



Institute of Refrigeration

Kelvin House, 76 Mill Lane Carshalton, Surrey SM5 2JR United Kingdom

Tel: +44 (0)20 8647 7033 Fax: +44 (0)20 8773 0165

Email: ior@ior.org.uk Website: www.ior.org.uk

Refrigerant Selection and System Design – the role of HFCs

The Institute of Refrigeration has compiled this guidance note to provide non-partisan advice on the effects of refrigerant choice and system design on the carbon footprint of a refrigerating system. Two effects are considered: the direct global warming potential of the refrigerant selected and the climate change effect of energy use by the system. The direct effect is measured as a “global warming potential” (GWP), usually against a reference of the potential of carbon dioxide over a 100 year period. Strategies for the reduction of carbon footprint include designing more efficient systems, minimising sources of leakage through the selection of more robust system components, reducing the quantity of refrigerant required to operate the system in order to mitigate the effect of a large leak and substituting refrigerants with a high GWP for those with a lower potential. These include ammonia, hydrocarbons, carbon dioxide, some low-GWP HFCs and hydrofluoroolefins (HFOs - a subset of hydrofluorocarbons with a very short atmospheric life).

There are many situations where the direct substitution of a hydrofluorocarbon (HFC) with a “natural” refrigerant is not reasonably practicable, either due to toxicity or flammability or high pressure. In such cases it would be possible to minimise HFC charge, or even eliminate it, by using a secondary fluid but this would tend to make the alternative system more expensive and less efficient. Rather than promoting a total ban of HFCs a more appropriate course would be to advocate a policy of “responsible use” of fluorocarbons in order to ensure that the climate effects of refrigerant emissions are minimised. A responsible refrigerant policy would place a high emphasis on the elimination of leak sources, the efficiency of the overall system and the life cycle cost of ownership. The government could make a significant step in this direction by introducing either regulation or incentives in these three areas to encourage significant improvement in the behaviour of manufacturers and users.

Low GWP hydrofluorocarbons (those with a global warming potential lower than 150) have been investigated, but none has yet been commercialised. Flammability is an issue in some cases, but there are prospects for creating useful blends combining low GWP HFCs with other compounds.

There is very little probability of HFOs being adopted for use in commercial or industrial refrigeration in the near future. R-1234 is unusual in this chemical family because it is of low flammability and low toxicity – other members of the same group are significantly more hazardous and are unsuitable for use as refrigerants. R-1234 is likely to be commercialised in two isomers: R-1234yf in MACs and R-1234ze in foam blowing. However in both cases the flammability of the substance is a barrier to acceptance (they would be classed as “A2” (mildly flammable) under the current classification rules. The difference between them is in the pressure-temperature characteristic, which makes the former more suited to MAC applications. At present there are no firm details of any other HFO or HFC refrigerants to meet requirements of commercial or industrial refrigeration. It seems highly unlikely that anything else will be commercialised in the next 5 years – particularly for the industrial market. It is also very unlikely that any other HFO will be suitable for use in these markets.

Energy Efficiency and Refrigerant Choice

Energy Efficiency of refrigeration systems is governed by the laws of physics and by practicality. Practicality embraces cost, cycle, legislative requirements, refrigerant choice and maintenance. Efficiency is not only dependent on choice of refrigerant but also on good design, selection of an appropriate system and good maintenance. Selection of the refrigerant demonstrating highest efficiency in an appropriate system is unlikely to improve system efficiency by more than 10% over efficiency of an optimized system using an HFC refrigerant. Some “natural” refrigerants such as carbon dioxide may result in reduced system efficiency unless they are integrated into a heat recovery system. At current levels of knowledge and expertise, practicality often leads to a choice of HFCs for good efficiency to be realistically achieved and maintained. In some applications, ammonia, carbon dioxide or hydrocarbons would be the preferred choice, but these refrigerants are not suitable for all applications. Good efficiency is vital to minimize emissions of greenhouse gases.

Additional Notes:

1. The practicality element will change as costs and design changes associated with HFC use evolve, and more components, experience and skills for ammonia, HCs and CO₂ are developed. This can be expected to reduce the applications that require HFCs, but not eliminate them in the foreseeable future.
2. Examples of highly practical HFC applications include split A/C systems, and in particular VRF combined cooling/heating systems.
3. Arbitrary constraints on how designers can specify systems (such as bans on the use of specific refrigerant fluids) should not be imposed. Such constraints could result in less efficient systems being installed and will not drive the industry along the path of lowest GHG emissions.
4. To obtain ‘good efficiency’ attention needs to be given to the following steps:
 - 1) Avoid refrigeration / reduce the cooling load. This is the most important first step – there is no point designing an efficient system if the load was unnecessary!
 - 2) Get the overall system design right (e.g. best cycle, splitting loads at different temperatures onto different suction levels, etc. etc)
 - 3) Get the control philosophy right (don’t forget the “off-design” operating conditions which are much more common than the peak “design point”, avoid head pressure control, avoid partly loaded compressors, avoid fixed speed auxiliaries like pumps and fans, etc. etc.)
 - 4) Optimise individual components for efficiency (e.g. how big should heat exchangers be, which compressor has best efficiency etc.)
 - 5) Operate and maintain the plant for best efficiency.

Mistakes in any of the above can change the efficiency of a plant by large amounts (e.g. 20% to 50%). Where does refrigerant selection fit in? It can either be thought of as a system design issue or a “component optimisation”. The impact of the refrigerant on efficiency is likely to be less than 5%, assuming all other design parameters are optimised.

The key message is that refrigerant choice matters, but many other design issues matter much more.

Issued by the Institute of Refrigeration Technical Committee. The IOR is an independent learned society and leading professional association for individuals working in the refrigeration and air conditioning sector.