EU F-Gas Regulation Guidance

Information Sheet 29: Low GWP Alternatives

Target audience for this Information Sheet

This information sheet is aimed at organisations that may be affected by the 2014 EU F-Gas Regulation. This includes end users, maintenance contractors and equipment manufacturers. It is also of relevance to F-Gas producers, importers and exporters.

1. Background

This guidance is for organisations affected by the 2014 EU F-Gas Regulation (517/2014). The F-Gas Regulation creates controls on the use and emission of fluorinated greenhouse gases (F-Gases) including HFCs, PFCs and SF_6. The 2014 EU F-Gas Regulation replaces the 2006 Regulation, strengthening all of the 2006 requirements and introducing a number of important new measures.

The 2014 F-Gas Regulation includes a significant phase down in the supply of HFCs to the EU market – by 2030 there will be a 79% cut in supply[1]. The phase down will force end-users of HFCs to find alternatives that have a much lower global warming impact. This Information Sheet provides guidance for HFC users about the use of low global warming potential (GWP) alternatives. In Sections 2 to 5 we provide general background to the selection of low GWP alternatives and in Sections 6 to 17 we give specific details for different market sectors.

A wide range of further guidance is available for other aspects of the EU F-Gas Regulation – see Information Sheet 30 for a full list and a glossary of terms.

2. GWPs of HFCs in current use

The global warming potential (GWP) of a fluid is a measure of its contribution to global warming compared to the most common greenhouse gas, carbon dioxide (CO_2). The GWP values used in the 2014 F-Gas Regulation are based on the UN IPCC's 4th Assessment Report, as listed in Annex I of the Regulation. The GWP of CO_2 is 1. The GWPs of common HFCs in current use are between 750 and 4,000. The most widely used HFCs in 2012 are shown in Table 1. It is the very high GWPs shown in Table 1 that make HFCs so potentially damaging to the environment.

The HFC phase down is based on "GWP-weighted" amounts of HFCs. It is interesting to note that the average GWP of all the HFCs used in 2012 was approximately 2,000. To achieve a 79% reduction in GWP-weighted sales over the next 15 years, the average GWP of HFCs and their alternatives sold in 2030 will need to fall to around 400[2]. This will be achieved by:

a) Using non-HFC alternatives with ultra-low GWPs that are not part of the HFC phase down

b) Using new HFC products with much lower GWPs than those currently used.

[1] See Information Sheet 28 for details of the phase down process

[2] This assumes that the actual mass of fluids sold will remain approximately constant

Table 1: GWPs of HFCs widely used in the EU, 2012

HFC	GWP	Example Applications
HFC 404A	3,922	Supermarket and industrial refrigeration
HFC 227ea	3,220	Fire protection systems
HFC 410A	2,088	Air-conditioning
HFC 407C	1,774	Air-conditioning
HFC 134a	1,430	Refrigeration, air-conditioning, foams, aerosols
HFC 365mfc	794	Foams
Average, all HFCs sold	2,000	

3. Why are HFCs so widely used?

It is useful to note that HFCs are in widespread use because they have a number of properties that are well suited to their end use applications. In particular, the fact that the commonly used HFCs are non-flammable and non-toxic makes them easy to use.

It is important to recognise that the physical properties required vary because the range of end uses is so broad. HFCs are used for many applications including refrigerants, foam blowing agents, aerosol propellants and solvents. HFCs are well suited to this wide range of end user requirements as they form a large family of fluids providing a wide range of different physical properties.

4. Fluid properties that affect selection of alternatives

The process of selecting an alternative fluid is complex and must take into account many different properties. Some of the most important are:

a) Basic suitability to the relevant application (e.g. as a refrigerant, foam blowing agent etc.)
b) Impact on energy efficiency (especially for refrigerants and foam blowing agents)
c) Flammability
d) Toxicity
e) Suitable operating pressure
f) Good materials compatibility (e.g. with metals, flexible seals, lubricants)
g) Reasonable cost.

As a general rule, HFCs used in current applications have a better set of properties than the available alternatives – if the alternatives were better, then market forces would lead to their adoption. This is illustrated by the fact that in some markets there has already been widespread voluntary uptake of low-GWP alternatives where there has been a good commercial driver (e.g. hydrocarbons used in domestic refrigerators, in aerosols for personal / domestic products and in certain types of polyurethane foam).

