



*The Voice of European Air-Conditioning, Refrigeration and Heat Pumps Contractors*

## INPUT PAPER

Brussels, 30<sup>th</sup> June 2009

### **RE: HFCs vs. alternatives in refrigeration & air-conditioning equipment**

#### **What is AREA?**

AREA ([www.area-eur.be](http://www.area-eur.be)) is the European organisation of air-conditioning, refrigeration and heat pumps contractors. Established in 1988, AREA voices the interests of 24 national members from 19 European countries, representing more than 9,000 companies across Europe (mainly small to medium sized enterprises), employing some 125,000 people and with an annual turnover approaching € 20 billion.

#### **Introduction**

There are numerous applications where alternatives to fluorinated refrigerants are both desirable from a political perspective and preferable from an environmental perspective. There are also, however, certain applications where it is beneficial to retain the use of fluorinated gases.

The objective of this paper is to provide technical data on the most adapted refrigerant from an energy point of view according to the specific type of refrigeration and air-conditioning (RAC) installation under consideration.

#### **Background**

The most obvious downside and most frequent objections to using HFCs are because of their global warming potential (GWP) relative to the alternatives commonly compared to them. The GWP varies depending on which HFC you look at. For the purposes of this discussion we will concentrate on the fluorinated refrigerant gas commonly known as R410a as this is the most common refrigerant in use in small to medium sized air conditioning systems used throughout most of the developed world. Older systems may still be running on HCFCs or even a few remaining CFC systems but, by and large, these systems are being decommissioned and replaced with those utilizing the newer HFC gas.

In some cases, as a more cost effective answer to phasing out HCFCs, certain fluorinated blends were used as retrofit drop in replacements. This often entailed simply recovering the old HCFC gas and charging the system with the alternative non-ozone depleting substance. This has had varied results across Europe due to several factors, including: the molecular structure of the drop in was often much smaller than the HCFC resulting in leakage where a standard pressure gas tightness test had passed since the molecular structure of the inert test gas (oxygen free nitrogen) is larger; efficiency drops have been well documented; lack of specialist technical knowledge among the

majority of the craftsman population in the field. These factors have often led to wholesale decommissioning of equipment that is replaced with new systems running on R410a.

On small systems, such as domestic refrigerators and freezers and point of sale display fridges, it has been demonstrated that hydrocarbon refrigerants (HCs) are very good in terms of energy efficiency compared with the old HCFCs, according to reports by the hydrocarbon industry. As the refrigerant circuit in these cases is very small and the volume of gas charged is very small, there is less of a problem with HCs here with the normal worrying flammability issues. If the circuit were to leak out its charge the resultant mixture in the air would probably not be in the high-risk category due to the overall volume of the room in which these are normally located.

On large systems, such as central plant systems serving an office block or a shopping mall, it is normal practice to have a remote plant area either on the roof or besides the building. In these cases again the flammability or toxicological issues are less of a risk to the occupants of the building. However, it is generally accepted that in these cases it is preferable to use either CO<sub>2</sub> or ammonia as the primary heat exchange refrigerant. They have documented efficiency benefits over both HFCs and HCs in large applications.

In between these scales of R&AC systems there is a huge range of cooling and heating equipment, which uses HFCs as the heat exchange fluid. These systems include room air conditioners installed in their thousands across the EU in homes, offices, shops, IT server rooms, specialist production areas and more. They include small single outlet units, known as “mini-splits”, and large heat recovery variable refrigerant flow (VRF) multiple outlet systems that allow buildings to fully utilize the diversity of cooling and heating needs in a way that helps minimise the energy consumption in a building, thus improving a building’s ratings under the Energy Performance of Buildings Directive.

