INDUSTRY, SPECIAL APPLICATIONS & SPORTS

NH_3

For cooling industrial processes, such as in the chemical, petrochemical, and pharmaceutical sectors, ammonia refrigeration systems are used to provide effective and stable cooling performance. Neste Oil in Finland replaced its R22 refrigeration system with an ammonia system. In Belgium, a 500 kW ammonia heat pump was installed in Emerson's factory in Welkenraedt, where waste heat from the factory is reused.

Following a recommendation by the Commission for a Sustainable London 2012, the cooling system of the Aquatic Centre was converted to an ammonia-based system, reducing its climate change impact. The large-scale Olympic Energy Centre also features ammonia chillers and provides efficient and low-carbon power by using new technology, including biomass boilers and a trigeneration plant (delivering power, heating and cooling), which captures heat generated as a by-product of electricity production.

Oxford's popular ice rink was refurbished with an ammonia refrigerant cooling system. A 360kW ammonia chiller, which reduces running costs by up to 20%, was installed.

HC / CO_2

A propylene/CO_2 cascade refrigeration system was installed in a German chemical plant. The evaporator (propylene) in the high cascade stage is simultaneously the condenser of the lower cascade stage (CO_2). The liquid CO_2 evaporator cools the chemical process down to -50°C.

HC

In a plastic production plant of Borealis, a Belgian manufacturer of polyethylene and polypropylene, the original R22 refrigeration unit was replaced by an R1270-based refrigeration system. Thanks to the conversion, Borealis now saves approximately 33% on its energy bill.

The gas processing plant of NAM in Den Helder, the largest natural gas producer in the Netherlands, adopted a refrigeration unit with R290 as a refrigerant and a cooling capacity of 2 x 2110kW to replace its old R22 units.

NH_3 / CO_2

NH_3/CO_2 cascade refrigeration systems are widely used where low temperatures must be attained economically and within compressor application ranges. A NH_3/CO_2 soil-freezing containerised refrigeration unit was used in the underground construction works of a building in Germany. The NH_3/CO_2 cascade refrigeration system was selected to enable lower cooling temperatures down to -50°C.

CO_2

In the ice rink industry today, mainly in Europe, there are more than 20 rinks that have adopted CO_2 in the second-cycle of the refrigeration system. The first ice rink in Europe that was purely cooled with CO_2 is in Gimo, Sweden. It has been in operation for nearly two years and has already shown significant reductions in energy consumption by now. In fact, during the first 6 months of operation, the energy cost reductions were more than 60% compared to the previously used system. The project thus proves the huge potential for CO_2 cooling in the ice rink industry.

NH_3 / H_2O

A final-year student at Loughborough University in the UK designed a backpack to keep vaccines cool for up to 6 days, using ammonia-water absorption refrigeration technology. Currently, it is often problematic to deliver vaccines to developing countries while meeting the World Health Organisation's safe vaccine transportation practices. The innovative prototype of the ammonia-water backpack unit cooler can be recharged on the go in just over one hour and could solve those issues.

FOOD CHAIN

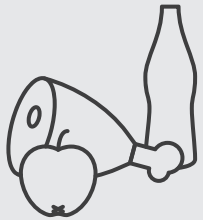
REFRIGERANTS

- CO_2 Carbon dioxide
- NH_3 Ammonia
- HC Hydrocarbons
- H_2O Water
- AIR Air

USE

- heating
- refrigeration
- air-conditioning

Food and drinks processing



CO_2 NH_3 HC H_2O AIR

Wineries & breweries

CO_2 NH_3 HC H_2O AIR

Food storage / distribution

CO_2 NH_3 HC H_2O AIR

Supermarkets

CO_2 NH_3 HC H_2O AIR

Transport refrigeration

CO_2 NH_3 HC H_2O AIR

Fast-food restaurants

CO_2 NH_3 HC H_2O AIR

Ice makers

CO_2 NH_3 HC H_2O AIR

Ice cream freezers

CO_2 NH_3 HC H_2O AIR

Water dispensers

CO_2 NH_3 HC H_2O AIR

Water dispensers

CO_2 NH_3 HC H_2O AIR

FOOD CHAIN

Food processing

NH_3

An ammonia-based refrigeration unit was installed in Vlevico, Colruyt's renewed meat plant in Halle, Belgium. The heat released from the refrigeration unit is recuperated for the production of hot water. The plant also reduced its CO_2 emissions by 1,602 tonnes per year. The BESS study (Benchmarking and Energy management Schemes in SMEs) has declared Vlevico one of the most efficient and ecological meat processing companies in Europe.

One of the largest Swiss food retailers, Coop, installed a new integrated ammonia chiller heat pump system in their chocolate factory in Basel. The system provides both process heat and cooling for the chocolate production process. The system can work with two types of condensation, namely by means of water or with an air-cooled condenser. The system integrates six chillers with screw compressors that offer a combined refrigeration capacity of 6,000 kW. Moreover, the heat pump system with the chiller is integrated with a water circuit. Reciprocating compressors condensate the ammonia at high temperatures and provide 2,000kW of heating capacity. The ammonia then condensates at 65°C and delivers water at 60°C.

CO_2

In a Norwegian ice cream plant, a transcritical CO_2 cooling and freezing system was installed. The 220kW (at -38°C) CO_2 system with 150kW of heat recovery and hot gas defrost achieves reductions of 1,000 tonnes of CO_2 equivalent per year (direct and indirect emissions) in comparison with a similar R404a system.

Schlachtbetrieb Zürich AG installed the largest CO_2 heat pump system with 800kW in Switzerland. The three CO_2 heat pumps are used to produce high temperature hot water (90°C) for the slaughterhouse based on waste heat from refrigeration systems. As a result, about 260,000 m^3 of natural gas has been saved per year and the annual CO_2 emissions have been reduced by around 30%, or 510 tonnes per year.

HC

Eight 650kW water-cooled water chillers using hydrocarbon refrigerant R290 were installed at the Co-operative Group's new headquarters in Manchester, the largest ever propane chiller project in a commercial building in the UK. The building has achieved the highest BREEAM rating, receiving the 'outstanding' accreditation for a large, commercial building in the UK.

HC / CO_2

A meat processing plant in Osnabrück (Germany) has installed a propane-CO_2 cascade system for refrigeration and deep-freezing in processing and cold storage applications. The technical and constructional innovation of this system is the combination of propane (R290) and CO_2 in a single loop. The new, integrated solution reduces the amount of space required as well as installation costs.

NH_3 / CO_2

An NH_3/CO_2 cascade system was installed in a German bakery plant, where the CO_2 cycle was used for direct cooling in the freezers applied in the system, with limited NH_3 quantity. When calculated over one year of operation, 870,000 kWh of energy could be saved per year. At 70 cents per kW, this would result in savings of more than €600,000 per year.

