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FORANE REFRIGERANTS

Forane® 516A Very-Low GWP R-134a Replacement Refrigerant

Chillventa Specialist Forums 2022

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11/11/2022

Agenda

- → Introduction of Forane® 516A Refrigerant
- → Fluid Properties and Simulated Performance
- → System Drop-in Test Results
- → Forane® 516A in Heat Pumps and Chillers
- → Material Compatibility
- → Total Equivalent Warming Impact (TEWI) Calculations
- → Conclusion

FORANE® REFRIGERANTS

Forane® 516A Very-Low GWP R-134a Replacement Refrigerant

Forane® 516A

→ Very-low GWP – 142*

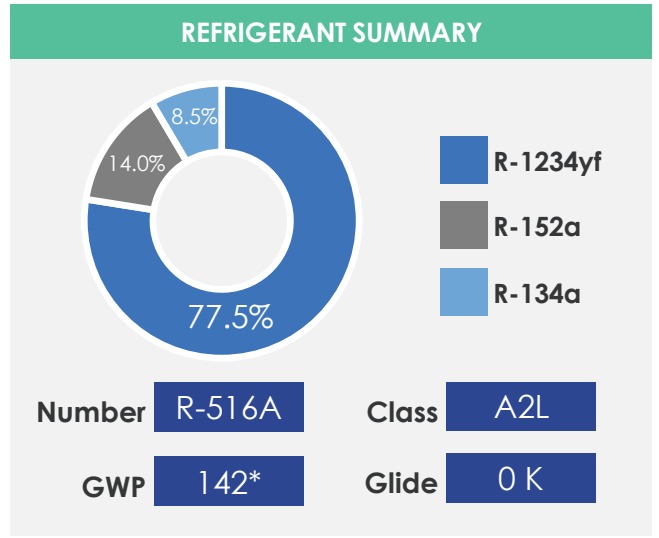
→ 90% GWP reduction from R-134a

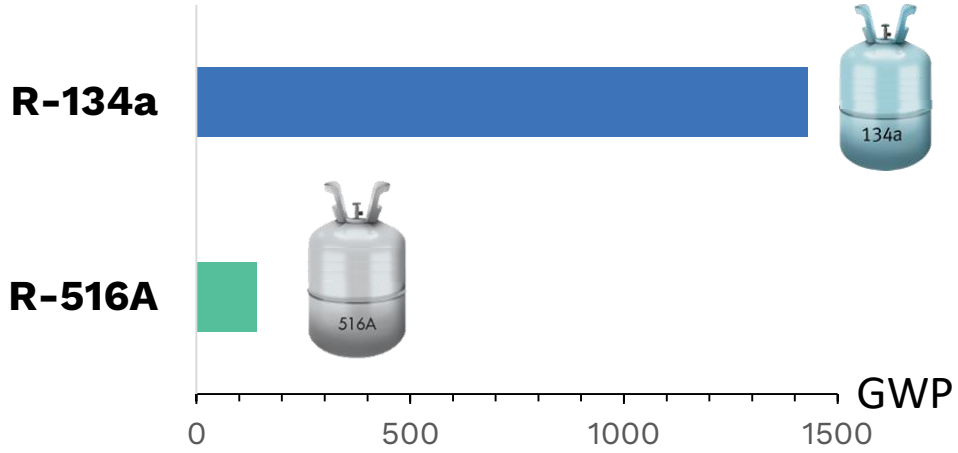
→ Azeotropic blend – no glide

→ Mildly flammable (A2L)

→ Design compatible alternative to R-134a

- **Evaluated for use in different systems**
  - Drop in tested in R-134a air-cooled screw chiller†
  - R-134a replacement for low ambient heat pumps**
  - Promising performance in R-134a optimized systems