### **Mitigation for use**

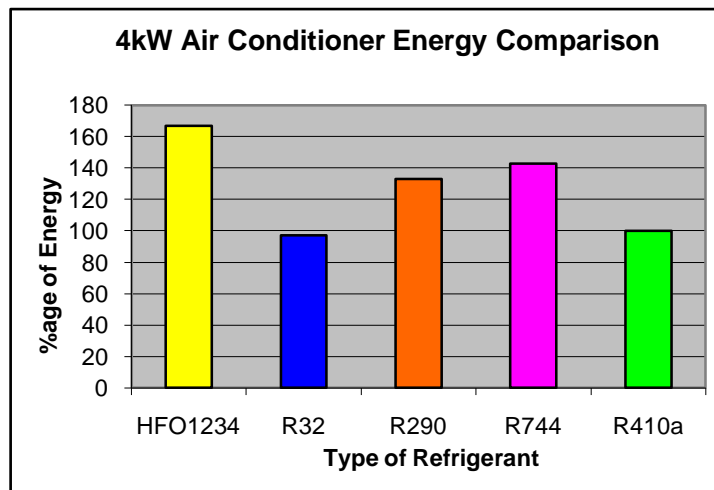
The GWP of substances is something that should be looked at carefully in relation to refrigerants and their suitability for use. EC842/2006 is designed to minimise fluorinated gas emissions from, amongst other uses, stationary refrigeration and air conditioning equipment. Assuming the various national Governments implement this Regulation properly and effectively under the scrutiny of the European Commission, there will be a massive reduction in greenhouse gas emissions (GHG) directly from R&AC systems.

Much of the reported leakage to date, and it has to be noted and remembered that these figures are largely made up or roughly guessed due to the fact that nobody has been able to collate accurate data, has come from the automotive industry – car air conditioning primarily. This is an unavoidable consequence of the nature of the design of an automotive AC compressor unless the system is operated constantly, or at least very frequently<sup>1</sup>. However, the car industry is already working towards phasing out HFC use for air conditioning over the next few years.

The majority of the balance of the leakage to date has tended to come from the supermarket industry, which has itself been actively working towards a voluntary phase out of HFCs towards large CO<sub>2</sub> plant. This means that the bulk of the HFCs left in use by the next decade will be in systems that come under the jurisdiction of EC842/2006. As the Regulation aims to minimise emissions by raising standards of working practice with a mutually recognised level of competence across the EU, it can be accepted that the remaining HFCs will, by and large, remain in the systems into which professional competent engineers charge them. The direct global warming effect of these gases is, therefore, zero. When the GWP of the substance is irrelevant we can concentrate on the more

important factors of efficiency and, therefore, CO<sub>2</sub> emissions from power stations – a far bigger contributor to GHG levels worldwide than stationary R&AC by a factor of around 80<sup>2</sup>.

In small to medium cooling duty applications, such as room air conditioners and localised process or comfort cooling applications, it has been demonstrated that HFCs are often the most energy efficient refrigerants to use compared with the alternatives. Comparisons of 2 sizes of room air conditioners with cooling duties of 4kW and 14kW respectively have been tested with various alternative refrigerants and compared to the standard R410a.

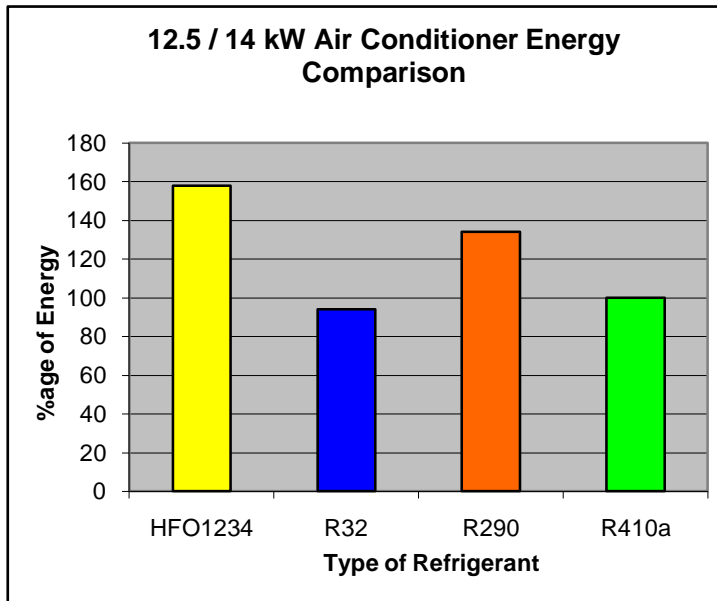


In this graph<sup>3</sup> we can see the results of the test on the smaller system, which would normally be installed as a local split system to control a comfortable environment in a domestic location or a small office space.