In Russia, Nestlé invested in an NH_3/CO_2 cascade refrigeration system at its coffee processing plant in Timashvesk. The system greatly reduces the ammonia charge, increasing system safety and facilitating system supervision. The use of screw compressors in the CO_2 stage reduces the number of compressors required by half and third the time needed between maintenance operations.

Wineries & breweries

NH_3

The Daniel Thwaites brewery in Northern England installed a reciprocating compressor using ammonia as the working fluid. The ammonia system has resulted in an increased output of 400 kW compared to the 310 kW supplied by the previous installation. In addition, the energy efficiency has improved, saving the owners approximately £2,000 (around €2,500) per week in electricity costs, which means that the investment will be paid back in less than 18 months.

CO_2

The Norwegian brewery Mack installed two CO_2 transcritical chillers with a total cooling capacity of 500kW. The system satisfies Mack's requirements for performance, safety and reduced environmental impact.

In an Anheuser Busch InBev Brewry in Leuven, Belgium, a 670kW CO_2- based refrigeration unit is used for process cooling. The system uses heat released during the refrigeration process to evaporate CO_2, which is essential to carbonate beer. Thanks to this heat recovery, InBev Belgium consumes no extra energy, limiting the impact on the environment and lowering the energy bill substantially.

H_2O

A solar cooling system in the cellar of the GICB winery (Groupement Interproducteurs du Cru de Banyuls) in the south of France installed an absorption chiller. The project was the first in France in the private food sector and one of the first in Europe. Energy consumption is 2,800 kWh which corresponds to a cost of only €280/year. The energy savings are estimated at €950/year (on the basis of an average increase of energy price of 5% per year).

Food storage & distribution

CO_2

A lettuce processing plant by the Staay Group in the Netherlands has installed a CO2-based cooling system with a total capacity of 3,36 Megawatts. The installation is considered to be the world's biggest CO2 plant to date. The system will use 45 compressors in total and will be able to reach a range of temperatures with different charges between 0°C and -28°C.

The food retailer SPAR opened the first ever distribution centre in Austria fitted with a transcritical CO_2 refrigeration system in autumn 2016. It is a large installation in a distribution centre in Ebergassing, Austria, where 19,000m^2 of floor space are used for product refrigeration. SPAR expects that the natural refrigerant-based solution meets its needs for long-term and cost-effective refrigeration solutions.

NH_3 / CO_2

At the site of the German discounter Lidl in Hüfingen, Baden-Württemberg, 6,000 m^3 of deep freezing and refrigerated space are cooled with a NH_3/CO_2 system. The waste heat from the refrigeration is recovered to heat other parts of the building.

One of the leading French food retailers installed a NH_3/CO_2 cascade system in October 2016 to serve one of its distribution centres. Compared to the previous system with glycol, the NH_3 evaporating temperature is higher, boosting the COP by 5% at full load. There are thus significant energy savings compared to the old setup with DX Freon coolers and commercial compressor racks. Moreover, the CO_2 distribution pumps need much less power to operate and indirect energy savings are thus also made.

NH_3

One of McDonald's suppliers in the UK, Keystone Distribution, has installed a 2,000kW two-stage ammonia refrigeration plant for its state-of-the-art Hemel distribution facility. The ammonia refrigeration system incorporates several energy saving features that contribute to 15Mw of yearly energy savings.

Bonduelle Group, supplier of canned or deep-frozen vegetables, and processed salads upgraded its cold storage with an ammonia refrigeration system in its site in Estrées, France. The facility lowers energy consumption by 25% compared to a conventional cold room and saves a total of 500 tons CO_2e per year.

HC

R1270 (propylene) chillers have a proven economic track record in terms of lower capital costs and reduced energy consumption, making them one of the preferred technologies for food cold storage. Mansfield's Fruit Farms, Grimsby Fish Market, Peake Fruits - Suffolk UK, Liverpool Fruit Terminal, as well as Nestlé in the UK installed R1270 chillers in their facilities.

Supermarkets

CO_2

Europe is the world leader in terms of CO_2 adoption in commercial refrigeration. For the food retail industry, CO_2 transcritical systems have become the mainstream technology amongst innovative and sustainable refrigeration solutions. Overall, as of March 2017 there are well over 9,000 stores in Europe (European Union, Norway and Switzerland) using CO_2 transcritical technology. This means about 8% of all European food retail stores are now equipped with this technology.

The efficiency of CO_2 refrigeration systems in warmer European climates has long been a matter of intense debate and source of concern among experts. However, recent findings indicate that technical challenges that often result from a lack of awareness are slowly being overcome. The number of supermarkets using CO_2 transcritical technologies has increased drastically in countries such as Spain, Italy, Romania and the south of France. In Italy, for instance, as of September 2016 there were 91 stores with CO_2 transcritical systems as opposed to 15 stores in 2013. This drastic increase in numbers further demonstrates that CO_2 refrigeration is advancing across Southern Europe as an efficient and viable solution.

HC

The Colruyt Group, a Belgian supermarket group, plans to reduce its overall emissions by replacing their current cooling systems (which primarily use R507 with GWP 3,900) with an unprecedented shift to R290 chillers in all of its 516 stores in Belgium. From 2017 onwards, all new cooling installations will use natural refrigerants. There are already 50-60 installations in the pipeline right now and at the planned pace, all replacements will be finished by 2027. The new R290 chillers use less than 2.5 kg of propane, compared to 100-150 kg of R507 before. The leakage rate is also reduced considerably from about 5% in the old systems to almost negligible in the new ones.

Aldi Nord announced in 2017 its plan to install brand new propane heat pumps at 10 of its sotres, that started in 2015.

Over a 12-month test period, the health and safety and energy efficiency of the entire installation was measured. After recording significant energy savings in testing, the retailer confirmed it will be further using an integral system with natural refrigerants. The systems are based on propane heat pumps in combination with optimised refrigerated cabinets and cold rooms, as well as an integrated ice energy storage unit and photovoltaic system.

HC / CO_2

Since 2009, German retailer Lidl has relied on compact refrigeration units using propane for normal refrigeration, a heat pump for heating and CO_2 for deep-freezing. More than 200 units are in operation today, showing that propane is already suitable for series production. The compact refrigeration unit is designed to be cost efficient and environmentally friendly, producing the refrigeration needed to cool shelves, refrigerate counters, cold rooms, cold storage cells and for air-conditioning. It also generates floor heating and integrates the electro technical equipment for the whole store.

Light commercial refrigeration (water coolers, drink dispensers and ice machines)

HC

The use of HFC-free technology in light commercial applications is now becoming a standard across Europe. As of 2013, there were already more than 480,000 hydrocarbon plug-in cabinets in usage across the continent. Expectations and market trends suggest that this number has increased exponentially over the past 3 years and will continue on this trajectory thereafter.