The HFC phase down will force a move to lower GWP alternatives. In many cases end users will need to adapt to the use a fluid with slightly less favourable properties (e.g. use of a flammable fluid in place of a non-flammable HFC). It is expected that, for particular uses, these difficulties will be overcome as the fluid and equipment suppliers develop new products and codes for their safe operation. It is likely that HFCs will get more expensive as the phase down restricts supply – this will create a better commercial case to use alternatives, which currently may be more expensive to use.

5. Overview of Available Alternatives

Table 2 summarises some of the alternatives under consideration in 2014. The GWP bands used in Table 2 are somewhat arbitrary, but show the GWP options available. It is worth noting that there are no alternatives currently being proposed with GWPs in the 10 to 140 range.

Ideally there should be maximum use of ultra-low GWP alternatives. There are a number of such fluids available as shown in Table 2, although they all have safety and practicality issues. Ammonia, hydrocarbons (HCs) and CO_2 have all been available for many years and are increasing in market share in some applications.

HFOs (hydro-fluoro-olefins) are newly introduced fluids. Like HFCs they consist of carbon, fluorine and hydrogen. A key difference is that they are unsaturated molecules – this means they have a double bond between 2 carbon atoms. This gives them much lower GWPs than HFCs. However, most HFOs have a small degree of flammability (referred to as "mildly flammable") which makes them more difficult to use than non-flammable HFCs. HFOs were first introduced for commercial use in around 2013 and there should be growing commercial availability from 2015.

A number of HFO/HFC blends are also under development. These are being formulated to provide properties similar to current HFCs but with much lower GWPs. Mildly flammable HFO/HFC blends are available with GWPs between around 140 and 700. To create non-flammable blends the GWPs are higher, in the 600 to 1,400 range.

Table 2: Examples of Low GWP HFC Alternatives

GWP Band	Alternative	GWP	Comments
Ultra-low (0 – 10)	Ammonia	0	Toxic and mildly flammable. Good option for large refrigeration applications
	Hydrocarbons (HCs)	3 to 5	Highly flammable. Already used in aerosols, foams and small refrigeration systems.
	CO_2	1	High operating pressure (for refrigeration). Already used in foam, fire protection and refrigeration.
	HFOs	1 to 9	New family of fluids. Most are mildly flammable.
Moderate (140 – 1,400)	HFC 32	675	Mildly flammable. Already being used for small air-conditioning systems.
	HFO / HFC blends	140 to 700	Mildly flammable. Various blends being proposed, but not fully commercialised yet.
	HFO / HFC blends	600 to 1,400	Non-flammable blends under development.
High (1,400 – 2,200)	HFC 134a	1,430	Various HFCs in this GWP band will be useful short-term alternatives for very high GWP refrigerants such as HFC 404A – but in long term other alternatives will be needed.
	HFC 407F	1,825	
	HFC 407A	2,107	

6. Energy Efficiency is Crucial

When purchasing a new refrigeration, air-conditioning or heat pump system or when selecting a suitable insulation foam it is important to maximise the energy efficiency. During the life cycle of products of this sort it is the energy related CO_2 emissions that dominate the overall greenhouse gas emissions. It is counter-productive, from an environmental perspective, to use an ultra-low GWP alternative but have to sacrifice energy efficiency. Always try to ensure that the low GWP alternative that you select has equal (or preferably better) energy efficiency to the best high GWP option available on the market.

7. Domestic Refrigeration – Low GWP Alternatives

After the phase out of CFCs in 1995 the domestic refrigeration market used HFC 134a as the main alternative. However, from around 2000, hydrocarbons (HCs) were introduced and they are currently the dominant refrigerant in this market. With refrigerant charges of under 0.15 kg the flammability issues related to use of HCs have been overcome.

A small proportion of large refrigerators and freezers, particularly imported models, still use HFC 134a. Under the 2014 F-Gas Regulation the use of any HFC with a GWP above 150 will be banned in this market from January 2015. Two alternatives are likely to be used:

a) Where possible, HCs will be used as these are well established in this market.

b) If flammability issues are especially important (e.g. a very large refrigerator with a charge above 0.15 kg) then HFOs may be adopted.

8. Commercial Refrigeration – Low GWP Alternatives

The commercial refrigeration market makes use of 3 main types of system:

a) Small hermetically sealed systems (refrigerant charge typically 0.1 to 0.5 kg)

b) Condensing units (split systems with refrigerant charge typically 2 to 10 kg)

c) Central pack systems (large systems with refrigerant charge typically 50 to 150 kg)

It is also important to note that this market uses 2 distinct temperature levels for chilled and for frozen products – that can affect the best refrigerant selection.