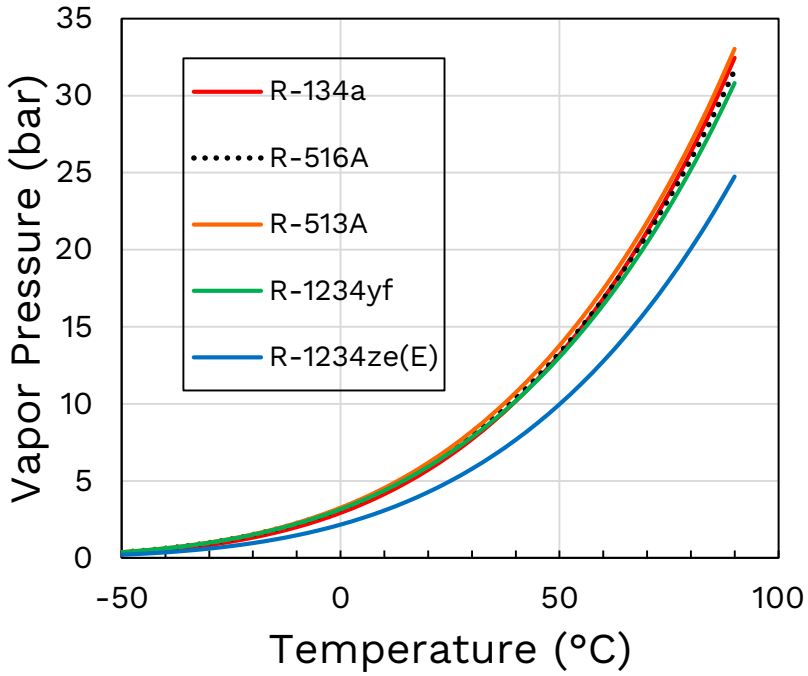
*Based on AR4 GWP Values

†Schultz K and Perez-Blanco, M. (2018). *Conference Paper CH-18-C063, 2018 ASHRAE* Winter Conference, Chicago, IL

**Kim S et al (2021). Proceedings of *13th IEA Heat Pump Conference*

R-134a and Alternative Fluid Properties

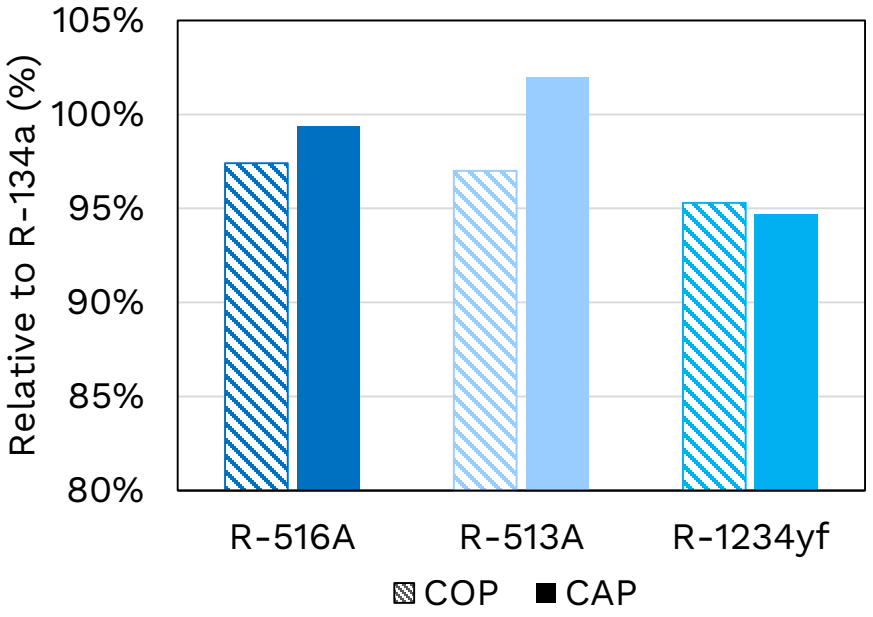
Property	R-134a	R-516A	R-1234ze(E)	R-513A	R-1234yf
ASHRAE 34 Safety Class	A1	A2L	A2L	A1	A2L
GWP (AR4)	1430	142	6	631	4
Boiling point at 101 kPa	-26.3°C	-29.6°C	-19°C	-29.6°C	-29.5°C
Glide	0 K	0 K	0 K	0 K	0 K
Efficiency Relative to R-134a		-2.4%	+0.3%	-2.9%	-4.3%
Capacity Relative to R-134a		-3.3%	-24.9%	-0.3%	-8.1%

