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Exploding myths

Challenges and opportunities for hydrocarbons

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EXPLODING THE MYTHS

With the phase-down of HFCs accelerating the need for alternatives, some are looking to hydrocarbons to take on a larger role in refrigeration and air conditioning, as **Sean McGowan** reports.

Hydrocarbons are organic compounds composed of hydrogen and carbon and fall under two chemical categories: alkanes (or paraffins) and alkenes (or olefins).

The four most common hydrocarbon refrigerants are propane (R290), isobutane (R600a), isopentane (R601a) and propylene (R1270). A number of proprietary blends incorporate two or more of these single elements.

All four have a GWP (global warming potential) value of 3 – meaning they have a much smaller impact than most hydrofluorocarbons (HFCs). All four are also categorised as Class A3 (flammable) refrigerants because of their high flammability.

Hydrocarbons have a similar volumetric capacity and performance to R410A and are therefore technically feasible as a replacement for many systems operating on that HFC.

R600a is arguably the most popular hydrocarbon refrigerant worldwide. A very high percentage of domestic refrigerators now operate on R600a – check the specification plate of your fridge at home and you may be surprised!

R600a – and more commonly R290 – are also used in commercial refrigeration supermarket applications including display cabinets. More recently, R290 has been used in a small number of domestic split air conditioning systems.

The cost of hydrocarbons is also very low compared to other very low-GWP refrigerants such as HFOs (hydrofluoroolefins).

Hydrocarbons offer favourable thermodynamic refrigerant properties that make them highly efficient. These include low liquid and vapour viscosities, high liquid specific heat, high liquid and vapour thermal conductivities and high latent heat.

Conversely, the main disadvantage of hydrocarbons is their higher flammability and resulting limited refrigerant charge. This has been the big barrier to their wider application.

There may also be additional costs associated with design and manufacture to ensure systems are suitable and compliant for the use of A3 class refrigerants. Finally, there is a lack of training in Class A2L and A3 refrigerants.

THE CHARGE

Perhaps the biggest barrier to the wider adoption of hydrocarbon refrigerants relates to charge limits.

While recent changes to the allowable hydrocarbon charge in some commercial refrigeration systems has seen this rise from 150g to 500g, limits remain in place on domestic systems in Europe, as well as here in Australia.

The current charge limits for flammable refrigerants in residential air conditioners were introduced in 2006 via AS/NZS 60335.2.40:2006.

Later versions of this standard have introduced some relaxations for Class A2L refrigerants; however there has been no change to the requirements for Class A3 refrigerants like hydrocarbons.

The flammable charge limit is determined by an equation that takes into account the height of the indoor section, the LFL (lower flammability limit) of the refrigerant, and the room area.

As an example, for a wall-mounted split system (at 1.8m installed height) in a 12m^2 room using R290, the maximum charge would be 260g.

The standard also places a cap on the maximum flammable refrigerant charge irrespective of room area. For air-to-air products using an A3 refrigerant the cap is 26 x LFL of the refrigerant.

R290 has an LFL of 0.038kg/m^3, so the maximum charge allowed would be 26 x 0.038 – 988g.

The limitation to the adoption of hydrocarbons in domestic split air conditioning systems therefore lies in the fact that for a wall-mounted split system with a charge of 988g of R290 refrigerant, it would be limited to being installed in a room with a floor area not less than 175m^2.

It's important to note that installers don't need to be familiar with this charge calculation, as manufacturers are required by the standard to specify the minimum floor area permitted in the product installation manual.

Larger refrigerant charges can be used where the whole hydrocarbon refrigerant circuit is located outdoors or in a ventilated enclosure.

FOLLOW THE LEADER

Hydrocarbon refrigerants are becoming more popular around the world as the phase-down of fluorinated gases (F-gases) continues, particularly in the European market.

This popularity led the International Electrotechnical Commission (IEC) – the world's leading organisation for the preparation and publication of international standards for electrotechnology – to increase the charge limit of hydrocarbon refrigerants in commercial systems.

"Last year's IEC hydrocarbon charge limit increase to 500g for commercial cabinets will allow an even wider uptake of this technology in the future once this has been adopted by individual countries or regions," says Ilana Koegelenberg, market development manager for Shecco.

Australia was among the first countries to adopt the IEC changes, with Standards Australia adopting new limits on the amount of A3 (flammable) and A2L (low flammable) refrigerant that is allowed to be used in commercial refrigeration appliances and ice makers in Australia and New Zealand.

This is reflected in AS/NZS 60335.2.89:2020 – an adoption of IEC 60335-2-89 Edition 3.

According to Mario Balen, Affil.AIRAH, general manager of Australian hydrocarbon supplier HyChill Australia, overseas markets – with the exception of the USA – have proven to be much nimbler and proactive in developing and adopting new technologies using hydrocarbons.

