energy to the pump system. The system covers almost the entire heating and hot water requirements of the factory and corporate headquarter. The heart of the system is a flooded evaporator, combined with a U-turn separator. It absorbs the thermal energy of the oil cooling system, which is heated to around 28 °C in the factory's production operations. After compression, the high-pressure system conducts the heat in the condenser to a closed heating-water circuit, thus boosting the water temperature to 65 °C. This system works with a comparably low amount of only 40 kg of Ammonia. Jesper Olson, Market Manager Industrial Refrigeration, of Alfa Laval emphasizes that this sustainable procedure saves the environment around 140 tons of CO_2 per year. It thus reduces Alfa Laval's need for expensive district heating by 3,700 MWh – which is an enormous cost factor. >

Ammonia, CO_2 and Glycol Coolers with Stainless Steel Tubes for Food Cold Storage and Blast Freezing Systems

- Stainless Steel Tubes and Aluminium Fins
- Natural Refrigerant
- Industrial Robust Design

SOSİAD Association of Refrigeration Industry and Businessmen
EAC TSEK CE
İSKİD
MEMBER OF EUROVENT
eurammon refrigerants delivered by mother nature

FRITERM®
since 1979

TÜV NORD ISO 9001
E.S.İ.A.D. 1990 ASSOCIATION OF THE AEGEAN INDUSTRIALISTS AND BUSINESSMEN OF REFRIGERATION
TEİD
ISKAV HEATING COOLING AIR CONDITION RESEARCH and EDUCATION FOUNDATION
EHEDG EUROPEAN HYGIENIC ENGINEERING & DESIGN GROUP COMPANY MEMBER 2017
rehva Federation of european heating and airconditioning associations Supporting Member
WE EMBRACE AND PRACTICE INDUSTRY CODE OF ETHICS

Head Office/ Factory 1:
İstanbul Deri Organize Sanayi Bölgesi Dilek Sokak No:10 X-12 Özel Parsel Tuzla 34957 İstanbul / TURKEY
Factory 2:
Makine İhtisas Organize Sanayi Bölgesi 6.Cadde 17. Sokak No:1 Demirciler Köyü Dilovası 41455 Kocaeli / TURKEY
Tel: +90 216 394 12 82 (pbx) **Fax:** +90 216 394 12 87
info@friterm.com www.friterm.com

twitter.com/friterm facebook.com/friterm linkedin.com/company/friterm

Scottish salmon processing company uses Ammonia-based cold store for holding incoming raw material

Pinneys of Scotland, located in the scenic town of Annan, is one of the UK's largest processing companies for smoked Scottish salmon and other fish-based products. The company looked for an economically advantageous and future-proof alternative when it came to replacing their existing HFC/R22 refrigeration system which they need as a cold store for holding incoming raw material prior to processing and dispatching. They found the ideal solution in an air-cooled Ammonia refrigeration system designed and installed by Star Refrigeration with components of BITZER Kuehlmaschinenbau. The refrigeration plan is based on a combination of low-pressure receiver technology, EC-fan and PLC control technology. The new refrigeration system was being installed in the existing one even before the old system had been dismantled, so that the conversion did not interrupt production. As Phil Moxon, Factory Engineering Manager, from Pinneys of Scotland explains, due to its special design the new system is 15 to 20 per cent more efficient than traditional systems with HFC-technology.

Norwegian District supplies environmentally friendly heat with Ammonia-based heat pumps

The city of Drammen, Norway, invested in a district heating plant, based on heat pumps to utilize the heat in the fjord water. The facility includes the world's currently largest ammonia based high temperature heat pump. The thermal energy of the fjord water is transferred to a closed circuit and successively heated to 90°C by three two-stage heat pumps connected in series and designed for 65 bar. This system supplies about 70 per cent of the district heating network with inexpensive and environmentally friendly heat. Each heat pump requires a filling quantity of only 1,000 kg Ammonia.

Andres Lian, production manager at Drammen Fjernvarme confirms that managing to boost the heat from the fjord to a useful temperature level in such an efficient way is a remarkable achievement, which is probably only possible with Ammonia. Its sustainability is considerably higher than possible alternatives such as waste burning. Also, it consumes about 15 per cent less energy than conventional district heating systems based on synthetic refrigerants.

German hospital saves big by soucing Ore water to deliver heating via Ammonia heat exchanger

The district hospital in Freiberg, Germany, is located in the Ore Mountains above an old silver mine. Water in tunnels 200 meters below the hospital flows at a constant temperature of around 14°C throughout the entire year. Johnson Controls designed a two-stage Ammonia heat pump and power plant that uses this water as the energy source to deliver heating to the hospital. The heat energy stored in the water is transferred to the Ammonia circuit by a plate heat exchanger at 200 m depth. At the heating centre on the surface, the temperature of the water is raised by a heat pump cycle. A gas-fired combined heat and plant then generates the electrical energy for operating the heat pump.

Achim Welz, Chief technician of Kreiskrankenhaus Freiberg reports that with this sustainable and cost-efficient solution, the hospital can cover about 80 per cent of its heat requirements and along the way save heating costs of about 350,000 euros per year.

The eurammon video case study is available for you to watch and download on our website
http://www.eurammon.com

eurammon website

The website of eurammon offers exciting data about natural refrigerants and their use as well as detailed information on the initiative

- Fact sheets and information papers
- Background articles, interviews and case studies
- Product directory of the eurammon members
- Events world wide

⟶ http://www.eurammon.com

YouTube

Our new case video shows the advantages of natural refrigerants. It highlights the usage of Ammonia and the reasons why it is is used in a wide range of different areas on an international level everywhere around us. In four different and exciting application cases in Germany, Sweden, Norway and Scotland, the capabilities and strengths of ammonia are vividly illustrated. The selection of cases shows just how versatile the use of ammonia is: from an individual solution with heat pumps for temperature control in the headquarters, to an ammonia-based cold store for fish processing, to the use of ammonia for district heating and finally to the temperature control of an entire hospital.

⟶ http://bit.ly/1lM7Q8I

Publishing Credits

About eurammon

eurammon is a joint initiative of companies, institutions and individuals dedicated to increasing the use of natural refrigerants. As a centre of excellence in the use of natural refrigerants in refrigeration technology, the initiative is committed to providing a platform for sharing information and promoting public awareness and acceptance of natural refrigerants. The objective is to advocate use of natural refrigerants in the interest of a healthy environment and thereby encourage a sustainable approach in refrigeration technology. eurammon provides experts, politicians and the public at large with comprehensive information about all aspects of natural refrigerants, and 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 systems. Established in 1996, the initiative is open to companies and institutions with a vested interest in natural refrigerants, as well as to individuals from a variety of fields such as science and research.
Website: http://www.eurammon.com

Disclaimer: The information contained in this publication was researched and compiled with all due care. However, the editors and publishers provide no guarantee for the accuracy and comprehensiveness of the content, or for any changes that may have arisen in the meantime.

Photo credits: Pages 1, 6, 8, 10, 14, 18, 20, 22, 26, 30, 35, 38, 40, 43 Adobe Stock,
pages 3, 6, 7, 10, 16, 19, 22–25, 28, 29, 32, 36, 37, 42 eurammon

Publisher

eurammon
Dr. Karin Jahn
Lyoner Straße 18
D-60528 Frankfurt

Editorial Office

FAKTOR 3 AG
Kattunbleiche 35
D-22041 Hamburg

Print Office

Druckpunkt Digital Offset GmbH
Print run: 3,000