Small Hermetic Systems

Where the refrigerant charge is below 0.15 kg, HCs can be used – a number of commercial hermetic units are already available with propane refrigerant.

CO_2 is an option for larger systems – it is already in use for some large bottle coolers.

It is likely that HFOs, including both 1234yf and 1234ze, will be used for commercial hermetic systems. The mild flammability of these refrigerants should not be an issue for such small systems.

Commercial Condensing Units

Currently many condensing units use HFC 404A – which has a very high GWP of 3,922. Use of HFC 404A in all new equipment should be avoided with immediate effect.

As an interim, refrigerants such as HFC 407A or HFC 407F can be used in new condensing units for frozen applications. These have a GWP that is only half that of HFC 404A. For chilled foods, HFC 134a offers an even lower GWP.

Various much lower GWP options are becoming available from 2014. CO_2 has been trialled in some convenience stores. HCs will not be suitable as the flammability risk is too high for such large refrigerant charges.

Some of the new HFO / HFC blends can be considered. For **chill applications** R450A has a GWP of 601 and is non-flammable. If a mildly flammable refrigerant is acceptable, then HFO 1234yf or 1234ze can be considered – these have GWPs below 10. For **frozen food applications** the non-flammable options (e.g. R448A and R449A) have GWPs just under 1400. Mildly flammable blends such as Opteon XL40 and Solstice L40 are under development – these have GWPs of under 300.

Commercial Central Pack Systems

Most central pack systems use HFC 404A – which has a very high GWP of 3,922. Use of HFC 404A in all new equipment should be avoided with immediate effect.

As an interim, refrigerants such as HFC 407A, HFC 407F, HFC 448A and HFC 449A can be used in new pack systems for frozen applications. These have a GWP that is only half that of HFC 404A. For chilled foods, HFC 134a offers an even lower GWP. However, there have already been significant developments of much lower GWP alternatives, so these interim options can be avoided.

There are now several hundred supermarket pack systems operating with CO_2. This is likely to become a widely used refrigerant for all new central pack systems.

Some supermarkets are using small hermetic HC systems together with a chilled water system to remove the condenser heat from each hermetic system. As the HC charge of each system can be very small, the flammability risk is manageable.

It is likely that mildly flammable HFOs and HFO/HFC blends will also be considered for central pack systems in the future.

9. Industrial Refrigeration – Low GWP Alternatives

The industrial refrigeration market is especially broad in scope, both in terms of system size and the temperature level required. Three main types of equipment are used:

a) Large central systems serving several major loads e.g. used for blast freezing and large cold stores. These systems often contain several tonnes of refrigerant.

b) Large chiller systems, cooling a secondary refrigerant such as glycol which is distributed to a number of loads. Chillers often contain several hundred kg of refrigerant.

c) Smaller dedicated plants, each serving a single cooling load. These usually contain less than 100 kg of refrigerant.

The majority of industrial plants operate at similar temperature levels to commercial systems e.g. to produce chilled or frozen food products. However, some industrial plants operate at much lower temperatures than commercial systems e.g. well below -100^{o}C.

Large Central Industrial Systems

Large central systems are well suited to ultra-low GWP systems. Ammonia is already widely used, especially in food manufacturing, breweries and cold stores. All purchasers of large industrial plant with an evaporating temperature above -50^{0}C should strongly consider using ammonia.

CO_2 is also an interesting candidate for industrial systems, especially if heat recovery (e.g. for producing process hot water) is a useful secondary objective.

Large central systems below -50^{o}C are more problematic as ammonia and CO_2 are unsuitable below this temperature. It may be necessary to use an HFC in cascade with ammonia. The very low temperatures required to produce liquid oxygen and liquid nitrogen (around -200^{o}C) are created using a very sophisticated form of air cycle refrigeration system.

Large Industrial Chiller Systems

Industrial chillers are also well suited to ultra-low GWP refrigerants. Ammonia is already widely used (e.g. in breweries). New HFO refrigerants including HFO 1234ze and HFO 1233zd will become available for large centrifugal chillers.

Small Dedicated Industrial Systems

These will be the most problematic type of equipment to find a suitable ultra-low GWP refrigerant. Most existing plants in this category use HFCs such as HFC 404A, HFC 407C and HFC 134a.

