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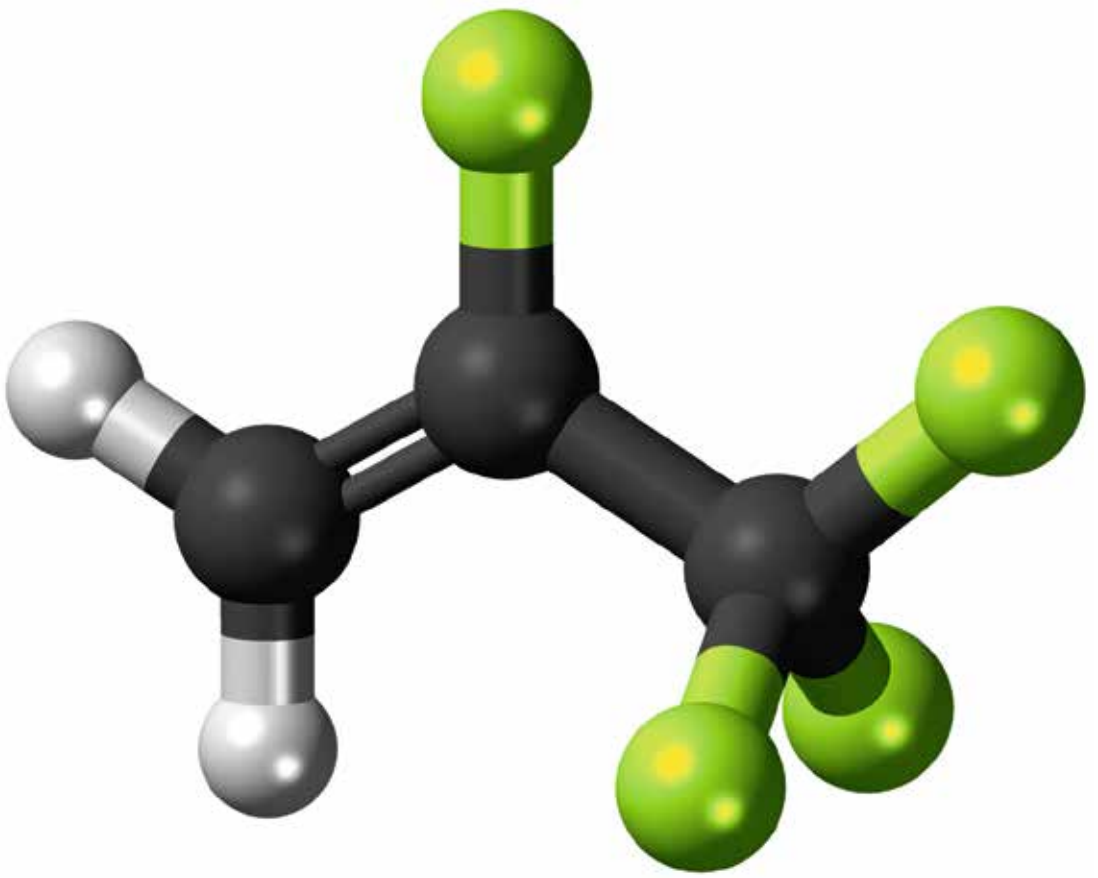
BALANCING ACT



*With the HFC phase-down now under way, a new type of alternative refrigerants called HFOs have emerged. **Sean McGowan** explores the issues associated with these next-generation gases, and looks at the role they could play as the industry moves into a critical transition period.*

On January 1 this year, a historic event took place in Australia's HVAC&R sector: the government began to phase down the quantity of hydrofluorocarbon (HFC) bulk gas that can be imported into the country.

The phase-down was enacted under the internationally ratified Kigali Amendment on HFCs (an extension of the Montreal Protocol on gases that deplete the ozone layer), and will see a gradual reduction in import quotas over the next 18 years. By 2036, Australia has committed to reducing HFCs by 85 per cent.

As a consequence, the HVAC&R industry will need to transition to other low or zero global warming potential (GWP) refrigerants. These include natural refrigerants such as ammonia (R717), carbon dioxide (R744), and hydrocarbons (R290 propane, R1270 propylene and R600a isobutane) – all of which are finding a niche in certain markets, including supermarket refrigeration.

Another alternative that has entered the market are hydrofluoroolefins or HFOs.

THE SCIENCE OF HFOs

Commonly referred to as fourth-generation refrigerants, HFOs feature a similar chemical structure to HFCs.

