



The use of CO<sub>2</sub> as a refrigerant for air conditioning systems requires high operating pressures. These represent a risk for vehicles in the event of accidents and during maintenance – completely different to the situation with the new HFO-1234yf

## First-Class Air Conditioning

Safe and environmentally friendly: Independent tests confirm new refrigerant for air conditioning systems

**Since 2006, Europe has placed strict requirements on refrigerant for air conditioning systems. Therefore, two concepts in particular have been discussed since then. Carbon dioxide, i.e. R-744, and the new substance HFO-1234yf which, in contrast to CO<sub>2</sub>, only remains in the atmosphere for eleven days. In addition, an independent study has confirmed that, compared to the alternatives, this refrigerant, when used in mobile air conditioning systems, has the lowest risk and most clearly meets environmental and customer requirements.**

Car manufacturers supplying the European market are faced with a fundamental decision concerning the development of future air conditioning systems for new models. For the EU Directive on air conditioning systems in cars (2006/40/EC) dated 17 May 2006 (Mobile Air-Conditioning (MAC) Directive), places strict requirements on the refrigerants used. The reason is climate protection. The catalyst for this is the refrigerant R-134a, which has become a global standard, i.e. the substance that serves as a medium for cold production in refrigerators. This fluorocarbon (FC) was introduced to replace chlorofluorocarbons (CFCs), which damage the ozone layer. FCs such as R-134a protect the ozone layer but have a not insignificant potential to contribute to the greenhouse effect (Global Warming potential GWP). The GWP specifies the extent to which a substance, if it escapes into the atmosphere, contributes to climate change.

### MAC Directive: Strict regulations in the EU

Refrigerant from air conditioning systems, unlike the CO<sub>2</sub> produced by burning organic materials, is not blown into the atmosphere, but re-

mains in the system. Nevertheless, losses occur through leakages and these must be taken into account for climate protection. In terms of technology, mobile air conditioning systems (MAC) are particularly prone to leakages. For this reason, the MAC-Directive of the European Union was particularly strictly conceived: For mobile use, in the long term only refrigerants with a GWP <150 will be permitted. Together with its suppliers, the automotive industry has a great interest in finding standard solutions for the development of new vehicle models that correspond to the MAC Directive and can be implemented on a global scale. Two refrigerants are currently being discussed.

Firstly, there is the concept of using carbon dioxide (CO<sub>2</sub>, the technical refrigeration expression is R-744) as a refrigerant. Secondly, the chemical companies Honeywell and Du Pont have jointly developed a new substance which, on the basis of its performance and energy efficiency, was identified by the Society of Automotive Engineers International (SAE), as the best solution for the environment and consumers. This substance has the designation HFO-1234yf (tetrafluoropropene).

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### Crucial: The effect on the climate

As regards direct effects on the climate, both solutions are comparable. The current standard R-134a has a GWP of 1200, new limit value becomes 150; the HFO-1234yf has 4 and CO<sub>2</sub> the value 1. Although it should be borne in mind that according to the estimates of experts, CO<sub>2</sub> stays in the atmosphere for around 500 years, while HFO-1234yf, on the other hand, only remains in the atmosphere for 11 days.

The biggest advantage of the new substance is that it has similar physical properties to conventional R-134a, so that it can be introduced into existing systems without major modifications. Thus a conversion to the new, environmentally friendly substance is possible quickly, development costs are reduced.

When using CO<sub>2</sub> on the other hand, massive modifications have to be made. This gas works differently and less effectively. Higher operating pressures are required, for example. As a result, the air conditioning system requires more installation space in the automobile and the greater weight increases fuel consumption. Also exhibit high pressures in vehicles equipped with a CO<sub>2</sub> system, a risk in the event of accidents and during maintenance. With the use of CO<sub>2</sub> air conditioning systems will look very different to before.

Manufacturers and suppliers must also put more time and effort into developing these new air conditioning systems, which will of course also have an effect on the cost of new vehicles. Last but not least, it would not be possible to retrofit old vehicles with the new refrigerant.