"China has actively encouraged their air conditioning industry to develop hydrocarbon technology," Balen says.

"They have completed pilot programs such as installing thousands of air conditioning systems in university buildings and other public institutions, with some 160,000 propane systems installed."

Balen points to major manufacturers having considerable capacity to commence production of hydrocarbon air conditioning systems once barriers are removed.

"Hydrocarbon domestic air conditioning systems have already been tested and some approved for sale and use in Europe, with Midea expected to start sales in Germany before the end of the year," he says.

India is also a growth nation for hydrocarbons, with local manufacturer Godrej & Boyce using R290 in its range of domestic split air conditioning systems.

A MANUFACTURER'S PERSPECTIVE

Despite the international experience, the take-up of hydrocarbons in Australia has been slower.

Some blame the established synthetic refrigerants industry for curtailing its progress, while others point to the risks associated with flammability and charge limits as driving factors.

According to Robert Beggs, managing director of Australian air conditioning manufacturer Temperzone,

CALLS TO BAN HFCs IN SINGLE SPLIT SYSTEMS

The Environmental Investigation Agency (EIA) recently engaged German researchers to look into the benefits of switching split system air conditioning units from HFC refrigerants to R290.

With the European Union's F-Gas regulation currently under review, the EIA has called for a ban on HFCs in single split air conditioning units. In support of its call, it is working to secure an amendment to current rules to allow for a greater volume of R290 to be used in residential air conditioning systems. The change would also allow for increased charge sizes of A2L refrigerants, such as R32.

In the case of hydrocarbons, the change would not increase charge sizes for appliances used in very large rooms; this would remain at about 1kg. But it would change the charge for an ordinary-sized room.

To hold this increased charge, systems will need circulation airflow, safety shut-off valves, and will need to satisfy new construction requirements for a more robust design.

So far the focus of Grosvenor Engineering Group with natural refrigerants has been in the areas of package units extending through to chiller systems used within larger commercial premises.

there are very few brands entering the Australian market that have adopted hydrocarbons.

"The Australian government's energy rating register currently features 14 air conditioning brands that claim to use a hydrocarbon refrigerant," Beggs says.

"Of these, 12 brands are portable air conditioners using R290 with a cooling capacity of less than 4kW, and all these with the exception of one (De'Longhi – Italy) are made in China. The other two brands are local suppliers offering imported split systems, package units and ducted systems using a refrigerant listed as M60."

M60 is a proprietary blend of hydrocarbons R290, R1270 and R600a offered by Australian hydrocarbon supplier Engas.

Beggs says that from a local air conditioning manufacturer's point of view, the barrier to the wider adoption of hydrocarbons is the cost to build the product, and the additional risk of a serious accident.

"No reputable manufacturer should release a product onto the market that has a risk of serious incident associated with it that is not acceptable to the manufacturer or the market," he says.

> For a multi-national manufacturer, even an ignition risk during use of 1 in 10 million may not be acceptable

"For a multi-national manufacturer, even an ignition risk during use of 1 in 10 million may not be acceptable considering the cumulative result of the millions they sell each year with a life of, say, 10 years."

It's this balance of risk versus reward that has always held back the wider adoption of hydrocarbon refrigerants in Australia.

While the small refrigerant charge in domestic refrigerators (less than 100g) can be managed without increasing the likelihood of an incident related to ignition of the refrigerant, the risk is deemed to increase according to the size of the charge.

It has left many manufacturers to take the perceived safer option, which in the case of modern domestic split system air conditioners, appears to be the use of the A2L-classified refrigerant R32.

SUPERMARKETS LEAD THE WAY

One sector where hydrocarbons are gaining a foothold, however, is in supermarket and commercial refrigeration.

According to HyChill, leading supermarket groups are either trialling significant hydrocarbon systems or are installing them as a matter of course.

"Hydrocarbon refrigerants are recognised as one of the most effective and efficient in the industry," says Balen. "Their performance has been well researched and there are many studies evidencing their benefits.

"The number of local and particularly global companies developing, or even manufacturing, standalone air conditioning systems such as heat pumps and chillers is impressive."

This follows trends in Europe where regulatory barriers have been removed, resulting in the marketing opening up to hydrocarbon refrigerants.

"Chest freezers, supermarket cabinets and displays, commercial refrigeration installations, ice making machines, ice cream installations, water coolers – the list goes on – have all adopted hydrocarbons as a mainstay refrigerant."

Other common applications here in Australia include automotive air conditioning, small-scale refrigerated cabinets and even agricultural conversions in dairies and wineries.

HYDROCARBON HEROES

Grosvenor Engineering Group

Such is the demand among its clients – particularly local councils – for the use of low-GWP HVAC technologies in any new developments, technical services company Grosvenor Engineering Group has introduced a dedicated natural refrigerant technology service.