In Europe, R290- and R600a-cooled water coolers, vending machines, ice cream freezers and fountains are widely used. Moreover, the use of hydrocarbons in domestic and commercial ice machines is steadily growing in Europe.

In domestic refrigeration, all new equipment in Europe uses hydrocarbons as a standard. Globally, there are more than 700 million domestic fridges using hydrocarbons.

CO_2

CO_2 is another alternative for light commercial refrigeration (mainly bottle coolers, vending machines, refrigerated cabinets), which is used by a number of end-users. In 2009, the Coca-Cola Company had decided to shift to CO_2 vending machines, which helped in pushing this market forward on a global scale.

3

Training in Europe – an overview

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THE IMPORTANCE OF HVAC&R TRAINING

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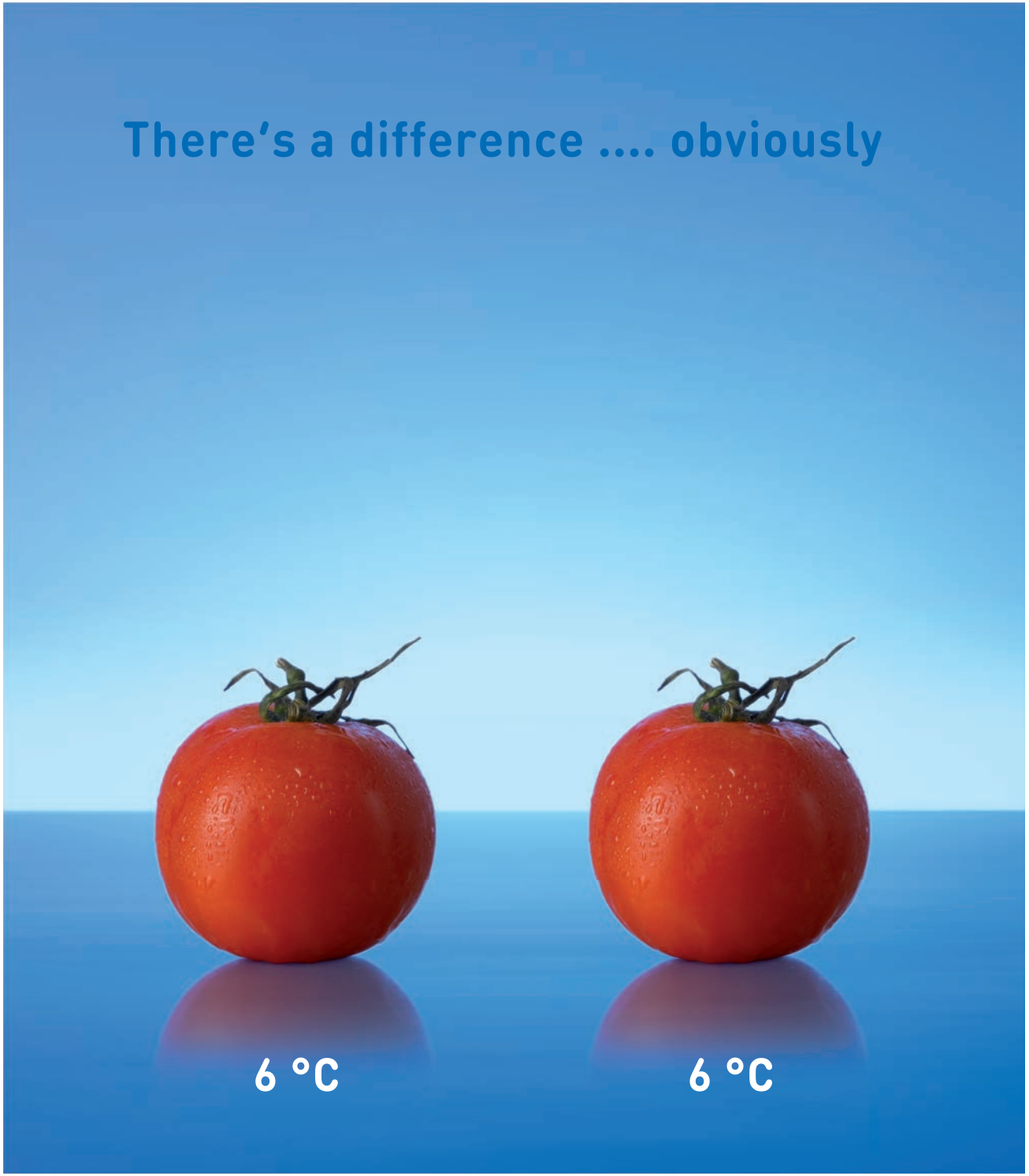
Besides the fact that it is legally required that persons handling refrigeration, heating and cooling equipment are properly trained and hold appropriate certification, training is a prerequisite to ensure a safe and correct handling of refrigerant-containing equipment. To keep pace with the rapid technology advancements in the HVAC&R sector, technicians need to have access to continuous training to ensure they are up to speed with the latest developments.

With growing trends such as the greening of HVAC&R technology, the adoption of smarter and energy efficient heating and cooling systems, and the changing environmental regulations set forth by local and national governments, HVAC&R is expected to be a thriving field in the future promising a boost of jobs in the sector.

The key factors that determine the importance of HVAC&R training can be identified as follows:



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Safety

Any technician or engineer handling heating and cooling technology that uses refrigerants has a duty of care. The health and safety duties require technicians to consider all risks, not only those for which regulations, codes of practice, and industry guides exist.

Safety is of concern when applying any refrigerant, with respect to hazards arising from toxicity, asphyxiation, pressure explosions, mechanical injury, and others. It is therefore important to be familiar with the potential safety hazards that each refrigerant can represent. In principle, all refrigerants can be dangerous if misused or applied in a system inappropriately.

Safety features of refrigerants vary and so does the design of systems using different refrigerants, which should mitigate potential risks. It is therefore important that technicians have thorough understanding of the specific characteristics of refrigerants (whether fluorinated or natural) and practical training before they install, maintain or service the equipment. Education and lifelong training, as well as enforcement of safety rules are the key measures to ensure the safety of refrigeration systems.

Performance & energy efficiency

The growing emphasis on reducing emissions of greenhouse gases (direct and indirect) encourages organisations and individuals to pay special attention to preservation of energy. Energy efficiency has become an integral part of HVAC&R systems design, maintenance and modernisation.

To ensure energy efficient operation of HVAC&R systems, it is essential that professional technicians carry out proper and regular maintenance. Adequate training should also ensure that the personnel handling the equipment are skilled at identifying opportunities for energy saving during their routine day-to-day activities.