What sets HFOs apart is that most have a chemical double-bond between atoms (HFCs only have single bonds), which allows them to break down very quickly in the atmosphere. This results in very low GWP.

For example, the atmospheric lifetime of HFO-1234yf is estimated to be about 11 days compared to HFC-134a (R134a), which has an atmospheric lifetime of 14 years.

Additionally, HFOs have zero ozone-depleting potential (ODP) because they contain no bromine or chlorine atoms, and are destroyed in the lower atmosphere.

In their pure form, however, HFOs are generally classified as flammable, and are therefore not a suitable drop-in replacement for HVAC&R systems operating on HFCs.

HFO BLENDS

To assist the HVAC&R industry transition away from HFCs, HFO-HFC blends have been developed as an interim measure. The blends include R513A (marketed under several brand names).

R513A is a blend of HFC-134a and HFO-1234yf and has been developed to replace HFC-134a in some systems. It has a GWP of 573, which is less than half that of R134a.

Other HFO blends include R448A (replacing R404A and R22), R449A and R452A (both replacing R404A and R507).

John Morgan is technical manager for refrigerant and gas at Heatcraft. He says HFO blends are a transitional refrigerant required to keep the marketplace supported during the HFC phase-down.

"Not all refrigerants being introduced to the market today are pure HFOs," he says.

"The equipment currently in service and being sold today needs to be supported through the phase-down activity. So HFO blends play an important part in the step-change in order to maintain the non-flammable classification and compliance requirements."

R448A is a blend of the HFCs R32 (26%), R125 (26%) and R134a (21%), with HFO components R1234yf (20%) and 1234ze(E) (7%).

> The idea that HFOs are simply HFCs rebranded oversimplifies the issue

HFCs REBRANDED?

Despite the obvious low-GWP advantages that HFOs offer, environmental groups like Greenpeace have already been active in opposing their uptake as new-generation refrigerants.

In a position paper released in July 2016, Greenpeace said that HFOs are a form of HFC being marketed under a different name "due to the negative connotations that HFCs have acquired".

Dr Armin Hafner from the Norwegian University of Science and Technology also prefers to call HFOs by another name.

"Unsaturated hydrofluorocarbons represent another kind of HFCs, which are potential replacements for HCFCs and saturated HFCs, especially in air conditioning units," he says.

"We should not use the brand name introduced by the manufacturers," Hafner adds. "Unsaturated hydrofluorocarbons is the correct description of these HFCs, or short-life HFCs."

However, a spokesperson for the Department of the Environment and Energy says the idea that HFOs are simply HFCs rebranded oversimplifies the issue.

"All HFCs have individual characteristics – some have high global warming potential, some are low," the spokesperson says.

"Some are flammable and some are not. HFOs are a form of HFC that have been developed to break down rapidly after they are emitted and to have a low impact on the climate system."

TOXICITY CONCERNS

As with most new products on the market, HFOs also have their detractors.

Concerns have been raised by environmental groups, academics and some members of the HVAC&R industry as to the toxicity of pure HFOs – particularly after they break down in the environment.

A study on the environmental and health effects of HFO refrigerants was prepared for the Norwegian Environment Agency in December 2017. The study found that a number of knowledge gaps exist about the environmental impact of trifluoroacetic acid or TFA – an atmospheric by-product of HFOs.

TFA is produced when some HFOs break down in the atmosphere. Similarly, some – but not all – of the more traditional HFCs also produce TFA when they break down.

It is thought that TFA finds its way into water bodies such as rivers and lakes through precipitation, where it may pose an environmental threat.

Prepared by Risk and Policy Analysts, the report notes that the consensus among academics is that "TFA will have a negligible effect on the environment," but points to a number of knowledge gaps that need to be filled to support that conclusion. These include studies on the cycle of TFA in the atmosphere and hydrosphere, the amount of TFA used globally, and other potential sources of TFA in the environment.

The Montreal Protocol's Scientific Assessment Panel reported on breakdown products in its 2014 Quadrennial Assessment Report. It summarised its review of TFA as follows:

"Some of these candidate low-GWP compounds are hydrofluoro-olefins (HFOs), one of which

HFO SIGHTINGS – THE STORY SO FAR

Daikin recently launched a new range of chillers that use the HFO R-1234ze (E).

John Morgan, Heatcraft Australia technical manager, refrigerant & gas, filled us in on how much HFOs and their blends have penetrated our market so far.