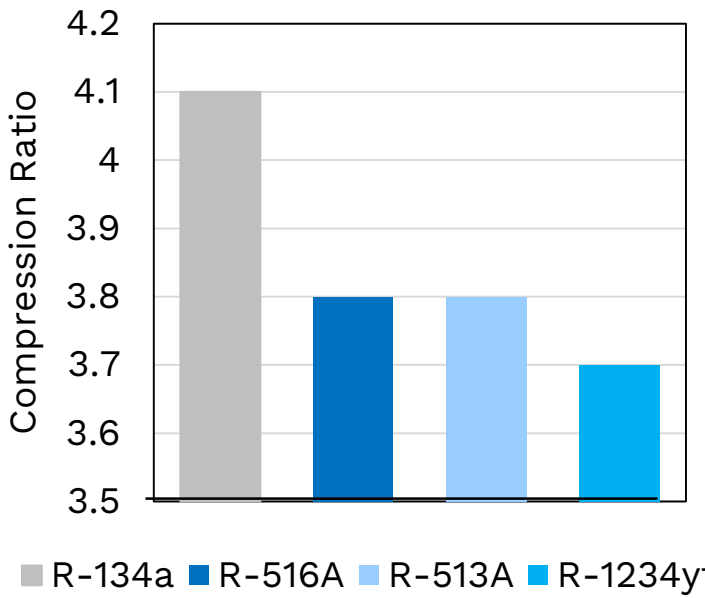


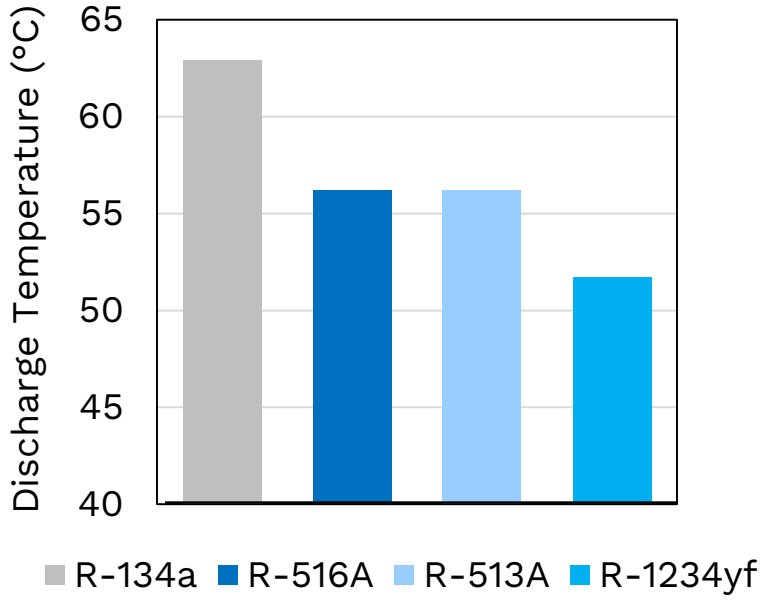
→ R-516A provides matching thermodynamic properties and cycle performance to R-134a making it an ideal design compatible replacement for both heating and cooling applications

Thermodynamic Cycle Performance

*Modeled Conditions: -3.9°C evap, 40.5°C condensing, 5K SH, 5K SC







→ Both R-516A and R-513A showed comparable COP and CAP vs R-134a while R-1234yf showed 5% drop in performance

→ The HFO based refrigerants showed favorable compression ratio and discharge temperature