Durability

HVAC&R systems are here to perform a function, whether it is to provide refrigeration, heating or air conditioning. Unless they are properly maintained, they will not be able to perform as desired or as long as they are intended to last. Without proper maintenance, the service life of HVAC&R systems and components might fall.

The average life expectancy of various HVAC&R equipment tends to stay around the same range. However, each system has unique characteristics that may lead to variations in life expectancy. Regardless of age, regular precautionary and seasonal maintenance as well as the quality of installation play an important role in determining products lifecycle. Proper training and keeping skills up to date will guarantee that the lifespan of systems is enhanced as much as possible.

CAREER OPTIONS AND SPECIALTIES IN HVAC&R SECTOR

THE HVAC&R SECTOR OFFERS A WIDE VARIETY OF CAREER OPTIONS TO BOTH TRAINED AND UNTRAINED WORKERS, INCLUDING ARCHITECTURE AND ENGINEERING, INSTALLATION AND MAINTENANCE, PRODUCTION, SALES AND A NUMBER OF HORIZONTAL FUNCTIONS. THESE ROLES SUPPORT KEY FUNCTIONS AT HVAC&R MANUFACTURERS, WHOLESALE DISTRIBUTORS, CONTRACTORS, ENGINEERING COMPANIES AND OTHER INDUSTRY ACTORS ACROSS THE ENTIRE HVAC&R SUPPLY CHAIN.

Each of the occupation families requires different level of practical and / or theoretical training concerning HVAC&R technologies. The largest occupation family in terms of job openings is installation, maintenance and repair. Jobs in this field also require the highest level of practical and theoretical HVAC&R training, including relevant licences or certificates.

Level of skill or experience of a worker in the HVAC&R sector in the installation, maintenance and repair depend on the position. The basic positions can be identified as follows:

Assistant is someone who normally supports technicians in all aspects of the trade while learning on-the-job. The assistant is normally required to have some experience in HVAC&R sector.

Technician installs, maintains and repairs HVAC&R systems. Technician may also specialise in installation or in maintenance and repair, and in either refrigeration, heating or air conditioning systems.

Apprentice learns the HVAC&R trade by combining on the job training with formal technical education. Some businesses employ HVAC&R apprentices without any former training.

Supervisor assumes complete responsibility for installation and repair of all HVAC&R equipment-related operations and maintenance. A supervisor is responsible for assigning tasks, scheduling personnel, inspecting and auditing work in process and completed work. Several years of experience in the HVAC&R field are normally required at this position.

Contractor is self-employed, has a strong operational experience in HVAC&R and normally works independently. Contractor might be also responsible for recruiting and training sub-contractors, controlling the communications with the customer, ensuring that proper permits and licenses for all the jobs and installations have been obtained.

Occupational families, like architecture and engineering, construction, production also require theoretical and practical knowledge concerning HVAC&R equipment, in order to be able to perform the jobs properly. Other occupations, including sales, IT, office and administrative support, transportation, business and financial operations, do not require formal training. Nevertheless, theoretical knowledge regarding the functioning of HVAC&R systems might be necessary, depending on the position.

TOP HVAC&R OCCUPATION FAMILIES INCLUDE

theoretical and practical training

ARCHITECTURE, ENGINEERING, CONSTRUCTION, PRODUCTION

- SYSTEM & APPLICATION ENGINEER
- ARCHITECT
- CONSULTANT/ DESIGN ENGINEERS
- PRODUCTION/ PROJECT/ SERVICE MANAGEMENT
- QUALITY ASSURANCE
- R&D ENGINEER
- TECHNICAL TRAINER
- PROFESSOR/ ACADEMIC STAFF

formal practical and theoretical training with certification and / or licences (vocational training in most cases)

INSTALLATION, MAINTENANCE AND REPAIR

- CONTRACTOR
- SUPERVISOR
- TECHNICIAN refrigeration, heating, gas, geothermal
- MECHANIC Refrigeration, AC
- TECHNICAL ASSISTANT
- PLUMBER
- APPRENTICE

theoretical training might be required (at secondary or higher education level)

HORIZONTAL FUNCTIONS

- SALES
- BUSINESS & FINANCE
- HR
- IT
- TRANSPORT & LOGISTICS
- OFFICE & ADMINISTRATION

KEY HVAC&R SPECIALTIES

ALL HVAC&R JOBS CAN BE GROUPED INTO TWO MAIN STREAMS DEPENDING ON WHETHER THE TRAINING OBTAINED IS MORE PRACTICAL OR ACADEMIC. THE PRACTICAL STREAM REPRESENTS QUALIFICATIONS THAT ARE ACQUIRED AT TECHNICAL COLLEGES, SCHOOLS OR RECEIVED VIA THE ON-THE-JOB TRAINING, WHILE ACADEMIC QUALIFICATIONS ARE NORMALLY ACQUIRED AT UNIVERSITIES.

Careers in the practical stream

Refrigeration and air conditioning mechanics / technicians install, alter, repair and maintain refrigeration and air conditioning systems in residential, commercial and industrial applications.

Gas technicians install, service, maintain, troubleshoot, and repair gas systems and appliances. The systems and appliances that gas technicians typically work on include boilers, ovens, central heating systems, gas fires, and water heaters, among others.

Domestic / commercial gasfitters install, test, maintain, manufacture, assemble, construct, operate, alter and repair propane/natural gas regulated products, such as: supply lines, appliances, equipment and accessories for use in residential and commercial premises.

Plumbers install and repair piping, fixtures, appliances, and appurtenances in connection with the water supply, drainage systems, etc., both in and out of buildings.

Oil burner mechanics install and service heating systems, components, piping equipment and controls to residential, commercial, institutional, industrial or public buildings. They work in cooperation with other trades to ensure that all specifications, including legislative requirements are met to guarantee safe and efficient operation.

Sheet metal workers fabricate, assemble, install, and repair sheet metal products and equipment, such as ducts, control boxes, drainpipes, and furnace casings.

Heating technicians perform construction-related tasks in the residential market dealing with the design, installation and servicing of heating, ventilation and cooling systems through forced air or hydronic means, often including either sheet-metal / duct work and / or piping installation.

Geothermal technicians operate, maintain or repair geothermal power plants and commercial and residential geothermal heating installations. Their tasks include monitoring the processes that lead to electricity and heat production and intervene when adjustments of parameters or equipment repair is necessary.

Pipefitters / steamfitters install, assemble, fabricate, maintain and repair mechanical piping systems. They deal with industrial / commercial / marine piping and heating / cooling systems.

Careers obtained via academic stream

Sales engineers / managers work as technical sales consultants to engineers, architects, utility companies, contractors, and owners/ developers in the design, application and sale of heating and ventilation systems, controls and related material across a distributor network.

