REASONS WHY HFO REFRIGERANTS ARE A STRONG ALTERNATIVE TO NH3/AMMONIA

PILLAR 4 - NEAR ZERO VS ZERO GWP

INTRODUCTION

When installing an industrial chiller in a food, beverage, or dairy setting, it is important to consider whether NH3 (Ammonia) is indeed the most appropriate refrigerant solution.

In food and beverage processes, it has been a traditional approach to have the cooling process applied by an "Industrial" cooling system, typically using ammonia as refrigerant. Some reasons are based on unconscious bias, some other reasons are the "natural" aspect of ammonia.

But now companies that need a mild freezing cooling system are increasingly turning to Hydrofluoroolefin refrigerants – known as HFOs – to improve sustainability, boost performance, and significantly reduce costs.

The ideal refrigerant for these sectors needs to be non-toxic, non-flammable, non-explosive, non-corrosive, not harmful to the environment, cheap and easy to produce / work with and have good thermodynamic properties. Luckily, HFOs meet this criterion. And simply put, HFO solutions are always lower cost versus NH3/ammonia.

HFO refrigerants are categorised as having zero ozone depletion (ODP) potential and low global warming potential (GWP) and R1234ze is a synthetic refrigerant, rather than a natural refrigerant like ammonia. Interestingly the GWP value of R1234ze is less than the GWP another natural refrigerant CO2 (being 1) and importantly R1234ze doesn't create TFA (trifluoroacetic acid and its salts).

Here we look at the aspect of refrigerants and low GWP.

WHAT IS A REFRIGERANT?

Industrial chillers remove heat from liquid via vapor-compression, adsorption refrigeration, or absorption refrigeration cycles. Refrigerants, or working fluids, are the substances used in refrigeration cycles where in most cases they transition from a liquid to a gas and back again. Fluorocarbons, especially chlorofluorocarbons, became commonplace refrigerants in the 20th century, but are now being phased out because of their ozone depletion effects. Other common refrigerants are ammonia, sulphur dioxide, and non-halogenated hydrocarbons such as propane.

IDEAL REFRIGERANT PROPERTIES

The ideal refrigerant would be non-toxic, non-flammable, non-explosive, non-corrosive, not harmful to the environment, cheap and easy to produce and work with and have good thermodynamic properties operating at low pressures.

The desired thermodynamic properties are a boiling point somewhat below the target temperature and a high latent heat of vaporization to move more heat per volume when it boils. Ideally, the refrigerant should have moderate density in liquid form, a relatively high density in gaseous form, and evaporate and condenses at temperatures easily manipulated with compression. Since boiling point and gas density are affected by pressure, refrigerants may be made more suitable for a particular application by appropriate choice of operating pressures. Lastly, refrigerants should mix well with oil, so that the oil can effectively lubricate the compressor.

In reality, different refrigerants have varying degrees of these desired properties making choice a matter of trade off. The change in priorities over the last century from safety to environmental protection continues to drive change in refrigerant choice.

HISTORY and REGULATION OF REFRIGERANTS

The first commercial refrigerants used toxic or flammable gases, such as ammonia, methyl chloride, or propane that could result in fatal accidents when they leaked. A non-toxic and non-flammable chlorofluorocarbon (CFC) gas was developed in 1928 (R-12) and branded Freon by DuPont later replaced by hydrochlorofluorocarbon (HCFC) commonly R-22 and hydrofluorocarbon (HFC) refrigerants. These refrigerants were frequently used for industrial purposes as they delivered a high level of safety and efficiency combined with low installation costs.

Most of these common CFC, HCFC, and HFC refrigerants are greenhouse gases that contribute to global warming and may deplete the ozone layer when leaked to the atmosphere. R-22 for example has a global warming potential (GWP) about 1,800 times higher than CO2.

Protocol in 1987 and the Kyoto Protocol in 1997 resulting in a shift to refrigerants with even lower environmental impact. In the UK, regulations came into force in 2002 banning the use of ozone-depleting HCFC refrigerants such as R-22 in new systems. Legacy chillers that use this refrigerant however can still be serviced and maintained.

EU F-gas regulations came into force in 2015 to reduce emissions of fluorinated greenhouse gases (F Gases) through phasedown quotas, bans and maintenance requirements.

Regulations have become increasingly strict with the Montreal Protocol in 1987 and the Kyoto Protocol in 1997 resulting in a shift to refrigerants with even lower environmental impact. In the UK, regulations came into force in 2002 banning the use of ozone-depleting HCFC refrigerants such as R-22 in new systems. Legacy chillers that use this refrigerant however can still be serviced and maintained.

These regulations and market demand for more environmentally friendly solutions has driven much innovation in industrial process and HVAC temperature control with many new refrigerants such as R-454b and R-513a being adopted.

REFRIGERANT SAFETY CLASSIFICATIONS

Refrigerants are categorised according to toxicity and flammability. There are two classes for toxicity; lower toxicity (Class A) where toxic concentrations are less than or equal to 400 parts per million (PPM) by volume and higher toxicity (Class B).

There are four classes of flammability: 1, 2L, 2 or 3. Class 1 is for refrigerants that show no flame propagation at 140°F (60°C) ranging to class 3 highly flammable. The purpose of the 2L subclass is to reflect the lower flammability properties of the new low-GWP refrigerants, such as hydrofluoroolefins (HFOs), like R-1234yf and R-1234ze.