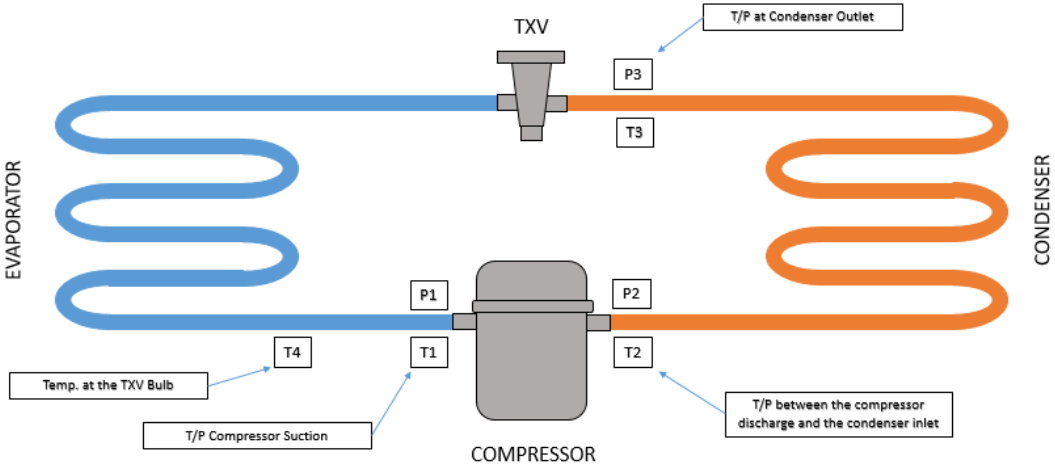
System Drop-In Testing

→ Test System

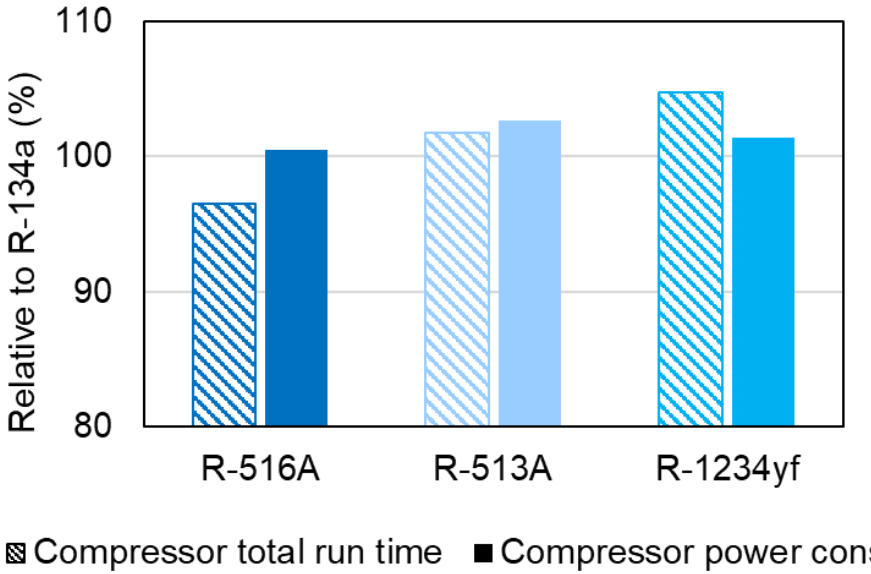
- **Single glass door, reach-in refrigerator**
- **Top mount single refrigeration system**
- **Factory charged with R-134a**