System & application engineers' daily tasks include engineering and equipment selections, HVAC&R system design, specification review, unit pricing, and project quoting. Application engineers are responsible for coordination with vendors, basic accounting and invoicing, submittal creation & review, review of terms and conditions, preparation of subcontract agreements, release of equipment.

Installation managers ensure installers are completing the installation properly including technical competency, paperwork, post installation checklist, etc., approve completed installations.

Production, project, service managers make strategic and tactical decisions on the overall operation of the organisation to meet quality, delivery, revenue and cost objectives, including: manufacturing / production, production control and planning, quality engineering, equipment and facilities engineering, inventory and materials control, and customer support.

Professors / lecturers teach various HVA&R courses at the universities, and vocational training organizations. They are responsible for providing quality instruction to students through classes, relevant assignments, etc.

R&D engineers take an active role in modelling, prototyping, evaluating, testing, and collaborating with others. They are also involved in hands-on testing of custom equipment designed to meet the stringent requirements of clients.

Consulting / design engineers work directly with clients to design new or replacement heating, cooling and refrigeration systems, specific to customer needs and building specifications. Their tasks include completing HVAC&R-related drawings, preparing project estimates, and overseeing the installation of projects to completion.

Quality assurance managers plan, coordinate, and direct quality assurance programmes designed to ensure quality production of products consistent with established standards.

Technical trainers are responsible for facilitating the skill advancement and education of HVAC&R and plumbing application and service solutions by continuously enhancing the knowledge level of the industry through designing, coordinating and executing training (live, eLearning, webinars, and recorded).

TRAINING ON NATURAL REFRIGERANTS

REFRIGERATION AND AIR CONDITIONING EQUIPMENT USING NATURAL REFRIGERANTS IS INCREASINGLY BECOMING POPULAR ACROSS DIFFERENT APPLICATIONS IN EUROPE. TO A LARGE EXTENT, THIS IS THE RESULT OF NATIONAL, REGIONAL AND GLOBAL POLICIES PHASING DOWN HIGHLY POLLUTING HFCS. AS END USERS HAVE GAINED EXPERIENCE AND CONFIDENCE USING NATURAL REFRIGERANTS, A GROWING NUMBER OF THEM ARE COMMITTING TO USING HFC-FREE EQUIPMENT IN NEW SYSTEMS.

The growing demand for natural refrigerant-based systems puts pressure on the existing workforce, to update their knowledge, practical and theoretical skills to enable them to safely handle equipment using natural refrigerants.

This chapter explores the specificities of training requirements for natural refrigerants. In addition, based on the results of an industry survey, the GUIDE outlines key drivers and barriers for the uptake of natural refrigerants training.

General requirements for natural refrigerant training

This GUIDE covers training related to carbon dioxide, ammonia and hydrocarbon (R290, R1270, R600a) used as refrigerants in heating, refrigeration and cooling equipment. Natural refrigerants have specific properties that are different to fluorinated gases, which require particular attention and specialised theoretical and practical training in order to ensure safety, energy efficiency, durability and proper functioning of equipment.

Compared to fluorinated gases, natural refrigerants have zero or near to zero GWP. Due to the difference in properties as compared to traditional f-gas refrigerants a number of aspects need to be considered:

- Operating pressures;
- Performance – capacity and efficiency;
- Material compatibility, including compressor lubricant;
- Safety, including flammability and toxicity;
- Temperature glide;
- Ease of use and skill level of design engineers and technicians who install, service and maintain equipment.

While each natural refrigerant has its specific characteristics, which need to be addressed in the training, certain general minimum requirements for training could be applied for all natural refrigerants. The European association of refrigeration, air conditioning and heat pump contractors (AREA) has made recommendations for minimum requirements for training and certification concerning HFC replacements, including both theoretical and practical training.

The minimum requirements outlined here are not exhaustive, but serve as a basic overview of theoretical and practical knowledge and skills that technicians should acquire in order to be able to safely and properly handle equipment using natural refrigerants.

Theoretical training should include classes on refrigerant basic thermodynamics and physics, health & safety requirements, and regulations & standards, including:

- Thermodynamic properties of natural refrigerants: temperature, pressure, density, thermal capacity, p/h diagram
- Differences between natural refrigerants and HFCs
- Toxicity characteristics, grades and limits for the human body
- Flammability characteristics, lower and upper flammability limits, occupancy
- Specific components needed for specific refrigerant in the refrigeration cycle
- Material compatibility
- Oil compatibility, requirements and oil return
- European and national regulations and standards
- Storage & transport of refrigerants
- Health & safety rules, incl. location of emergency exists, fire alarms, leak detectors, and others
- Calculation of lower flammability limits (LFL) in confined space
- Calculation of confined space risk for asphyxiation

During practical training technicians should acquire relevant skills to be able to perform the following tasks:

- Select appropriate tools, equipment and personal protective equipment for work on natural refrigerant RAC systems
- Recover the refrigerant
- Vent the refrigerant in a safe way (in accordance with national legislation)
- Calculate safe fill weight for the recovery cylinder (density difference between HFCs and natural refrigerants)
- Check leaks with the correct equipment
- Make refrigerant vacuum preventing moisture in the system and refrigerant emissions
- Refill refrigerant without emission relief
- Make connections without brazing with alternative connections
- Check the correct functioning of the safety ventilation system
- Check the correct functioning of the safety system controls
- Perform safe system shutdown and isolation
- Extinguish a fire
- Perform first aid for frostbite, fire burn, suffocation due to breathing problems

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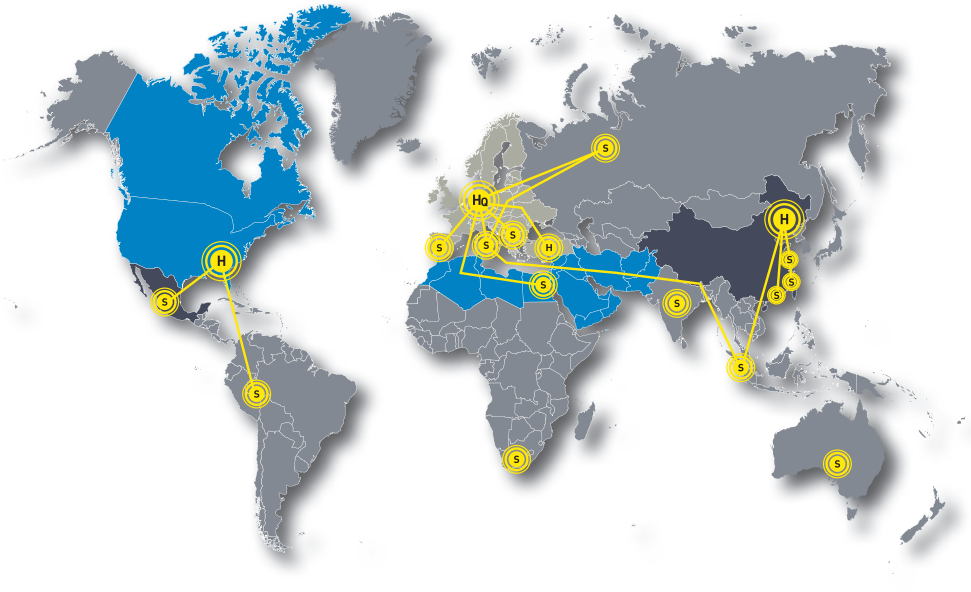


At Secop the development of leading compressor technologies goes hand in hand with global customer support.