Q: How long have the HFO blends been in Australia, and how is this market developing?

A: HFO blends have been available for the past one to two years. As the product gains acceptance through trials, the demand is growing.

Q: Are there any particular areas of the industry or applications where they are being used?

A: The large commercial sector tends to embrace the technology first, due to the level of investment and installation lifecycle expectation by the specifiers/end users.

The new generation refrigerants are also being driven by some OEMs as they trial and approve the new refrigerants for use in their existing and new generation equipment. For example, Heatcraft is currently in the process of releasing new literature incorporating the use of R448A across its Kirby condensing unit and refrigeration equipment range.

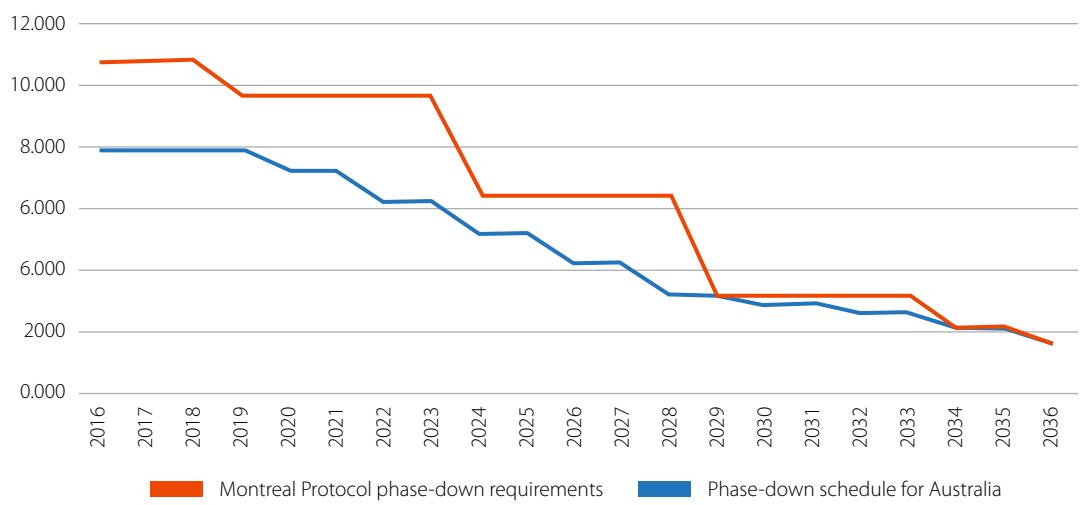
Their use in HVAC in particular may initially be limited but will increase as equipment is geared towards the newer refrigerants.

Q: What about the pricing of the HFO blends compared to the HFCs that they are replacing?

A: HFO blends are presently more expensive in comparison to HFCs. But as volume usage of HFO blends increase, the costs are expected to decline and will reach a price parity with HFCs. This will be the point where the largest switch away from HFCs to HFOs will be seen.

Q: Are the pure HFOs available yet, and if not, when can people expect to see them arrive?

A: Yes. R1234ze is available now. Customers should check their local branch for more information.



Australia plans to stay ahead of the global phase-down schedule.

(HFO-1234yf) yields the persistent degradation product trifluoroacetic (TFA) upon atmospheric oxidation. While the environmental effects of TFA are considered to be negligible over the next few decades, potential longer-term impacts could require future evaluations due to the environmental persistence of TFA and uncertainty in future uses of HFOs."

TWO MINUTES WITH DR ARMIN HAFNER

Q: What is preferable in a refrigerant: low toxicity or low flammability?

A: If we do good engineering and apply current safety standards, 99 per cent of all HVAC&R units can be made applying natural working fluids (refrigerants). These systems with natural working fluids will also be more energy efficient than those applying available HFCs.

Flammability can be handled, and there are no decomposition products in case of an event with hydrocarbons. In the case of small leaks from HFC (high-GWP and short-life) indoor units, there is a large risk that the fluid is decomposing inside the house if there are hot surfaces (oven, etc.)

Q: Why has the HVAC&R industry (at least in Australia) been slow to move to natural refrigerants?

A: Business as usual is low risk. However, if the market is changing and the end users are informed, it is a good opportunity for first movers to gain market share. Training is key, too.

Q: You have just been in Sydney to attend the Refrigeration 2018 conference. What was the focus of your visit?

A: The focus was on natural working fluids. These fluids do have favourable thermodynamic and fluid properties enabling energy-efficient refrigeration system configurations. In addition, their environmental impact is well known and safety standards are established.