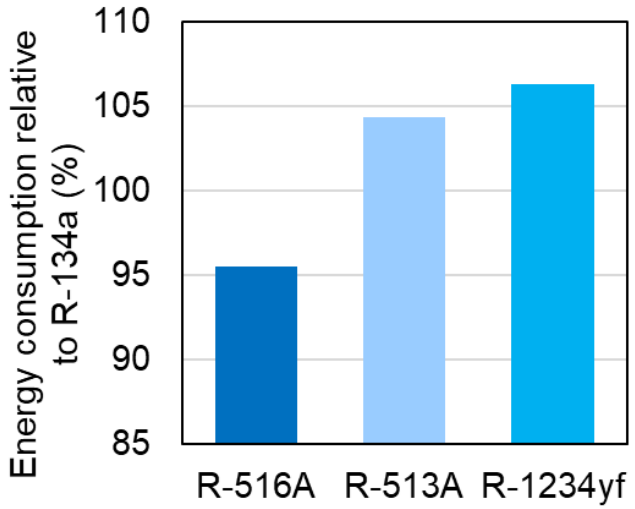
→ All refrigerants were drop-in tested

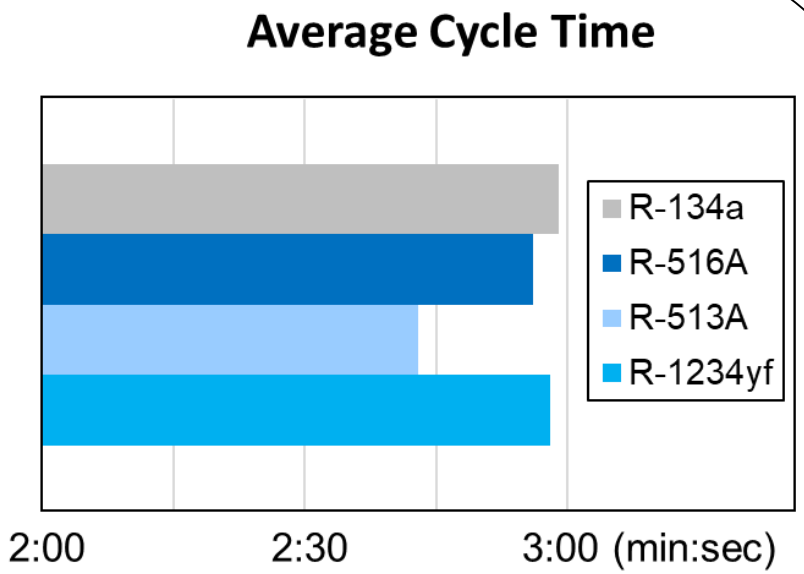
- **Test data collected for 24hr+**
- **Compressor & fan power, total energy consumption monitored**
- **TXV was adjusted to maintain proper superheat per manufacturer's recommendation**



Experimental Results – 23.9°C/75°F







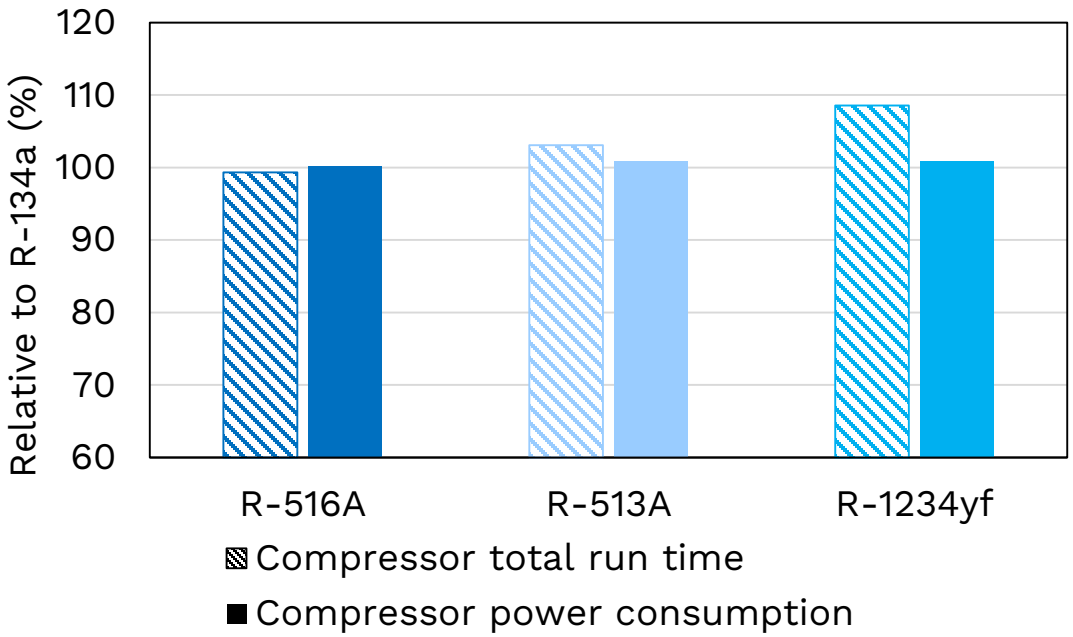
→ Energy consumption of the test refrigerants:

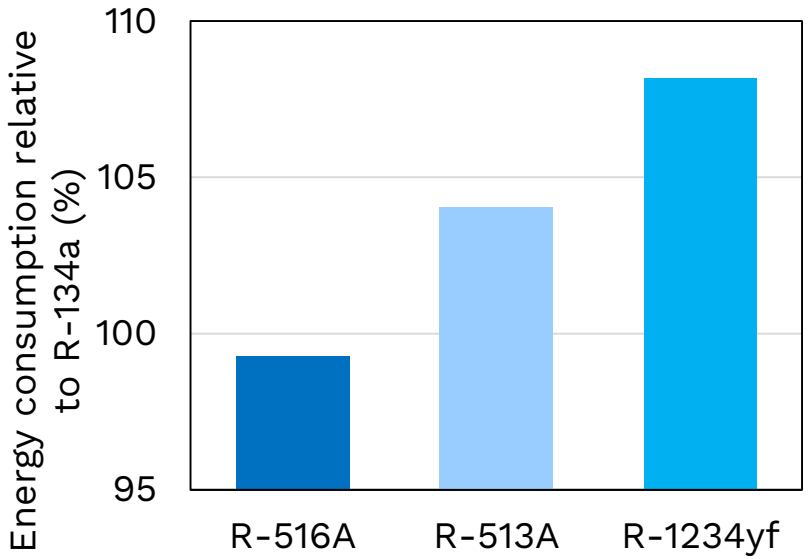
R-516A < R-134a < R-513A < R-1234yf

→ R-516A offers potential energy savings over all refrigerants tested

→ Favorable discharge temperatures also verified through testing

Experimental Results – 32.2°C/90°F





→ Energy consumption of the test refrigerants:

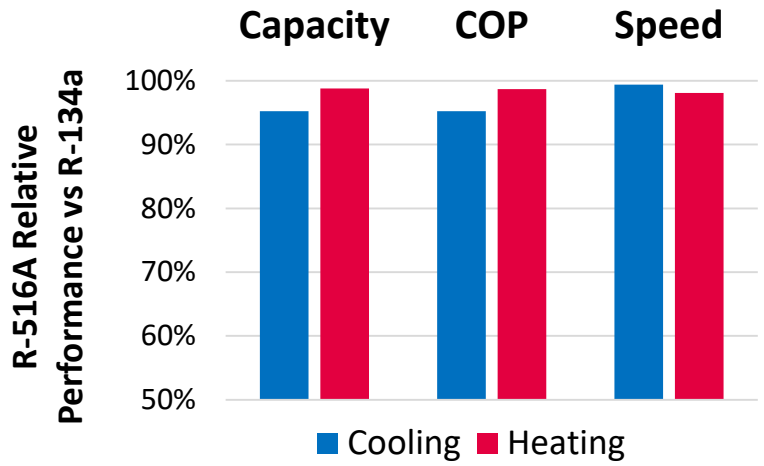
→ R-516A < R-134a < R-513A < R-1234yf

R-516A for Heat Pumps

→ Target Application: Low ambient air to water heat pump (AWHP)

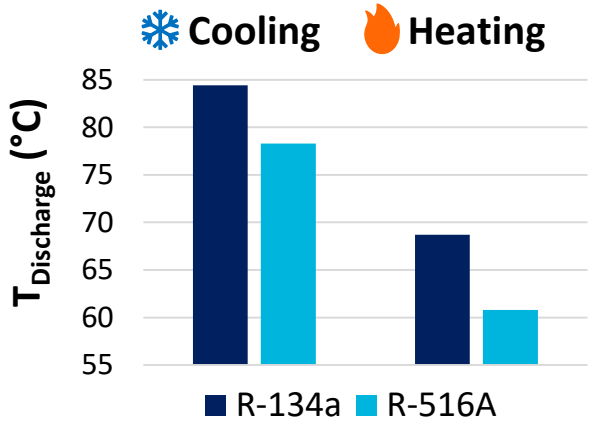
- Oil free, centrifugal compressor technology
- 30-50% energy reduction than conventional compressors

→ Joint 516A paper presented at 2021 Heat Pump Conference [1]



