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Refrigerant Options

Guidance Note:
Replacing HFCs in New and Existing Cooling Equipment

Many business-critical cooling systems rely on HFC refrigerants. These high global warming potential substances are becoming scarce and expensive and will eventually be phased out. It is essential that businesses develop a strategy to reduce their reliance on these refrigerants. This guidance note outlines the options available for both new and existing systems.

The strategy developed should minimise the risk to your business regarding refrigerant supply and should reduce the environmental and financial cost of your cooling equipment.

There are several alternative refrigerants that are already being widely used. You should consider the following when selecting which option is best for you:

- Maturity and experience of the market with the refrigerant;
- Knowledge and experience within the equipment supply sector;
- Availability of refrigerant, service equipment and trained service technicians;
- Inclusion within standards such as EN 378;
- Safety – flammability, toxicity and operating pressures;
- Environmental impact;
- Performance and efficiency.

The strategy should also cover the conservation of your existing refrigerants by reducing leakage and leak potential.

The F Gas Regulation (EU 517/2014)

Most of the refrigerants currently used in cooling equipment are very high global warming potential HFCs. They are subject to control under the EU Fluorinated Gas regulation and are consequently becoming increasingly expensive and scarce.

The F Gas regulation aims to reduce emissions of HFC refrigerants through use bans, service bans, a quota supply scheme and mandatory leak checks. The most relevant parts of the regulation summarised in the time table below:

Year	Quota for HFC based on 2015 [1]	Placing on the market bans for new equipment [2]	Service bans [3]
2018	63%		
2020	63%	Ref GWP > 2500 in hermetically sealed systems and stationary ref systems	Ref GWP > 2500 in systems > 40 tonnes CO_2 equivalent (e.g. 10 kg R404A)
2021	45%		
2022	45%	Ref GWP > 150 in hermetically sealed systems and central plant ref systems	
2024	31%		
2025	31%	Ref GWP > 750 in single split AC systems with < 3 kg charge	
2027	24%		
2030	21%		

This is not a complete list, see the F Gas Support documents listed at the end of this guidance note for full information.

1. The Quota system is an EU wide phase down and its effect is market dependent. Already high GWP HFCs such as R404A are becoming expensive and scarce. It is likely that 404A will not be available in the UK after 2018, and the mid range GWP refrigerants will become more expensive and less widely available.

2. The placing on the market ban initially covers R404A and other high GWP refrigerants, but in 2022 most HFCs are included in the ban for the system types listed.

3. The service ban primarily covers R404A in systems above 10 kg charge size. To reduce the impact of this and the quota system on your existing equipment you should ensure systems are well maintained and have minimum potential for leakage.

HFC Refrigerants

Refrigeration and air conditioning equipment has widely used HFCs in the past and today there is a legacy of this equipment. In addition, there are many systems still being manufactured and installed using HFCs, including the high GWP R404A.

The table below lists the common HFCs with key information.

Refrigerant	Used in …	GWP
R404A	Many refrigeration systems	3922
R410A	Split AC systems and chillers	2088
R407A	In place of R404A in new and existing systems	2107
R407C	Older AC systems	1774
R407F	In place of R404A in new and existing systems	1825
R422D	To convert R22 systems	2729
R448A	In place of R404A in new and existing systems	1387
R449A	In place of R404A in new and existing systems	1397
R452A	In place of R404A in existing systems	2140
R134a	Small refrigeration systems	1430
R32	Split AC systems	675

Leak Reduction

To conserve refrigerant in existing systems and to minimum the cost and environmental impact of cooling systems it is important that the leak potential of systems is minimised. This can be achieved through:

- Proactive maintenance, for example condenser cleaning to minimise operating pressures;
- Visual inspection to highlight issues such as pipe work vibration or chafing which can lead to failure and leakage;
- Leak testing – the F Gas regulation sets a minimum standard for leak testing, many systems require more frequent testing.

Detailed information about leak reduction is provided by the Real Zero and Real Alternatives projects – the website is listed at the end of this document.

Refrigerant Options – New Systems

For new systems there are several very low GWP "future proof" refrigerants which are currently used in new commercial RAC systems. These are listed below.

Refrigerant	Safety [1]	Type	System cost compared to R404A	GWP	Current deployment / future use
R290 Propane	Flammable (A3)	HC	Similar	3	HCs are widely used in integral systems and are also used in some chillers, e.g. HC is the only refrigerant type used in several hundred Waitrose stores.
R1270 Propene (propylene)	Flammable (A3)	HC	Similar	3	
R744 Carbon dioxide	High pressures (A1)	CO_2	Higher	1	Widely used in retail central plant systems and in some industrial systems. Used in a very small number of integral systems. Starting to be used in mid-sized condensing unit systems.
R32	Flammable (A2L)	HFC	Similar	675	Starting to be used split AC systems.
R1234ze	Flammable (A2L)	HFO	Currently higher, likely to be similar in the long term	7	Used in a very small number of integral systems and chillers.

1 There is an explanation of the safety classification at the end of this document.

Other HFOs are available with cooling capacities similar to R134a or R404A. These have not been included because there is even less experience with these than with R1234ze.

Not all the refrigerants listed above have a similar cooling capacity to the HFC they replace (uusally R404A) and therefore different compressors are required:

- R744 has a significantly higher cooling capacity, so smaller displacement compressors are used;
- R1234ze has a lower cooling capacity than R404A or R134a, therefore a larger compressor displacement is required – these are not yet readily available. Also R1234ze is unlikely to be suitable for LT applications as the system will run on a vacuum on the low side;
- The cooling capacity of R32 is similar to R410A.

