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**Flammability of refrigerants and oil evaluated**

**Recent tests by Obrist Engineering assessed the performance of different refrigerants in case of a vehicle front end collision. While CO<sub>2</sub> would be safe at different temperature ranges, using the new HFO-1234yf will significantly increase the risk of fire, Obrist concludes.**

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To shed light into the performance of working fluids for Mobile Air Conditioning, Obrist Engineering assessed the risks associated with different refrigerants regarding their flammability. Using an air conditioning system from a Volkswagen Lupo, the company compared three refrigerants, R134a, R744 (CO<sub>2</sub>), and HFO-1234yf, under realistic conditions simulating a vehicle front end collision, where the mixture of refrigerant and oil would leak. Refrigerants were tested at different temperature ranges, 970° Celsius (C), 800°C, and 600°C. As lubrication medium PAG oil ND8 (135ml for all tests) was used, and a separate flammability test to the lubricant was also conducted (see video 6 below).

"A damaged refrigerant line or system component (due to a front end collision), results in a release of a refrigerant/oil mixture into the engine compartment. This in combination with oil circulating in the system leads to the release of a flammable mixture of refrigerant and oil onto hot engine parts" explains Martin Graz, Technical Director, conducting the tests at Obrist Engineering. "Test showed that HFO-1234yf in combination with PAG oil burns significantly. Such an initial fire from HFO-1234yf and oil can lead to a bigger fire involving other components in the engine compartment. On the other hand, tests showed that R744/oil mixture cannot be ignited. We therefore conclude that R744 is the safest solution for our future", Graz continues.

**R134a and CO<sub>2</sub>**

No flame propagation was observed during first tests with R134a, which established the baseline (see video 1 below). Obrist however noted that the mist of oil and refrigerant vapor could potentially be ignited. At the same temperature condition (970°C) with R744, the risk of mist ignition and the causing of a pilot fire can be reduced (video 2).

Obrist therefore concluded that R134 cannot be ignited during an accident simulation and under realistic operating conditions including circulating oil. R744 would behave similarly to R134a and the risk of ignition was judged to be lower than with R134a, therefore improving the system's safety level.

**HFO-1234yf**

For different testing conditions, Obrist observed the following results for this new refrigerant:

- At 970° C (video 3): The refrigerant oil mixture was ignited, leading to a quite significant flame propagation. The risk of a pilot fire is therefore increased significantly.
- At 800° C (video 4- simulating a hot turbo charger): Pilot fire was observed. The flame propagation and the flammability envelope led to a secondary fire in the engine compartment.
- At 600° C (video 5- simulating a hot exhaust manifold): the refrigerant oil mixture was also ignited. Even though the flammability envelope was reduced, the flame propagation was still significant, and was judged to be sufficient to cause a secondary fire (see movie five).



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- Pure refrigerant container with cigarette lighter (video 7): The refrigerant was ignited and flame propagation was observed. The person handling the test was equipped with an active carbon filter mask and fire protective gear to ensure safety due to the refrigerant's decomposition.



### Conclusions

Whereas R744 would increase an air conditioning systems' current safety level in case of a front end accident, using HFO-1234yf (2,3,3,3-Tetrafluoroprop-1-ene) reduces significantly today's safety level in terms of flammability, as it puts human life at risk, Obrist concludes.

Although the HFO-1234yf flammability level is judged to be slightly reduced when compared to R152a, Obrist judges necessary to introduce either an oil free circuit or a secondary loop for the front end heat exchanger to mitigate the risks associated to HFO-1234yf.








Obrist will investigate, in a next phase, side impact collisions during which refrigerant lines inside the passenger compartment are ruptured.

### More information





Files linked to the present article include: Obrist's original research paper (with a comprehensive description of the methodology followed), videos with all operating conditions, an image gallery (right-hand side), Material Safety Data Sheets for the refrigerants and the lubricant, and Certificate for refrigerant 1234yf.

 [Flammability Investigation of different Refrigerants - Obrist Engineering \(3.6 MB\)](#)




### Videos:

-  [View Video 1](#) - R134a - 970° Celsius
- 
-  [View Video 2](#) - CO<sub>2</sub> - 970° Celsius
- 
-  [View Video 3](#) - 1234yf - 970° Celsius
- 
-  [View Video 4](#) - 1234yf - 800° Celsius
- 
-  [View Video 5](#) - 1234yf - 600° Celsius
- 
-  [View Video 6](#) - PAG Oil Test
- 
-  [View Video 7](#) - 1234yf Canister Test
- 

### Refrigerants & Oil Material Safety Data Sheets:

-  [Refrigerant R744 \(21 KB\)](#)
-  [Refrigerant 1234yf \(22 KB\)](#)
-  [Refrigerant R134a \(22 KB\)](#)
-  [Oil ND8 \(328 KB\)](#)

### More information:

-  [Test Setup \(142 KB\)](#)
-  [Test Background \(12 KB\)](#)
-  [Delivery Note - Refrigerant 1234yf \(5 KB\)](#)

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