Cooling
Tevap = 7.2°C, Tcond = 54.4°C
SH = 11.1 K, SC = 8.3K

Heating
Tevap = -7°C, Tcond = 50°C
SH = 1K, SC = 3K



→ R-516A showed comparable performance and compressor speed vs R-134a

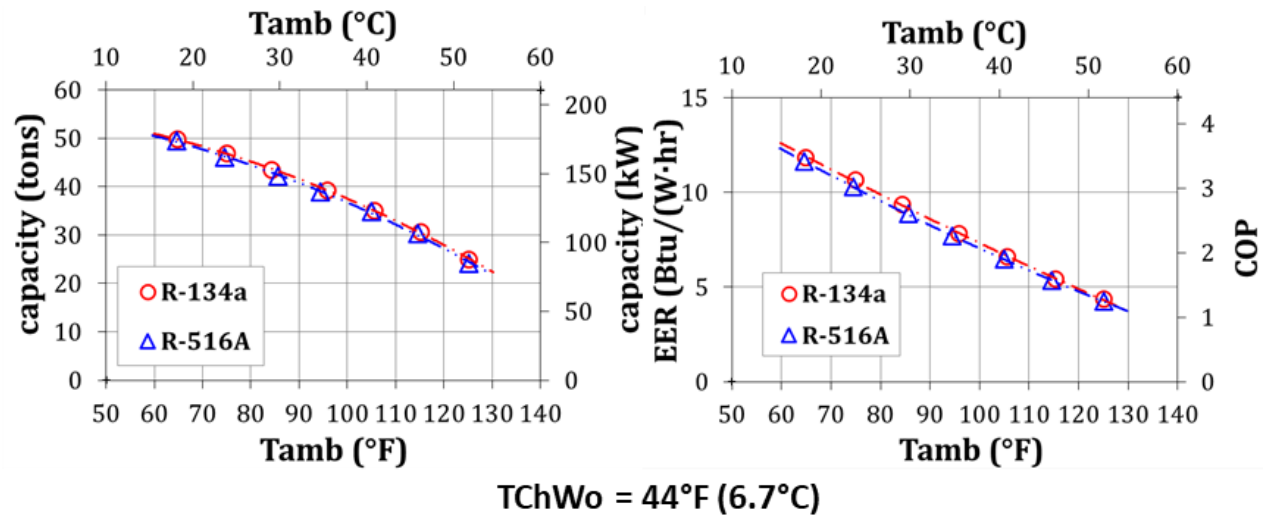
→ R-516A exhibited significantly lower discharge temperatures, which allows broader operation map

[1] Kim and Turner, IEA HPT Annex 54, Heat Pump Systems with Low-GWP Refrigerants, Progress Annual Report (2019)

R-516A in Chillers

→ Medium Pressure Chiller Evaluation

→ 105 RT (370 kW) air-cooled R-134a screw chiller drop in test[1]



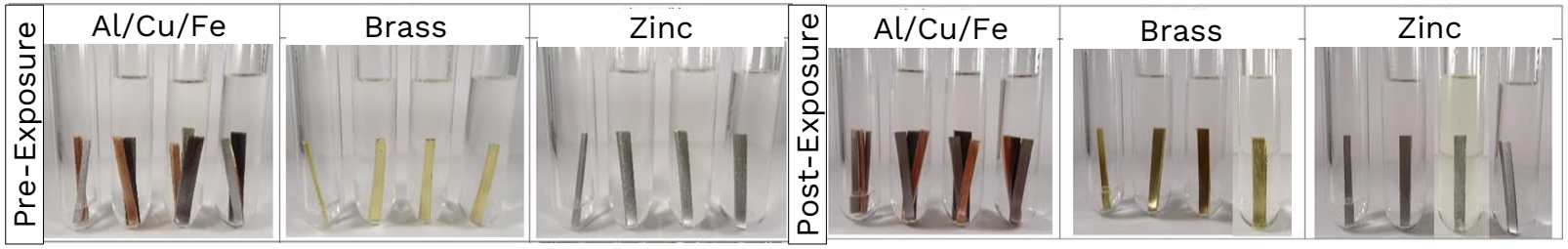
➢ **R-516A showed comparable performance to R-134a**

[1] Schultz K. (2018). Conference Paper CH-18-C063, 2018 ASHRAE Winter Conference, Chicago, IL