OZONE DEPLETION POTENTIAL (ODP) AND GLOBAL WARMING POTENTIAL (GWP)

All refrigerants have an Ozone Depletion Potential (ODP) and Global Warming Potential (GWP) rating. The Ozone Depletion Potential (ODP) is the relative amount of degradation to the ozone relative to R-11 (or CFC-11) being fixed at an ODP of 1.0. It is the ratio of global loss of ozone to the global loss of ozone from CFC-11 of the same mass.

Hydrochlorofluorocarbons have ODPs mostly in range 0.005 - 0.2 due to the presence of the hydrogen which causes them to react readily in the troposphere, therefore reducing their chance to reach the stratosphere where the ozone layer is present. Hydrofluorocarbons (HFC) have no chlorine content, so their ODP is essentially zero.

Global Warming Potential (GWP) is the heat absorbed by any greenhouse gas in the atmosphere, as a multiple of the heat that would be absorbed by the same mass of carbon dioxide (CO_2). GWP is a measure of how environmentally detrimental refrigerants can be relative to C02 which has a GWP of 1.0.

NEW LOW GWP REFRIGERANTS

Whilst the EU market was 71% R-410a for new equipment sold in 2020, new lower GWP refrigerants such as R-454b are poised to take over from 2021.

R-454b is an HFO (Hydro Olefin) refrigerant made by blending the single component R-32 refrigerant with R-1234yf giving some unique advantages. R-32 on its own has a high discharge temperature which can limit its operating envelope without some type of injection. R-454b however is an easier refrigerant to handle and offers similar properties to R-410a, making it a cost-effective and easy to use solution in new equipment without major modifications being necessary, ideal for industrial process applications.

R-454b also has a lower GWP of 466 compared to R-32 at 675 and has an ozone depletion potential (ODP) of zero.

OPERATING PRESSURE REQUIREMENT OF NEW REFRIGERANTS

Whilst the next generation of refrigerants balance the needs of safety and reduction in carbon footprint, the new trade-off is the development and cost of the equipment to cope with the increased pressures required for these refrigerants to work. As a direct replacement for R-410A, R-454B operates at a slightly lower pressure whereas R-32 requires a slightly higher pressure.

Next generation refrigerants deliver improvements in the coefficient of performance (COP), the ratio of useful heating or cooling provided to work required or energy usage of the compressor. This comes with a slight flammability trade-off having some implications on chiller placement and maximum charge (hence capacity). It also means components need to be compatible with flammable refrigerants, to ensure they cannot be considered an ignition source.

ICS COOL ENERGY REFRIGERANT DEVELOPMENT

ICS Cool Energy, the leading solution provider for process and critical temperature control, has vast experience in designing products operating with low-GWP refrigerants. The entire portfolio of screw compressor chillers is already available with low-GWP refrigerant alternatives such as R-1234ze and R-513a.

Throughout the first half of 2021, smaller i-Chiller Compact scroll compressor units will be developed to use R-513a whist the majority of ICS Cool Energy packaged i-chillers and larger scroll units will move to using R-454b as the lowest GWP value option to replace R-410a whilst maximising high-efficiency operation. Specifically compared to ammonia systems, ICS Cool Energy chillers use refrigerants that are non-toxic, proven, require easier maintenance and have a lower first cost as well as being low in GWP.

7 REASONS TO CHOOSE AN ICS COOL ENERGY HFO CHILLER OVER AN AMMONIA CHILLER

- Cost effective solution
- Zero Toxicity
- Ease of maintenance and operation
- Low GWP
- Standardized range of products with fast customisation options
- Proven performance
- Compact footprint

KEY TERMS DEFINED

ODP – ozone depletion potential – degree to which a substance can degrade the ozone layer; all measurements relative to a similar mass of CFC-11, which is indexed at 1.0.

GWP – global warming potential – degree to which a greenhouse gas (GHG) traps heat in the atmosphere; all measurements relative to a similar mass of carbon dioxide (CO^2), which is indexed at 1.0. The build-up of GHGs can cause climate change.

CFCs – chlorofluorocarbons (e.g. R-11, R-12) – phased out by the Montreal Protocol in 1996 because of their very high ODPs. Significant impact on both ozone depletion and global warming due to the chlorine and fluorine atoms and very long atmospheric lives.

HCFCs – hydrochlorofluorocarbons (e.g. R-22, R-123) – also contain chlorine, but contribute less to ozone depletion and climate change due to shorter atmospheric lives. Still in use globally but have phase-out dates scheduled under the Montreal Protocol.

HFCs – hydrofluorocarbons (e.g. R-134a, R-404A, R-407C, R-410A) – do not contain chlorine, but they do have high GWPs given their fluorine content. Currently targeted for global phase down under the Montreal Protocol.

HFOs and HCFOs – hydrofluoro-olefins (e.g. R-1234yf, R-1234ze) and hydrochlorofluoroolefins – next-generation refrigerants that are non-ozone-depleting with ultra-low GWPs and very short atmospheric lives (measured in days vs. years or decades).

HFO BLENDS (e.g. R-452b, R-454b, R-513a, R-514a) – blends including an HFO with lower GWPs.

Our International Offices: England and Wales: 0800 840 4210 | Ireland: 04692 52934 | Scotland: 01698 7445 40 | France: 01 60 66 80 83
Germany: 0800 0116 0117 | Netherlands: 088 258 2580 | Belgium: 0800 29 110 | Austria: 01236 81 73 | Switzerland: 055 505 66 22