First and foremost, for the evaluation of environmental friendliness, the direct effect of the coolant on the climate, caused by substances escaping into the atmosphere through leaks, is considered. In addition, there are also, however, indirect effects which must be calculated during the calculation of the actual impact on the environment. These include, for example, increased fuel consumption, refrigerants such as CO<sub>2</sub>. The higher fuel consumption generates further climate-damaging gases, which get into the atmosphere through the exhaust system. A sound decision in favor of one or other refrigerant requires a precise examination of all the environmentally relevant effects that occur.

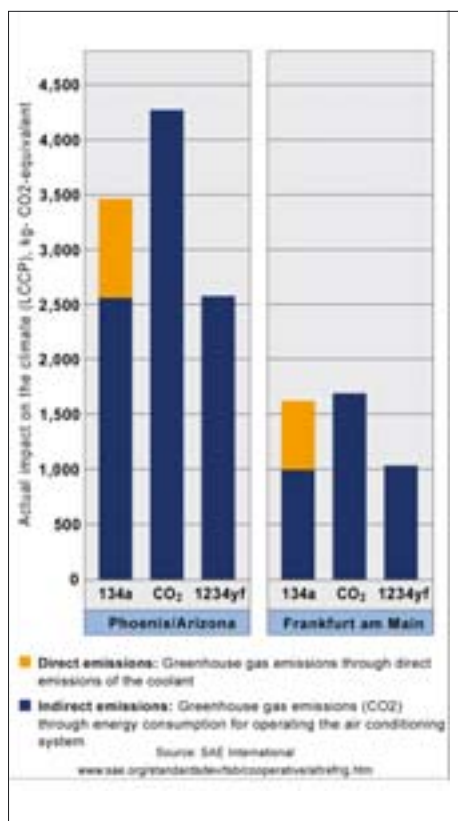
### Evaluation by the research program

SAE International has assumed this task. Since 2001, this association has implemented Cooperative Research Programs (Cooperative Research Programs CRP) to evaluate new, environmentally friendly coolants for use in air conditioning systems.

As part of the CRP 1234-1 and CRP 1234-2 programs introduced in 2007, the new HFO-1234yf was examined in relation to safety and performance. Under the management of international experts in this area from automotive manufacturers, Tier1 and Tier2 suppliers as well as independent test institutes, the performance in air conditioning systems, the material compatibility and the relative risks of HFO-1234yf were evaluated.

Among other things, the researchers used as a basis the results of the Life Cycle Climate Protection Analysis (LCCPA), an analysis of the climate relevant effects of a coolant for a mobile air conditioning system. This method was described under the designation "Green-MAC-LCCP" as standard SAE J2766 and recognized by 50 experts from industry, state and private organizations, state laboratories and universities throughout the world as suitable for the evaluation of the environmental friendliness

Emissions with greenhouse effect through the use of coolants



### SAE research program

Behind the SAE research program are automotive groups from

- Europe (PSA, Fiat, Renault, Jaguar, Land Rover),
- Asia (Toyota, Hyundai) and
- USA (General Motors, Ford, Chrysler).

Together these companies produce around 70 % of the new vehicles sold worldwide. Many distinguished independent test institutes have contributed to these results. These include

- National Institute for Study of Industrial Environments and Risks
- TNO Pharma (The Netherlands)
- DNV Klima Services (Japan)
- Research Laboratories (USA)
- Exponent Engineering and Scientific Consulting (USA)
- Gradient Corporation (USA)

of mobile air conditioning systems. It includes the manufacture, use and disposal of a coolant in the overall consideration.

### Result: HFO-1234yf best solution

The result of these studies is as follows:

For use in mobile air conditioning systems, in comparison to the alternatives examined, the refrigerant HFO-1234yf has the lowest risk and also most clearly meets environmental and customer requirements. The CCPA confirmed that with the use of CO<sub>2</sub> as a refrigerant, because of the increased fuel consumption for operating the air conditioning system, more greenhouse gases are released than with the use of HFO-1234yf.

The actual GWP value of the refrigerant only played a subordinate role here. Their performance and efficiency were critical. This was even the case for tests in moderate climate zones such as Frankfurt am Main. In the case of the desert temperatures in Phoenix/Arizona (USA), the difference was shown even more clearly to advantage. This data is important if the automotive industry is looking for a global standard to be used in all the world's climate zones.

Tests for toxicity and flammability did not show any appreciable risks. The SAE recommends HFO-1234yf as safe for use in automotive air conditioning systems.

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