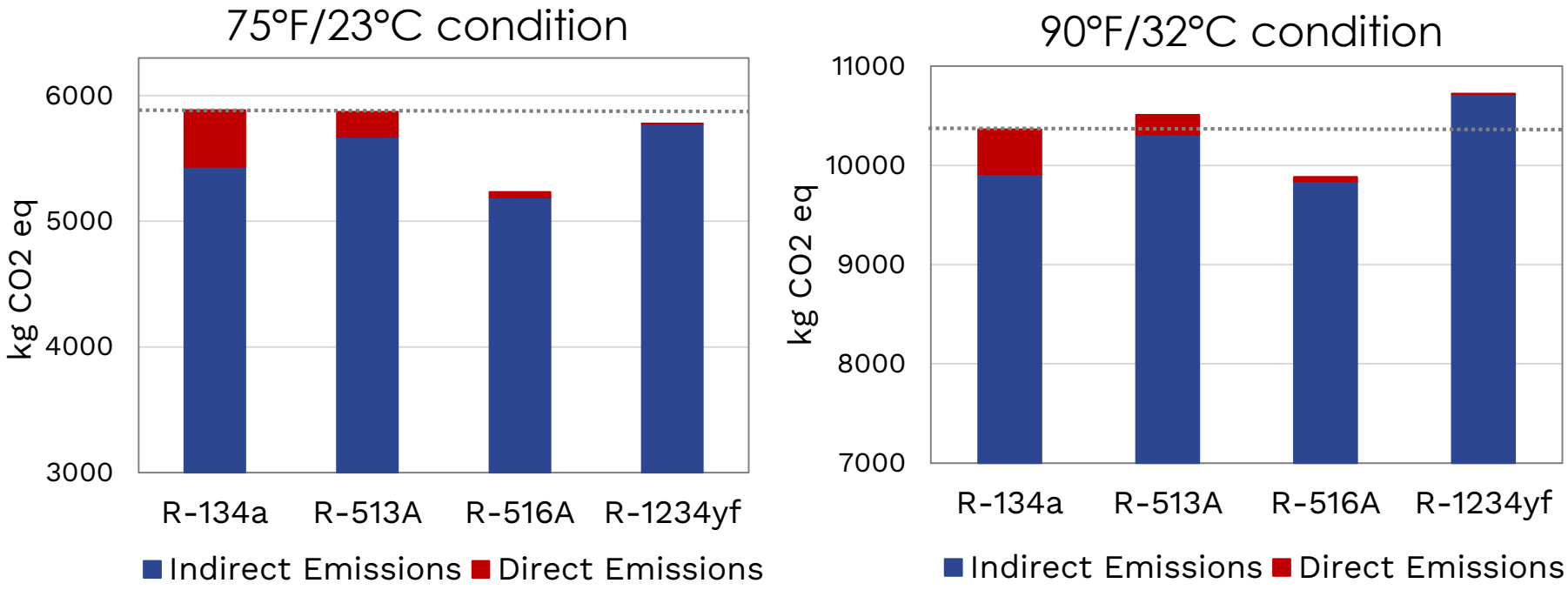
R-516A Material Compatibility

→ AHRTI-9016

- **Good materials compatibility**
- **Study ongoing, no compatibility issues expected**



R-516A - Total Equivalent Warming Impact (TEWI)



➢ **R-516A showed lowest total equivalent warming impact [1]**

Refrigerant	R-134a	R-513A	R-516A	R-1234yf
GWP (AR4)	1430	631	142	4

[1] AIRAH, 2012. "Methods of calculating total equivalent warming impact(TEWI) 2012. The Australian Institute of Refrigeration, Air Conditioning and Heating

Conclusions

- → Forane® 516A an ideal low-GWP replacement for R-134a
- → Fluid properties that closely match R-134a
- → Performance very close to, or potentially better, than R-134a
- → Better Performance than other low-GWP alternatives such as 1234yf
- → Performs well in a variety of applications; heat pumps, chillers, refrigeration
- → Good material compatibility
- → Lower total equivalent warming impact than other alternatives

FORANE® REFRIGERANTS

Thank You

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