Briefing notes from a UN Environment Program meeting state that current and future use of HFCs and HFOs are estimated to add less than 0.1 per cent TFA input to oceans and salt lakes to amounts already present from natural sources.

"More than 95 per cent of the salts of TFA found in the oceans are naturally produced," says the briefing note. "These salts are inert and not of toxicological or environmental concerns in small concentrations that are present in the oceans, playas, and lakes."

Tayler Stevenson, Affil.AIRAH, product manager of factored gases at BOC, says further research has drawn similar conclusions.

"A study in the Journal of Geophysical Research found that even if every vehicle in the USA had R1234yf, concentrations of TFA in rainwater will remain well below safety limits," says Stevenson.

> "HFOs have zero ozone-depleting potential because they contain no bromine or chlorine atoms, and are destroyed in the lower atmosphere"

Nevertheless, Hafner says the acidity of TFA is approximately 34,000 times stronger than that of acetic acid, and can be harmful when inhaled, causes severe skin burns and is toxic for water organisms even at low concentrations.

Another atmospheric product of some HFOs is hydrogen fluoride (HF), which upon contact with moisture immediately converts to hydrofluoric acid and is both highly corrosive and toxic.

"As long as the fluids stay inside the systems, everything is okay," says Hafner. "However, in reality these units do have leaks and decomposition will take place, even without a fire or an accidental event."

RISK-FREE REFRIGERANT? NO SUCH THING

What is clear is that each refrigerant offers distinctive characteristics, and each carries its own set of risks – be it flammability, toxicity, overall emissions, performance or cost.

"It is about choosing a refrigerant best suited to the application," says Stevenson.

"Refrigerants have always offered a choice of characteristics, however, due to the laws of physics and chemistry there are trade-offs, which is why so many options are available."

And according to Morgan, there will be no risk-free refrigerants in the future.

"As with natural refrigerants, it often comes down to the application, and the effects that methods to manage the risks have," he says. "That is why occupancy and location factors are now so important in informing the selection of fluids."

He says that HFO blends being offered to the market, such as R448A, still offer the best solution for the immediate future in support of a development equipment market.

"The move to further develop equipment for low-GWP refrigerants will continue with all OEMs (original equipment manufacturers), as is the intent of the Montreal Protocol."

WILL HFOs END UP THE WAY OF CFCs, HCFCs AND HFCs?

"A friend of mine brought it to the point," says Hafner.

"It took 60 years (1930 to 1990) to acknowledge that CFCs damage the ozone layer. It took 30 years (1990 to 2020) to acknowledge that HFCs contribute to global warming. It will take maybe less than 15 years to acknowledge that HFOs are harmful to the local environment."

While it's entirely possible that HFOs will be phased down or out in the future, for now the industry's major manufacturers and distributors see HFOs as the next evolution in refrigerants.

"Currently, HFOs offer the best balance of benefits, including low emissions, with no foreseeable end," says Stevenson.

"HFOs are endorsed or approved by peak organisations such as the EU, EPA (USA) and the National Industrial Chemical Notification and Assessment Scheme (NICNAS) in Australia. Overwhelmingly, it seems that with current technology, the low-GWP benefits of HFOs are one of the best solutions to reduce the overall global warming impact of HVAC&R."

Although the federal Department of the Environment and Energy does not promote or recommend particular solutions, it does recognise HFOs as being one of the answers to the HFC phase-down.

"Other refrigerants such as ammonia, carbon dioxide and hydrocarbons will also be part of the solution, as well as non-chemical approaches such as evaporative cooling," says a Department spokesperson. "And there is also exciting technology emerging such as phase-change materials and magnetic refrigeration."

Ultimately, however, it will be the market that determines the future of HFOs and how they will compete alongside natural refrigerants and new technologies.

Only time will tell. ■

Want to know more?

The Speaker Series at this year's ARBS conference features a session looking specifically at HFOs. The talk will be given by Honeywell's Global Business Manager – Refrigeration, Robert Kebby.

According to the program, the session will provide the audience with a clear understanding of how HFOs combined with diverse refrigeration architectures are already impacting the industry, through improvements in energy efficiency, refrigerant charge / leak reduction, total cost of ownership and reduced overall environmental impact. The session will examine case studies on end users who are experiencing challenging economic conditions and have chosen to primarily focus on the Total Cost of Ownership (TCO) of refrigeration.

For our full preview of ARBS, turn to page 20.