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OzonAction Kigali Fact Sheet 17

Refrigerant Trends in Mobile Air-Conditioning

UN environment

Background:

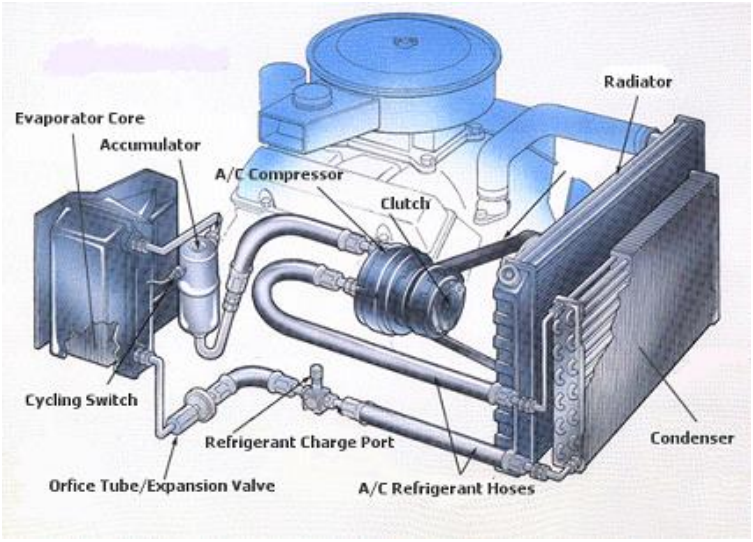
This market sector includes mobile air-conditioning (MAC) systems used to cool the driver and passengers in land transport including cars, vans, lorries, buses, agricultural vehicles and trains. Historically all car air-conditioning used the refrigerant CFC-12. This was completely phased-out during the 1990s in developing countries and around a decade later in developing countries and the global car market switched to HFC-134a, a refrigerant with a GWP of 1430. Larger vehicles such as buses and trains also use other HFC refrigerants such as R-407C (GWP 1774) and R-410A (GWP 2088).

During the last few years new ultra-low GWP alternatives have been introduced in some geographic regions in response to national and regional regulations. This Fact Sheet describes the progress being made towards the use of lower GWP refrigerants in the MAC sector.

Car Air-conditioning:

Passenger cars and other small vehicles such as vans and the cabs of lorries almost all use a very similar design of air-conditioning system. This utilises a compressor powered via a belt drive from the main engine, connected to an evaporator in the ventilation air inlet duct and a condenser located at the front of the car near the radiator. The main components are connected by flexible hoses. The system is assembled and charged on the main vehicle production line.

Some recent MAC designs use electrically driven compressors – these are a new requirement to ensure the function when the main engine is off (e.g. in hybrid vehicles) and for fully electric vehicles.



Car MAC systems contain between 0.4 kg and 0.8 kg of refrigerant. The annual demand for refrigerant in the MAC sector is split between refrigerant used in new cars and refrigerant used in the service sector to top-up systems that have leaked.

Historically car MAC systems suffered from high levels of leakage – it was common to re-charge the system with refrigerant on an annual basis. During the last 10 years there have been major design improvements, especially to the compressor shaft seal and to the materials used for flexible hoses. Modern MAC systems suffer from relatively low levels of leakage in normal use (although may suffer total refrigerant loss following a major car accident). It is now estimated that around 70% of annual refrigerant demand is for new cars and 30% for topping up existing systems.

Low GWP Refrigerant Options

Following the phase-out of CFCs in non-Article 5 countries the mid-1990s, all multinational car manufacturers switched from the use of CFC-12 to HFC-134a. Prior to 2012, all car MAC systems were being built using HFC-134a and in 2016 this was still the predominant refrigerant used in new car MAC systems.

The switch to a lower GWP refrigerant has been forced by legislation in some geographic regions. In particular, the 2006 EU “MAC Directive” required the use of a refrigerant with a GWP below 150, from 2013 for new models and from 2017 for all new vehicles sold in the EU. This legislation prompted a lot of work by MAC designers and car manufacturers to identify a suitable low GWP alternative to HFC-134a.

R-744 (CO_2, GWP 1) was originally the leading contender, although its properties required a major redesign of MAC systems (e.g. very high operating pressure and transcritical operation). There were considerable concerns about possible increase to capital cost and about energy efficiency.

In 2009 HFO-1234yf (GWP 4) was launched and it quickly became the more popular choice amongst car manufacturers as it has properties that closely match the properties of HFC-134a. A key concern about HFO-1234yf is that unlike HFC-134a and R-744 it is "mildly" flammable (safety class A2L). Car manufacturers have carried out extensive safety testing and the majority have concluded that HFO-1234yf can be safely used in car air-conditioning.

Cars using HFO-1234yf started to be introduced from 2013. From January 2017, all new cars in the EU were using HFO-1234yf and this refrigerant was also becoming used in other regions including the USA and Japan.

Legislation in various countries will force a switch to a low GWP refrigerant (e.g. Turkey from 2018, South Korea from 2020, USA and Canada from 2021 and Japan from 2022). This switch is likely to be achieved in these regions using HFO-1234yf and multinational car manufacturers are likely to standardise on use of a single refrigerant as they did in the 1990s when they switched to HFC-134a.

A few car manufacturers, especially in Germany, are still developing R-744 systems. A limited number of cars are being sold with R-744. It is not clear whether this will be a growing trend or whether the preference for a single global refrigerant for MACs will prevail.

The situation in Article 5 countries will initially depend on whether cars are imported or built locally. Countries that mainly import cars from major multi-national manufacturers are likely to make increasing use of HFO-1234yf as these manufacturers switch to a single global refrigerant. Large Article 5 countries with local manufacturing may decide to keep using HFC-134a as it is a lower cost refrigerant.

Bus and Train Air-conditioning:

Bus and train air-conditioning makes use of a number of different design configurations and uses a number of different HFC refrigerants. Larger MACs used in buses and trains are often located in a single unit containing all the system components. The unit is factory built and pre-charged with refrigerant. It is fitted by the vehicle constructor and is usually roof mounted.

The compressor is usually electrically driven with electricity from the main vehicle supply (e.g. from the track supply for an electric train or from a generator connected to the vehicle's main engine). Some units have a dedicated diesel engine to supply electricity or to directly drive the compressor. On some small bus and coach systems the compressor is located adjacent to the main vehicle engine and driven via a belt connection. The refrigerant charge on these large MAC systems is typically in the range of 2 to 20 kg.

As bus and train MAC systems have a much higher cooling capacity than car MACs (typically 5 to 10 times larger) they often utilise stationary air-conditioning refrigerants including R-410A (GWP 2088), R-407C (GWP 1774) and HCFC-22 (GWP 1810). There has been slower progress towards lower GWP alternatives because there is less regulatory pressure in relation to bus and train air-conditioning. However, under the Kigali Amendment, the phase-down of HFC usage will create a new policy driver.

A key issue regarding lower GWP alternatives will be the acceptability of a mildly flammable refrigerant. As the refrigerant charge is much higher than for car MACs, the safety issue is more complex. If A2L refrigerants are acceptable it is likely that HFC-32 (GWP 675) will be used in place of R-410A. HFO-1234yf (GWP 4) can also be considered. If a non-flammable refrigerant is required it will be possible to use R-513A or R-450A (both with GWPs around 600 and properties similar to HFC-134a). R-744 is also being trialled by some bus and train MAC manufacturers.