It is worth considering ammonia, although many plants in this category are too small to make ammonia cost effective. CO_2 is also an important new option – relatively small CO_2 plants are being used in supermarkets and this technology may be transferable to small industrial systems.

As with commercial refrigeration systems, a key question is whether mild flammability is an issue. In many industrial plants flammability can be managed, by careful compliance with well-established safe codes of practice for design, maintenance and operation.

If mild flammability is acceptable then a range of pure HFO or HFO / HFC blends may be applicable. HFOs 1234yf and 1234ze have properties similar to HFC 134a and have ultra-low GWP (4 and 7 respectively). These could be suitable for medium temperature and high temperature systems (e.g. with evaporating temperatures above -10^{o}C. Some new mildly flammable HFO / HFC blends are being developed with properties similar to HFC 404A, with GWPs below 300 (e.g. XL40 and L40). These could be suitable for lower temperature applications, down to around -50^{o}C.

If a non-flammable refrigerant is required then CO_2 is the only ultra-low GWP option. For medium and high temperature applications HFO/HFC blends such as R450A and R513A may be suitable – these have GWPs around 600. For lower temperatures it may be necessary to use blends such as R448A and R449A – these have GWPs around 1400.

As discussed above for large central systems, very low temperature plants (below -50^{o}C) are more difficult and may require use of an HFC.

10. Transport Refrigeration – Low GWP Alternatives

Most refrigerated trucks and trailers and refrigerated containers use HFC 404A. They require a non-flammable refrigerant (e.g. due to rules travelling through certain tunnels) and the flexibility to provide chilled or frozen temperature levels. There are rigorous testing rules (through ATP

Regulations) that make development of systems with new refrigerants more difficult in this sector than some other refrigeration sectors.

CO_2 is being trialled by some equipment manufacturers and may become the dominant replacement for HFC 404A. Currently, various other non-flammable options are being considered including R452A (GWP 2,140), R448A and R449A (GWPs around 1,400) and R407F (GWP 1,825).

For smaller systems (e.g. in delivery vans) a mildly flammable option may be acceptable. Pure HFOs and blends such as DR7and L40 (GWP below 300) are being trialled. Non-flammable options such as R407F are also being trialled.

11. DX Air-Conditioning – Low GWP Alternatives

DX (direct expansion) air-conditioning includes:

a) Small single splits, typically with refrigerant charge in the 1 kg to 3 kg range
b) Larger single and multi-splits with refrigerant charge in the 4 kg to 15 kg range
c) VRV systems with refrigerant charge in the 15 kg to 30 kg range
d) Packaged roof-top systems with refrigerant charge in the 15 kg to 30 kg range

Currently HFC 410A (GWP 2,088) is the dominant refrigerant for all these categories. Older systems often used HFC 407C.

Hydrocarbons have been proposed for small splits, although the flammability risk is considerable. HCs may be acceptable for very small splits (e.g. with a refrigerant charge below 1 kg) but are unlikely to be considered safe for larger charges.

CO_2 has also been trialled, but it is very difficult to achieve high enough energy efficiency, especially as air-conditioning equipment needs to run in hot weather, when CO_2 is least efficient.

Pure HFOs are possible where mild flammability is acceptable, although systems would require a much bigger compressor than those used with HFC 410A, which could add a significant extra cost.

A good candidate for a mildly flammable refrigerant is HFC 32 (GWP 675). This is already in widespread use in the Far East and was being sold commercially in Europe in 2014. HFC 32 systems have the potential to be more energy efficient than HFC 410A. For small splits a mildly flammable refrigerant will be acceptable in many circumstances. However, for larger systems (e.g. VRV) there is much work to be done to prove the safety of refrigerants like HFC 32 and also safety codes may need to be updated. Other mildly flammable options are becoming available including R447A (GWP 582). Wherever mildly flammable gases are used, all relevant safety codes must be followed.

If a non-flammable refrigerant is required there are no easy choices at present. HFO blends with properties similar to HFC 134a are available with a GWP around 600, but these may not produce the same energy efficiency as HFC 410A.

12. Air-Conditioning Chillers – Low GWP Alternatives

Currently most small chillers use HFC 410A and large chillers use HFC 134a. Air-conditioning chillers are usually located in a plant room or in an enclosure that is out of doors, hence in most situations a mildly flammable refrigerant will be acceptable (note, this may not be the case in certain basement locations).