Secop has headquarters in Flensburg, Germany and further production facilities in Austria, China and Slovakia. Moreover, Secop has sales offices in USA, Russia, China, Italy and Turkey as well as strategically located support centres.

We operate with a global "hub and satellite set-up." The idea is simple: Always to have the best possible technical support nearest you.

SPECIFIC REQUIREMENTS FOR TRAINING ON CO_2, AMMONIA AND HYDROCARBONS

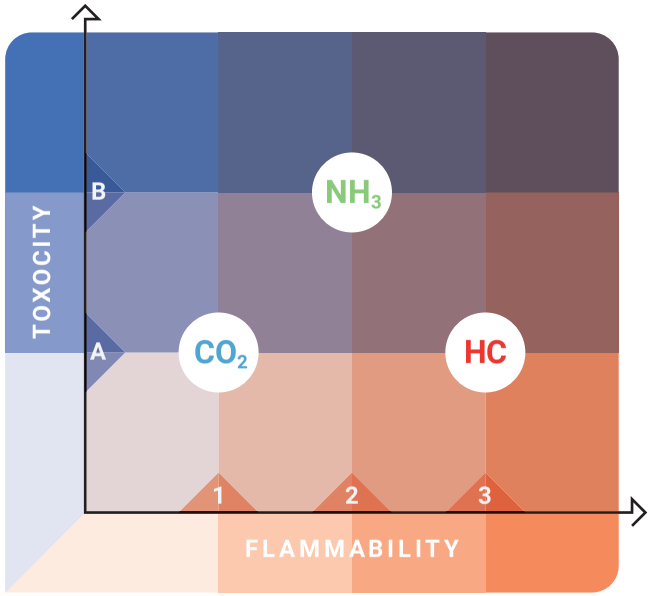
IT IS IMPORTANT TO HIGHLIGHT THE SPECIFIC CHARACTERISTICS OF EACH NATURAL REFRIGERANT, WHICH NEED CAREFUL CONSIDERATION.

Within the HVAC&R industry refrigerants are assigned safety classification, which is a function of toxicity and flammability. The classification scheme is adopted by standards such as EN 378 and ISO 817. The toxicity classification is divided into two toxicity classes:

- **Class A** refrigerants are those where no toxicity has been observed below 400 ppm
- **Class B** refrigerants are those where toxicity has been observed below 400 ppm

The flammability classification depends upon whether or not the substances can be ignited in standardised tests, and if so, what the lower flammability limit (LFL) and the heat of combustion are. There are three flammability classes:

- **Class 1** refrigerants are those that do not show flame propagation when tested in air at 60°C and standard atmospheric pressure
- **Class 2** refrigerants are those that exhibit flame propagation when tested at 60°C and atmospheric pressure, but have a LFL higher than 3.5% by volume, and have a heat of combustion of less than 19,000 kJ/kg
- **Class 3** refrigerants are also those that exhibit flame propagation when tested at 60°C and atmospheric pressure, but have an LFL at or less than 3.5% by volume, or have a heat of combustion that is equal to or greater than 19,000 kJ/kg



Training on carbon dioxide

R744 is not flammable, but its higher operating pressures, toxicity at high concentration and potential for dry ice formation must be taken into account when applying and handling.

Technicians need to follow strict safety procedures when handling, servicing and installing CO_2-based equipment. Prior to working or training on a system or handling refrigerant, technicians should be equipped with necessary safety equipment, as well as check the material safety data sheet regarding the refrigerant. Technicians should wear safety glasses and goggles at all times when handling the refrigerant and system. They should wear a proper respiratory protection for any work on CO_2 equipment in a closed area where leak is suspected.

Compared to fluorinated and other natural refrigerants, CO_2 operates at a higher pressure, especially when ambient temperatures cause the system to work above the critical point. However, only in a few parts of a CO_2 system will the pressure be higher than in a conventional system, and special components are available and used for that purpose. Systems are typically designed to withstand the maximum working pressures of CO_2 of up to 52 bar in subcritical cycles and 140 bar in transcritical cycles (although such pressures are rarely reached). When working with a CO_2 system, personnel should always check the operating pressures of the refrigerant by using gauges to monitor the pressure. CO_2 system components, pipe work, tools and equipment must be rated to safely operate at a higher pressure. To make sure that the pressure does not reach the relief pressure in case of power failure or an unexpected shutdown, the systems can also be fitted with a small supporting cooling system.

R744 is an asphyxiant with a threshold limit value (TLV) of 5,000ppm (0.5%), beyond which CO_2 concentration might affect health. One must ensure that the facilities with CO_2 equipment are equipped with ventilators, as well as with gas sensors that will prompt an alarm when the CO_2 concentration reaches a specific limit.

Formation of dry ice (solid R744) can occur if a system is not handled properly. This happens when CO_2 pressure and temperature drop below the triple point if the refrigerant is vented during servicing or when a system below 4.2bar is charged. Dry ice absorbs heat from the surroundings as it transforms into gas. With significant increase in pressure dry ice can block vent lines and care must be taken by servicing personnel to ensure this does not happen.

Technicians must also learn how to charge CO_2 systems safely. Some systems, such as cascade systems and parts of transcritical systems, have a lower maximum operating pressure than the CO_2 cylinder pressure. Therefore, to prevent pressure relief valves discharging, the systems must be charged slowly and carefully.

Training on hydrocarbons

Hydrocarbons carry an A3 safety classification, which means they have a low toxicity but are in the higher range of flammability. Hydrocarbons are subject to strict safety requirements concerning the quantities permitted in occupied spaces. Therefore, an increased training offer must remain a priority for the industry in order to safely handle hydrocarbon refrigerant-based systems. Training techniques and tools are in place to manage safety challenges.

Before starting to train or work on systems containing hydrocarbon refrigerants, safety checks are needed to ensure that the risk of ignition is minimal. The area should also be checked with an appropriate refrigerant detector to ensure that technician is aware of potentially flammable atmospheres.

All the equipment and tools must be checked for suitability to work on hydrocarbon systems, with particular attention to refrigerant recovery and leak testing units, electrical test meter, refrigerant recovery cylinders, portable lightning.