The column annotated as HFO1234 represents the new brand of fluorinated olenes under development by Honeywell. Although these are fluorinated gases they have a comparatively low GWP. They are also flammable substances though and

there have been safety concerns raised. It is thought that when these gases become commercially available they will be used in the automotive systems rather than cooling applications of this type. R290 is better known as propane and is a flammable HC. R744 is better known as carbon dioxide (CO<sub>2</sub>). R32 is a fluorinated gas that is normally used in refrigerant blends – indeed it is a component of R410a. Its high pressures make it unsuitable for general use as a standalone refrigerant in occupied spaces.

It is clear from the graph above that, compared to the CO<sub>2</sub>, HC and HFO gases here, R410a is a far more efficient heat exchange medium. Using R410a as the baseline we can see that the HC uses 33% more energy, the CO<sub>2</sub> uses 43% more energy and the HFO uses 67% more energy to achieve its cooling duty<sup>3</sup>. The two HFCs clearly will have a far smaller effect on the environment than the alternatives - due to the lower demand on power giving less indirect GHG emissions via the power stations.



In this graph<sup>3</sup> the same gases have been tested except CO<sub>2</sub>, which had proved to be problematic because of the high working pressure at these larger volumes of charge and component size for room air conditioner use.

Again it is clearly demonstrated that the HFCs are more efficient. The HC uses 34% more energy and the HFO 58% more energy than R410a. Again R32 is slightly better (by 6%) purely in terms of energy efficiency, but is not regarded as being suitable for direct expansion applications such as these due to the high operating pressure.

As with the smaller duty systems, the HFC clearly has an overall benefit to the environment through lower indirect GHG emissions.

As many of the domestic heat pumps being installed across the EU, which have now been accepted as genuine renewable technology for heating purposes, fall into the same range of heat exchanger compressor duty as the second of these examples it is fair to expect similar results to those given above<sup>4</sup>.

### SUMMARY

⇒ There are no easy answers to the question “which refrigerant is most efficient?”, as ***no refrigerant represents the ideal solution in all cases and for every equipment*** – each cooling application has to be looked at in its own merits and a professional choice must be made taking into account many more factors than simply GWP

⇒ In view of the Total Equivalent Warming Impact of greenhouse gases, ***energy efficiency is the most relevant criterion to assess the suitability of a refrigerant in R&AC systems;***

⇒ Applying this criterion to R&AC equipments according to their size reveals that:

- *On small systems*, HCs are more energy efficient
- *On large systems*, CO<sub>2</sub> or ammonia are more energy efficient
- *In between these scales*, each equipment should be analysed on a case by case basis. Existence technical evidence already shows that:
  - For room air-conditioners with cooling duties of 4kW, HFCs prove between 33% and 67% more energy efficient than alternatives
  - For room air-conditioners with cooling duties of 14kW, HFCs prove between 34% and 58% more energy efficient than alternatives. The renewable energy technology of heat pumps falls into the same range of heat exchanger compressor duty.

## Notes:

1. Automotive air conditioning (AC) uses compressors with open drive shaft seals similar to those used in static refrigeration systems 50 years ago. When operating, the shaft is sealed by the nature of the refrigerant oil keeping the gasket wetted. In many of the Northern countries within the EU there is little need for cooling other than during a few months of the year apart from the benefit of demisting windscreens quickly in colder months. As there is a consequence on fuel consumption levels during AC use many people simply switch their AC off for many months of the year. This results in the refrigerant oil dropping naturally to the lowest point in the system and the seal at the shaft leaks, thus resulting in a partial loss of refrigerant to atmosphere. This is not to be confused with the frequent catastrophic total loss that occurs when stone chips are thrown up at the front of a car and pierce or puncture the condenser coil, which is normally located immediately behind the front grille of a car.
2. HFCs account for approximately 1.5% of GHG emissions according to the figures used by environmental lobbying groups on this subject. As automotive AC is responsible for nearly 70% of this total and refrigeration applications are being voluntarily phased out on a large scale, it is fair to speculate that the emissions figure from SRAC applications will be less than 0.5% of the total GHG emissions worldwide. Compared to a GHG emissions rate from the world's power stations of approximately 40% of the world's total this equates to a multiplication factor of around 80.
3. Figures obtained from JRAIA (The Japan Refrigeration and Air Conditioning Industry Association) [LCCP calculations tests, 2008](#).
4. Manufacturers of split air conditioners have been producing reverse cycle heat pumps for many years based on a normal packaged air conditioning system and incorporating a reverse cycle valve that simply reverses the flow of refrigerant to turn a cooling system into a heating one. The efficiencies and COPs have been well documented elsewhere.