HFO 1234ze is being trialled in a range of chiller sizes and could become an ultra-low GWP option for most chillers. Also, HFO 1233zd is being considered for large chillers – it is a low pressure refrigerant and can be very energy efficient. For small chillers HFC 32 or HFC 447A may be considered.

13. Mobile Air-Conditioning – Low GWP Alternatives

HFC 134a is the refrigerant used worldwide for MACs in cars and other small vehicles. Other refrigerants such as HFC 410A may be used in larger systems in buses and trains.

For small MACs it is likely that HFO 1234yf will become the dominant refrigerant. It is mildly flammable, but most car manufacturers have been satisfied by the safety trials and are launching models with HFO 1234yf.

HFO 1234yf will also be acceptable for some larger systems. However, if a non-flammable refrigerant is required there are no obvious alternatives to HFC 410A. See comments above for larger DX stationary air-conditioning.

14. Technical Aerosols – Low GWP Alternatives

Under the 2006 Regulation the use of HFCs in two categories of aerosol was banned. For one component foam most of the market switched to flammable propellants (such as hydrocarbons) as it was shown that they were safe to use. For novelty aerosols most of the market switched to HFO 1234ze, as a non-flammable propellant was required.

Most technical aerosols use HFC 134a as a propellant. HFO 1234ze looks to be a suitable candidate for most applications.

15. Foams – Low GWP Alternatives

Extruded polystyrene foam (XPS) is currently manufactured using either HFC 134a or CO_2. For some types of XPS foam CO_2 is not considered suitable. HFO 1234ze has been successfully trialled for XPS and in 2014 was in commercial production in some premium foam products.

Polyurethane foam (PU) and similar foams (polyisocyanurate and phenolic) are manufactured using hydrocarbons (if a highly flammable blowing agent is acceptable) or HFC 365mfc or HFC 245fa. The use of a number of new ultra-low GWP HFOs (1233zd, 1336mzz and 1233xf) is being trialled.

16. Fire Protection – Low GWP Alternatives

In the UK HFC 227ea is the dominant HFC in current use. A fluoro-ketone (FK 5-1-12) with ultra-low GWP has been available for some years and can be used in many applications that might consider HFC 227ea.

17. Solvents – Low GWP Alternatives

HFC 4310mee and HFC 365mfc have had some minor use as solvents, although their market is not widespread. New HFO products, including HFO 1233zd are undergoing promising trials.

18. Low GWP Alternatives – Summary of Market Sector Trends

Market Sector	Equipment Type	Current HFC			Alternatives			Comments
		Name	GWP	Safety	Name	GWP	Safety	
Domestic Refrigeration	Refrigerators / freezers	134a	1,430	A1	HCs 1234yf	3 to 5 4	A3 A2L	HCs already dominant in domestic refrigerators. HFCs with GWP>150 banned from January 2015
Commercial refrigeration	Small hermetic	404A 134a	3,922 1,430	A1 A1	HCs CO_2 1234yf 1234ze	3 to 5 1 4 7	A3 A1 A2L A2L	HCs suited to small systems (<0.15 kg) and already used in many systems. CO_2 has been trialled in large bottle coolers. HFOs 1234yf and 1234ze may be well suited to chill applications requiring large refrigerant charge.
	Condensing units	404A 134a	3,922 1,430	A1 A1	407A 407F 134a 450A 513A 448A 449A XL40 L40 CO_2	2,107 1,825 1,430 601 631 1,386 1,397 246 285 1	A1 A1 A1 A1 A1 A1 A1 A2L A2L A1	Alternative to 404A, frozen Alternative to 404A, frozen Alternative to 404A, chill Alternative to 134a or 404A, chill Alternative to 134a or 404A, chill Alternative to 404A, frozen Alternative to 404A, frozen Alternative to 134a or 404A, frozen or chill Alternative to 134a or 404A, frozen or chill CO_2 operates at very high pressure
	Central pack systems	404A 134a	3,922 1,430	A1 A1	See alternatives for condensing units			Due to impact of Service Ban (which bans maintenance with virgin HFC 404A from 2020), 404A must be avoided in new systems with immediate effect. CO_2 may become the dominant refrigerant in this market – there are already several hundred systems operating in UK supermarkets.

