EVS35 OSL2022

Chemours™

Novel Refrigerant Solution for Electric Vehicle Heat Pumps

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The adoption of heat pumps in battery electric vehicles is becoming increasing important to address deficiencies in thermal management. Refrigerant blends can offer an improved performance to help meet these needs.

REFRIGERANT PERFORMANCE CRITERIA

Presently, no single refrigerant molecule can meet all the goals for the evolving EV industry.

CRITERIA	Volumetric capacity	COP	Average Glide	Safety Classification per ASHRAE 34	GWP	NBP
TARGETS	>20% over R-1234yf	> R-1234yf	< 3K	A2L	< 150	< R-1234yf for positive suction pressures

THERMO-PHYSICAL PROPERTIES

Summary of the key thermo-physical properties for incumbent fluids (R-134a and R-1234yf) compared to HFOG7 (7.5% R-32, 78.0% R-1234yf, and 14.5% R-152a).

Properties	R-134a	R-1234yf	HFOG7
Relative molar mass (g/mole)	102.0	114.0	95.5
Normal Boiling Point (°C)	-26.1	-29.5	-37.3
Dew-point temperature at 101 kPa (°C)	-26.1	-29.5	-32.1
Critical Temperature (°C)	101.1	94.7	94.1
Critical Pressure (kPa)	4059	3382	3956
Specific volume at the critical point (m3/kg)	0.00195	0.00210	0.00224
Latent heat of vaporization @ 60°C (KJ/kg)	139.1	110.4	127.9
Specific heat ratio of the vapor at 60°C	1.45	1.45	1.51
Occupational Exposure Limit (ppm)	1000	500	605
Global Warming Potential (AR5)	1300	<1	72
Safety Class (ASHRAE)	A1	A2L	A2L

THERMODYNAMIC CYCLE PERFORMANCE

Results exhibited relative increases in cooling capacity (22.6%) and COP (1.0%) for AC mode and increases in heating capacity (25.1%) and COP (3.7%) in heating mode when compared directly to R-1234yf.

Cooling	Refrigerant	Suction Pressure (kPa)	Discharge Pressure (kPa)	Discharge Temperature (C)	Avg. Glide (K)	Cooling Capacity (kJ/m³)	COP
	1234yf	316	1018	54.9	0	1974	3.73
	HFOG7	372	1223	64.0	3.5	2419	3.77

Evap = 0°C, Cond = 40°C, Evap superheat = 10°C, Subcool = 0°C and Isentropic Eff. = 70%

Heating	Refrigerant	Suction Pressure (kPa)	Discharge Pressure (kPa)	Discharge Temperature (C)	Avg. Glide (K)	Heating Capacity (kJ/m³)	COP
	1234yf	99	1302	73.3	0	838	2.19
	HFOG7	115	1557	90.3	2.75	1049	2.27

Evap = -30°C, Cond = 50°C, Evap superheat = 10°C, Subcool = 0°C and Isentropic Eff. = 70%

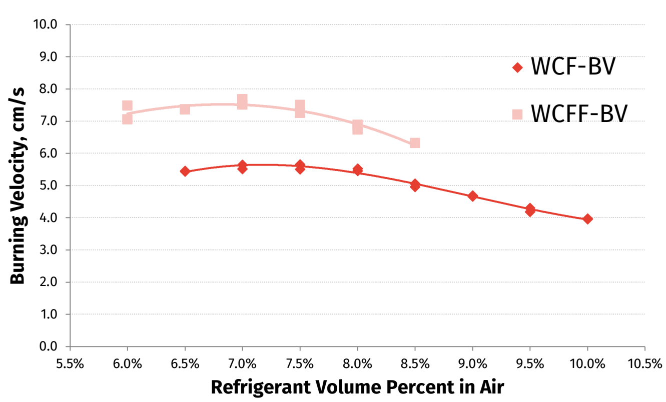
MATERIAL COMPATIBILITY

Commonly used plastics were evaluated in sealed glass tubes with HFOG7, POE lubricant (ND-11) and aged for 2 weeks at 100°C. Weight, linear swell, and hardness differences were assessed.

		0 hr Rating	% Weight Change	% Linear Swell	Hardness Change
PLASTICS AFTER 0 HRS	Torlon® polymer (polyamide-imide plastic)	0	0	0	-2
	Ryton® polymer (polyphenylene sulfide)	0	0	0	0
	PEEK (Ketaspire® 820 NT)	0	0	0	0
	Nylon 6.6 polymer plastic (Zytel® 101)	0	0	0	0
	Teflon™ PTFE	0	2	1	-2
	Nylon resin - Zytel 330	0	0	-10	1
PLASTICS AFTER 24 HRS	Torlon® polymer (polyamide-imide plastic)	0	-1	0	0
	Ryton® polymer (polyphenylene sulfide)	0	0	0	0
	PEEK (Ketaspire® 820 NT)	0	0	0	0
	nylon 6.6 polymer plastic (Zytel® 101)	0	0	0	1
	Teflon™ PTFE	0	2	1	-2
	Nylon resin – Zytel® 330	0	0	-10	1

FLAMMABILITY

ASHRAE Refrigerant Classification of A2L was met where maximum burning velocity is required to be equal or less than 10 cm/s for WCF and WCFF determined from vapor leak scenarios.



CONCLUSIONS

BEV Thermal management is a key issue and OEMs are seeking improvements in both heating capacity and efficiency in the heat pump system. Chemours novel refrigerant, HFOG7, has shown an increase in both heating and cooling capacity of greater than 20% plus an improved COP over R-1234yf.