

February 2026 ASHRAE Journal Online Content

On the following pages is supplementary information for the following article in the February 2026 issue of ASHRAE Journal:

An Investigation of Flammability in Low-GWP Refrigerant Blends for Military Transport

By Claire Erin O'Malley; Robert Ferguson; Enrique Velazquez; Sydney Tanguay; Steven Son; Davide Ziviani, Ph.D., Member ASHRAE

Online Table 1 Selected Refrigerant Properties

Name	Chemical Formula	Flammability Classification	Minimum Ignition Energy (mJ)	Lower Flammability Limit (% in air)	Upper Flammability Limit (% in air)	Density
R-290 (Superior Energy Systems, 2019) ¹	C ₃ H ₈	A3	0.25 (Sadaghiani, et al. 2021) ⁵	2.20%	9.50%	516.1 kg/m ³ (32.21 lb/ft ³)
R-1336mzz(E) (Chemours, 2020) ²	C ₄ H ₂ F ₆	None	None	None	None	1310 kg/m ³ (81.78 lb/ft ³)
R-1234ze(E) (National Refrigerants, 2017) ³	C ₃ H ₂ F ₄	A2L	None	None	None	1293 kg/m ³ (80.72 lb/ft ³)
R-134a (National Refrigerants Inc) ⁴	CH ₂ FCF ₃	None	None	None	None	1102 kg/m ³ (86.79 lb/ft ³)

Online Table 2 Amount of refrigerant used in each test and amount of refrigerant in air.

Name	Amount Added	Percent of Refrigerant in Air
R-290	0.033 kg (0.073 lb.)	6.10%
R-1336mzz(E)	0.180 kg (0.397 lb.)	9.0%
R-1234ze(E)	0.135 kg (0.298 lb.)	9.0%
R-134a	0.115 kg (0.253 lb.)	9.0%

Online Table 3. Results of ignition source testing on pure refrigerants

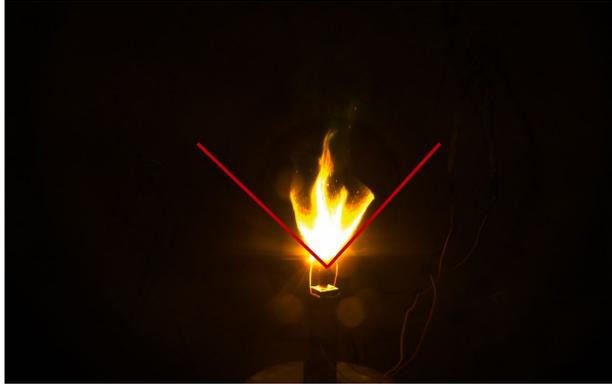
Refrigerant	Ignition Source		
	Spark	Nichrome	Propellant
R290	Go	Go	Go
R-1336mzz(E)	No Go	No Go	No Go
R-1234ze(E)	No Go	No Go	No Go
R-134a	No Go	No Go	No Go



Online Figure 1. R-1336mzz(E) with varying ignition sources



Online Figure 2. R-1234ze(E) with varying ignition sources



Online Figure 3. 90° Flame Angle Layered over Flame of Propellant Ignited 10% Proposed Blend

References

1. Online Ref. 1 Superior Energy Systems. 2019. Safety Data Sheet: R-290 Propane, December. <https://refrigerants.com/wp-content/uploads/2019/12/SDS-R290-Propane.pdf>.
2. Online Ref. 2. Chemours. 2020. Opteon 1150 Safety Data Sheet.
3. Online Ref. 3. National Refrigerants. 2017. Refrigerant R-1234ze(E) Safety Data Sheet.
4. Online Ref. 4. National Refrigerants Inc. R-134a Safety Data Sheet.
5. Online Ref. 5. Sadaghiani, M., A. Arami-Niya, D. Zhang, T. Tsuji, Y. Tanaka, Y. Seiki, and E.F. May. 2021. Minimum ignition energies and laminar burning velocities of ammonia, HFO-1234yf, HFC-32 and their mixtures with CO₂, HFC-125 and HFC-134a. *Journal of Hazardous Materials* 407.