Safety classification: A = non-toxic B = toxic 1 = non-flammable 2L = mildly flammable 2 = flammable 3 = highly flammable

Market Sector	Equipment Type	Current HFC			Alternatives			Comments
		Name	GWP	Safety	Name	GWP	Safety	
Industrial Refrigeration	DX systems	404A	3,922	A1	407A	2,107	A1	Alternative to 404A, low temperature (LT)
		407C	1,774	A1	407F	1,825	A1	Alternative to 404A, LT
		22	1,810	A1	134a	1,430	A1	Alternative to 404A, medium temperature (MT)
		134a	1,430	A1	450A	601	A1	Alternative to 134a or 404A, MT
					513A	631	A1	Alternative to 134a or 404A, MT
					448A	1,386	A1	Alternative to 404A, LT
					449A	1,397	A1	Alternative to 404A, LT
					XL40	246	A2L	Alternative to 134a or 404A, LT and MT
					L40	285	A2L	Alternative to 134a or 404A, LT and MT
					CO_2	1	A1	CO_2 operates at very high pressure, LT and MT
	Large pumped systems	22 404A Ammonia	1,810 3,922 0	A1 A1 B2	Ammonia CO_2	0 1	B2 A1	Ammonia should be considered for large industrial applications. It is already widely used in food and drink sectors. CO_2 may also be applicable to large industrial systems.
	Industrial chillers	134a	1,430	A1	Ammonia	0	B2	Ammonia is well established in this market
		Ammonia	0	B2	1234ze	7	A2L	1234ze can be used in place of 134a
					1233zd	4	A1	1233zd can be used for low pressure chillers
Transport refrigeration	Trucks and trailers	404A	3,922	A1	CO_2 452A 407F 448A 449A	1 2,140 1,825 1,386 1,397	A1 A1 A1 A1 A1	Not many alternatives yet on the market. Road transport will probably require an A1 refrigerant (non-flammable). CO_2 is being trialled and may become dominant. Currently the other options all have a fairly high GWP
	Small vans	404A	3,922	A1	For 404A, see trucks / trailers			Not many options yet tested
		134a	1,430	A1	450A	601	A1	

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Market Sector	Equipment Type	Current HFC			Alternatives			Comments
		Name	GWP	Safety	Name	GWP	Safety	
DX air-conditioning	Single splits	410A 407C	2,088 1,774	A1 A1	32 446A 447A XL41	675 460 582 466	A2L A2L A2L A2L	HFC 32 might dominate small single split market. Various HFO/HFC blends with GWPs in the 400 to 600 range also being developed (all A2L)
	Multi split / VRV / packaged	410A 407C	2,088 1,774	A1 A1	?			Potentially difficult market if non-flammable refrigerant required. If A2L is safe, then single split alternatives possible. If A1 required, currently no option available.
Air-conditioning chillers	Small	410A	2,088	A1	32 1234ze 1233zd	675 7 4	A2L A2L A1	New HFO refrigerants are being trialled in a range of chiller sizes. 1234ze is used in chillers similar to current HFC 134a chillers. 1233zd is a low pressure refrigerant and is suited to large centrifugal chillers.
	Large	134a	1,430	A1				
Mobile air-conditioning	Cars and small vans	134a	1,430	A1	1234yf	4	A2L	HFC 134a will be banned via the MAC Directive
	Buses and trains	410A 134a	2,088 1,430	A1 A1	1234yf 450A 513A	4 601 631	A2L A1	For small sized systems HFO 1234yf may be suitable; its mild flammability must be considered. Large systems need A1 refrigerant – R450A or R513A may be suitable.
Aerosols	Technical aerosols	134a	1,430	A1	1234ze	7	A2L	1234ze has been successfully used in novelty aerosols
Foams	XPS	134a	1,430	A1	1234ze	7	A2L	1234ze in commercial use for some foam products
	PU and similar	245fa 365mfc	1,030 794	A1 A1	1233zd 1336mzz 1233xf	4 9 1	A2L A2L A2L	These HFOs are currently undergoing development and trials in a range of foam types.
Fire Protection	Flooding systems	227ea	3,220	A1	FK 5-1-12	1	A1	This fluoro-ketone (Novec 1230) has been used for a number of years and suits many HFC 227ea applications
Solvents	Industrial cleaning	4310mee	1,640	A1	HFOs NIK			Various HFOs are being trialled as solvents. Various "not-in-kind" alternatives available

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This Information Sheet has been prepared by Gluckman Consulting

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