All work with the flammable refrigerants must be covered under the controlled procedures to make sure that the risk of the flammable gas and vapour is eliminated while the work is done.

Technicians must also train how to properly and safely charge the system with hydrocarbon refrigerant. The charging of the refrigeration system is similar to the fluorinated refrigerants. The system must be charged with hydrocarbon refrigerant in the liquid phase and technicians must ensure that contamination of different refrigerants does not occur while using charging equipment. After the system is charged, the system must be labelled, showing that hydrocarbon refrigerants have been charged in the system and that it is flammable. After the charging, the system must be leak tested.

Training on ammonia

Ammonia is categorised as a B2 refrigerant, which equals higher toxicity and mild flammability. The acute toxicity of ammonia is a major consideration in the safe design and operation of refrigeration systems. Ammonia is a gas with a distinctive pungent odor, which can normally be detected by smell at concentrations of 5-10 parts per million (ppm). Higher concentrations are easily detected. It should be noted that the effect of ammonia is a function of concentration level and length of exposure time. Higher concentrations can be tolerated for short periods but the effect of ammonia breathed into the lungs or in the eyes can persist for long periods.

Depending on the duration and quantity of the exposure, ammonia can cause slight irritation, suffocation or death, so adequate training is required wherever the product is stored or handled.

Technicians must always wear suitable personal protective equipment including gloves and goggles. Technicians must also ensure that breathing apparatus or respirator masks are available and close to hand to be used in case of emergency. In addition, fire-fighting equipment must be accessible in the machinery room.

If special work must be carried other than a routine check of the ammonia system, technicians should work in pairs.

NATURAL REFRIGERANT TRAINING – DRIVERS & BARRIERS

LACK OF TRAINED TECHNICIANS ABLE TO HANDLE NATURAL REFRIGERANT-BASED EQUIPMENT IS OFTEN CITED AS ONE OF THE MOST IMPORTANT BARRIERS TO INTRODUCTION OR WIDER UPTAKE OF THESE TECHNOLOGIES. THIS SECTION LOOKS AT THE KEY FACTORS THAT INCENTIVISE THE INDUSTRY TO TAKE UP A NATURAL REFRIGERANT COURSE OR INVEST IN SETTING UP A TRAINING FACILITY FOCUSING ON SUCH TECHNOLOGY.

The industry survey carried out by shecco also investigated the key barriers to uptake of natural refrigerants training both from the view of training providers and receivers.

Drivers

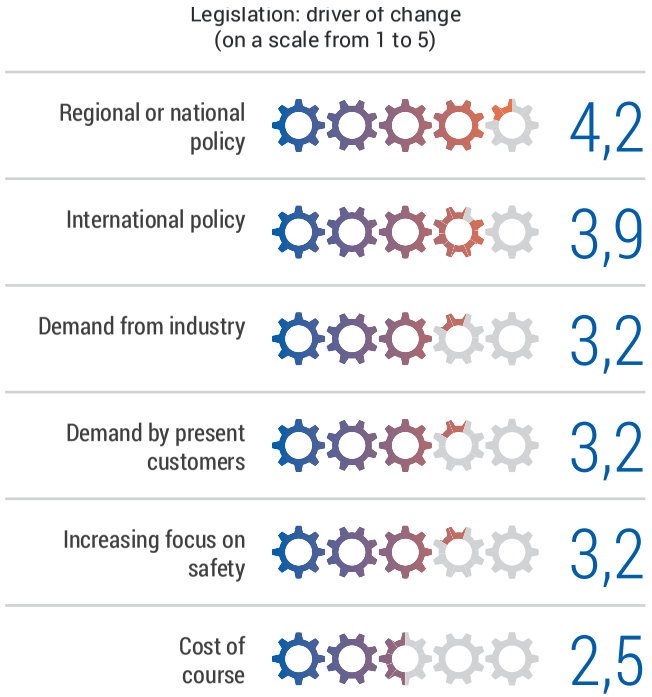
The future HFC phase down under the Montreal Protocol and the EU-F Gas Regulation are the key instruments incentivising the industry move towards environmentally friendly alternative technology. The uptake of new technology creates demand for training relevant to these technologies.

Demand by the industry and present customers, as well as increasing focus on safety are among relevant drivers. The survey respondents did not consider cost of a training course to play a key role in the uptake of natural refrigerant training, although in was mentioned as one of the barriers.

Policy as the main driving factor for natural refrigerants training

Legislative requirements that limit the use of HFCs and incentivise the adoption of natural refrigerants have clearly been identified as the most important factor in the uptake of natural refrigerants training. Policy developments are driving the uptake of natural refrigerants all around the world. The 2016 amendment to the Montreal Protocol will see a global phase down of HFCs - this major development is expected to change the face of today's HVAC&R industry.

The survey respondents ranked national and regional legislation as the most important driver for the European market. The EU F-gas Regulation is the main instrument that will require the industry to phase down HFCs by two-thirds (compared with 2014 levels) by 2030.



The current mandatory training and certification requirements under the F-Gas Regulation address only fluorinated refrigerants. Nevertheless, the changing legislative landscape will require the European HVAC&R industry to transition to alternative refrigerant technology that does not rely on HFCs. This will in turn propel the uptake of necessary training on natural refrigerants that technicians will have to acquire in order to be able to handle the equipment. Moreover, there are certain standards and directives that require technicians working with natural refrigerants to have appropriate training (N.B. this is explored in more detail in the following chapter).

Increasing focus on safety

Safety should always be in the centre of consideration when handling any refrigerant. Manufacturers of natural refrigerant-based equipment and components have a strong interest in ensuring safety of the technology, which has different characteristics than the traditional HFC-based. Safe installation and maintenance is a prerequisite for the success and wider uptake of the technology in the future. Any mishandling that could lead to potential accidents would be a major risk for the acceptance of the technology by end users.