Each of the refrigerant types listed above has challenges associated with their use, as shown overleaf. They are not suitable to replace refrigerant in existing systems.

Refrigerant type	System design	System service	Application considerations for end users
Flammable (HCs, R32, HFOs)	Systems are designed to prevent ignition in the event of a leak. This may require Ex rated electrical devices which are widely available and / or constant ventilation.	Well ventilated area free from sources of ignition is required for service. Special recovery machines are required. There is good availability of contractors and engineers experienced / trained in HC safe handling and this knowledge and skill is easily transferrable for HFOs and R32.	Maximum charge sizes apply. Some restrictions on location of electrical devices adjacent to systems may apply. Some restrictions on service may apply (e.g. out of hours service may be necessary).
R744 (CO_2)	Systems are trans critical for some of the time unless R744 is used in cascade or as a pumped secondary fluid. Systems are designed to safely contain the higher operating and standstill pressures (the maximum high side pressure is typically 90 bar g, and the standstill pressure in a 20^{O}C ambient is 56 bar g).	Refrigerant is vented not recovered. Most service providers working on large retail systems have R744 experience, but very few service providers for small commercial equipment have knowledge of R744 service or trained service technicians. Service equipment is available.	Some restrictions on service may apply (e.g. out of hours service may be necessary).

The recommended refrigerants below have been selected primarily because they are future proof but also because:

- They are already used and understood;
- Design expertise and components are available;
- Standards are in place regarding system design and application;
- The service sector can work with them;
- Performance is acceptable.

Application (new systems only)	Recommended Refrigerant
Integral refrigeration systems	R290
Commercial / condensing units refrigeration systems	R744
Large commercial / central plant refrigeration systems	R744
Chillers	R290
Split air conditioning	R32
VRV / VRF systems	R32

Due diligence is essential to ensure that the systems are designed in accordance with the relevant standard.

Replacing R404A in Existing Systems

For existing systems there are many mid range GWP R404A replacement refrigerants and those which are commercial available are listed below. It is important to understand the effect the replacement refrigerant will have on operating conditions and performance, so this information is included below.

Refrigerant	Type	GWP	Pressure at 55°C, bar g (bubble)	Ref. capacity relative to R404A, %	COP relative to R404A, %	Discharge temp relative to R404A	Temp glide, K
R407A	HFC blend	2107	24.9	95 HT	105 HT	+15K	5
R407F		1825	26.2	100 HT	105 HT	+23K	4
R448A	HFC / HFO blend	1387	25.5	94	Not known	+46K	4
R449A		1397	25.2	97 HT 102 LT	109 HT 115 LT	+46K	4
R452A		2140	25.9	98 HT 101 LT	102 HT / 110 LT	Not known	3

The pressure of R404A at 55°C is 24.8 bar g so all the available alternatives operate at a slightly higher pressure.

The capacity and COP comparisons are approximate. Actual values depend on operating conditions, compressor technology and heat exchanger design.

A conversion procedure is provided in EN 378-4:2016 clause 5.4 and this should be followed (although in most cases a lubricant change will not be possible or necessary). In addition, the following important points should be noted:

- At this time only R404A systems should be converted. R134a systems do not need conversion yet. There is no appropriate replacement for R410A.
- Flammable refrigerants (i.e. those with safety classification A2L and A3) must never be used.
- Check that the replacement refrigerant is approved by the equipment manufacturer.
- Only systems requiring replacement refrigerant due to leakage or service should be converted.
- The charge size of the replacement refrigerant should be accurately calculated and charged into the system – it will differ from the R404A charge amount.
- The evaporator superheat should be checked and expansion valves adjusted as necessary to provide 5K superheat:
    - For blends this is evaporator exit temperature – saturated liquid (bubble) temperature.
- The recovered refrigerant should be disposed of correctly – i.e. sent back to the refrigerant supplier for recycling. It should not be mixed with other refrigerants.
- Ensure condensers are clean and carry out other routine maintenance.

Abbreviations

Term	Definition
GWP	Global warming potential. Figures quoted are from EN 378:2016 (Refrigeration systems and heat pump – safety and environmental requirements)
HFC	A synthetic halocarbon containing only hydrogen, fluorine and carbon
HFO	A HFC but where the carbon has a double bond. These have lower GWPs than HFCs but are flammable
HC	A naturally occurring hydrocarbon containing only hydrogen and carbon
A1	A refrigerant with toxicity class A (low toxicity) and flammability class 1 (non flammable)
A2L	A refrigerant with toxicity class A (low toxicity) and flammability class 2L (lower flammability)
A3	A refrigerant with toxicity class A (low toxicity) and flammability class 3 (flammable)
COP	Coefficient of performance, a measure of the energy efficiency of a system: Refrigeration capacity / power input

For Further Information

The following website provide useful information:

www.vectisrefrigeration.com
www.coolconcerns.co.uk
www.realalternatives.eu for information about leak reduction and alternative refrigerants
www.gluckmanconsulting.com/f-gas-information-sheets for information about the F Gas regulation

Vectis Refrigeration Ltd provides service for HFC, HC, A2L and R744 systems. We can help with the development of your refrigerant strategy.