Announced in July, the company will train all 400 of its HVAC technicians in natural refrigerant technology within the next 12 months – following the accreditation of more than 30 technicians in the safe handling of R32.

"We have been observing market trends overseas and the exponential growth towards using environmentally friendly HVAC&R solutions which deliver significant energy savings," says Nicholas Lianos, Affil.AIRAH, managing director at Grosvenor Engineering Group.

"The technology that underpins the ability to achieve these outcomes is the use of natural refrigerants such as hydrocarbons."

Lianos says market research has highlighted a gap in the Australian market for technical people who can properly and safely handle, install and maintain natural refrigeration solutions.

"We will soon have a dedicated team of highly experienced and accredited staff equipped to implement natural refrigerant technology in commercial buildings."

In recognising the training gaps preventing the Australian market from truly embracing natural refrigerants, Grosvenor assessed what training programs were available in Australia – at one stage considering developing its own – before establishing a working relationship with Superior Training Centre.

The registered training organisation (RTO) based in Ingleburn, NSW, has developed a number of fully accredited courses in working with natural refrigerants, including:

- Handle class A2/A2L flammable refrigerants
- Apply safety awareness and legal requirements for hydrocarbon refrigerants
- Service and repair of self-contained hydrocarbon air conditioning and refrigeration systems
- Install and commission hydrocarbon refrigeration systems, components and associated equipment

Noting that common Class A2L refrigerants like R32 – as well as some HFOs – also present a flammability risk, Grosvenor is confident that training can alleviate any such concerns when it comes to the use of hydrocarbons.

"Compared to the most common refrigerants in use today, we don't believe that working with hydrocarbons presents a significant step change," says Lianos.

"Properly trained technicians using established installation and servicing guidelines, along with appropriate safety measures being fitted to equipment, should see no greater risks being incurred to that of other types of refrigerants."

EcoChill New Zealand

Committed to innovation in clean cooling technology, family-owned EcoChill has pioneered the design and installation of many New Zealand firsts.

These include the country's first natural refrigerant technology, the first retail glycol system, the first transcritical CO_2 system, the first waterloop system, and the first parallel compression CO_2 system.

More recently, the company has completed the end-to-end development of New Zealand's largest hydrocarbon system for the country's most easterly commercial shipping port, Eastland Port.

"The Eastland Port project is an exciting new step for hydrocarbons in New Zealand with the line between commercial and industrial applications no longer defined as it used to be," says Matthew Darby, founder and managing director of EcoChill.

"Delivering over 1MW of cooling, the R1270 system has broken through the industrial application barrier that previously existed, providing a very real alternative to both synthetics and ammonia."

Such is the company's success in natural refrigerants that in 2017 it committed to only delivering natural refrigerant solutions by 2020, with hydrocarbons a core part of its offering alongside CO_2 and ammonia.

"We did not want to be part of HFOs' introduction into New Zealand, only to find they needed to be rolled back once the impact of their use on the environment was understood," says Darby.

"It is clear that natural refrigerants are well understood and the technology is not only viable, but it can in fact provide superior system performance to synthetic F gases."

He says that once customers understand that hydrocarbon systems are safe, viable and a high-performance choice, EcoChill finds that users of synthetic refrigerants for many years become hydrocarbon converts.

"At this time, hydrocarbons are well placed as a future-proof solution regarding cost and supply considerations."

OVERCOMING THE RISK

If hydrocarbons are to fulfil their promise, the flammability risks associated with their use will need to be overcome both through technology and specific industry training.

But Balen says such flammability issues are often overstated.

"Under certain circumstances they may ignite, in a similar manner to other natural gases," he says.

Balen says that generally, additional precautions need to be undertaken when using hydrocarbon refrigerants.

"Those precautions relate to the work environment – such as ensuring proper ventilation of the workspace and eliminating ignition sources in the vicinity – as well as to the actual system, such as the use of suitable electrical connections and devices, leak detection devices in larger installations etc."

But whether Class A3 refrigerants like hydrocarbons, Class A2L refrigerants like R32 – or indeed both – are deemed to be the future, the HVAC&R industry will need to come to terms with regularly using flammable refrigerants in a safe and effective manner. ■

QUEENSLAND BORDER CLOSED TO HCs TOO

The rules for using hydrocarbon refrigerants in Queensland are stricter than in other parts of the country. This has been the case since the Department of Mines introduced regulations restricting its use in 2004.

Only the holder of a gas work licence (hydrocarbon refrigerants) can do work on the gas system of a refrigeration appliance.

You must also make sure that all devices that use fuel gas as a refrigerant are approved before they are sold, installed or used.

But with a state election due in late October, One Nation Party MP Stephen Andrew is supporting a push to bring the sunshine state in line with the rest of Australia.

At time of this issue going to print, an online petition had attracted around 600 signatures of support.