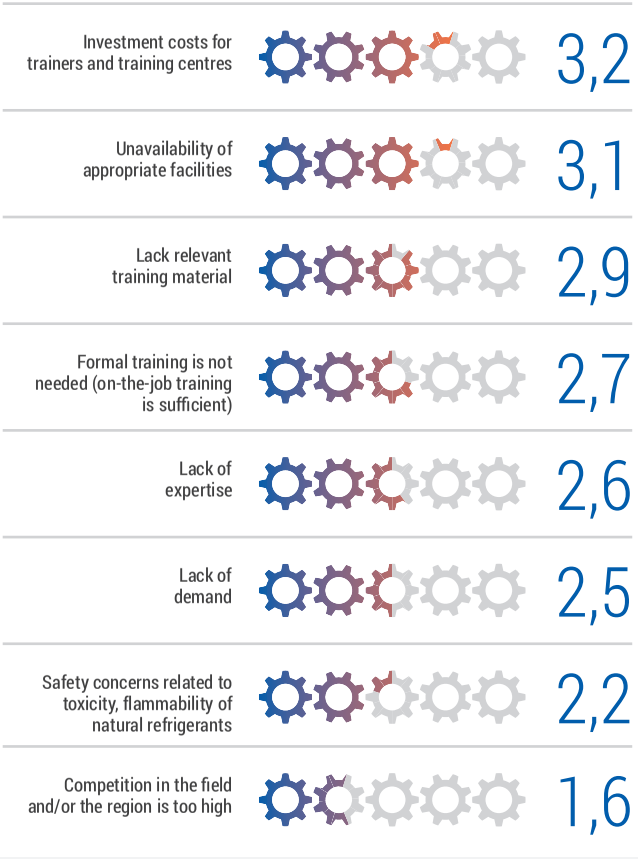
To this end, adequate theoretical and practical training to ensure safe design, installation, servicing and operation of natural refrigerant-based systems becomes even more important as the technology becomes more widespread.

Demand determines the offer

Whilst, policy might give a push to the industry to shift towards natural refrigerants, the real demand for the training derives from the industry and end users of the technology.

Barriers

Key reasons for not providing training on natural refrigerants (on a scale from 1 to 5)



Training providers

The survey asked industry representatives about the key reasons for not providing training on natural refrigerants. Training providers identified costs associated with investments in trainers with the adequate skills and setting up the training centres as the key constraint. Unavailability of adequate premises to offer the training as well as lack of relevant training material were also among important barriers for a number of training providers.

Training receivers

According to survey respondents the main reason for not taking up a formal training on natural refrigerants is the high cost of such training. For a number of representatives, on-the-job training is sufficient to perform their duties and no formal training is required. Several respondents noted that there is still a gap between the demand and offer as they see that there is either lack of available training courses or they find it difficult to access the training that is being offered.

Main reasons for not taking up training on natural refrigerants (on a scale from 1 to 5)

Investment costs rank high for both training providers and receivers

Training providers highlighted that it requires substantial investment costs to employ HVAC&R instructors, establish training centres and purchase the necessary equipment, including tools, systems and other material for training purposes. Nevertheless, with the growing demand for natural refrigerants training such investment becomes increasingly worthwhile.

From the point of view of training receivers (including contractors, end users and others), the investment cost to formally train technicians on natural refrigerants is seen as too high. A large share of European HVAC&R companies are small-sized businesses that do not have the necessary financial resources. To solve this issue, it is often the equipment and component manufacturers who offer their trained technicians to guarantee safe installation and maintenance of the natural refrigerant-based systems, rather than relying on external support. Alternatively, the manufacturers provide training for their customers free of charge.

Formal training & certification is not required

In Europe, it is not allowed to work in the HVAC&R sector without adequate training. Handling technology, which contains f-gases, requires technicians to undergo training and obtain special certifications. However, there are no mandatory certification requirements for natural refrigerant training at the EU level. Therefore, there is no requirement to report to national authorities whether someone handling natural refrigerant-based systems underwent appropriate training. It is therefore often the current practice, especially within smaller companies, to employ trainees who will learn the trade on the job working together with qualified professionals.

According to the training receivers, the absence of a requirement for a formal certificate is one of the main reasons for not following a training on natural refrigerants. This is not necessarily a barrier but it rather shows that formal training on natural refrigerants, compared to f-gas training, is not yet a common way of learning in Europe.

Lack of available training courses

Training receivers identified the lack of training courses on natural refrigerants as a third reason for not taking up such training. The training gap between available and required training varies from country to country and depends on the specific needs of individual companies. Overall, shecco has identified close to 200 companies in Europe that offer training related to natural refrigerants and this number is constantly growing. Theoretical, practical, online and on-site training is offered by training institutes, system and component manufacturers, universities, research institutes, associations and other organisations.

One of the ways to close the training gap would be to increase the awareness of the training that is already available in different countries. The following chapters look more closely at the current market situation, while the directory, which is an integral part of this report lists the current training providers.

A range of training material is available, many of which can be accessed free of charge. This is a good basis for the rollout of new training courses. These materials are, however, not available in all European languages - translations into all relevant languages could support a wider use across the EU.

INDUSTRY VIEWPOINT – ON CO_2 TRAINING...

Antoine Azar,
refrigeration consultant, former
global programme Director at
the Coca-Cola Company

"We have been hearing about the difficulties in servicing CO_2 in the field, but I can ensure you that [...] having proper training and proper people to do the job [is] all you need to service CO_2. It's a matter of being well trained."

Giovanni Dorin,
marketing manager
at Dorin Innovation

"Many local associations are setting up training courses in CO_2 applications and alternative systems, and this has to be implemented more and more. Actually the government should support these trends in order to put professionals in the position to handle the new refrigerants safely. At Dorin, we also conduct yearly training for our customers."

Kevin Glass,
UK managing director
at Bitzer

"Carbon dioxide, in particular, is clearly a major area of development for the future. Bitzer is supporting this with its focussed carbon dioxide training course, based at the company's headquarters in Germany."

Bart Driessens,
director, service operations
at Carrier Commercial Refrigeration Europe

"Participating in internal training activities under best-in-class conditions enables our field technicians to gain and apply the latest knowledge on how to install and service CO_2OLtec® turnkey projects with the highest level of quality and reliability."

Kim G. Christensen,
managing director
at Advansor

"The story that there isn't enough CO_2 training capacity is a lie."

José María De Santos,
head of refrigeration installations
at Makro

"The main handicap is training for installers and maintenance personnel. Most of them are not prepared or don't have a chance to work with this kind of installation. It will take a bit of time, three or four years."

Christian Heerup,
technology manager, refrigeration,
at DTI

"There are lots of people that want a better understanding of what's go and no-go with CO_2. The market has matured in Denmark and now we're seeing people with different kinds of occupations attend the courses.

The course is a combination of theory and hands-on, people can see it work with high pressures and train for set points.

A lot of people are a little bit afraid of CO_2 as a refrigerant because they are not used to working with high pressures and suddenly they can see a system working right in front of them with 100 bar reading on the gauge so they are much more confident after doing the hands-on training."

INDUSTRY VIEWPOINT – ON HYDROCARBON TRAINING...

Berty Jakob,
senior research and development manager
at Unilever

"Regarding the implications for servicing it is important to ensure that service engineers are skilled and properly trained for working with hydrocarbons. Training of service personnel is key. Do it right first time and it will serve you for years to come."

Marek Zgliczynski,
manager of commercial refrigeration
product engineering at Embraco

"EU refrigeration technicians' mandatory certification does not include flammable refrigerant topics. This gap has to be quickly corrected to allow fast and safe growth of natural refrigerant technologies."