

Chillventa Specialist Forums 2024
Chillventa Fachforen 2024

**CONNECTING
EXPERTS.**



ARKEMA

FORANE
REFRIGERANTS

Forane® Refrigerants

Low GWP Refrigerants for Heat Pumps

Kris Crosby, Arkema Booth 9-408

10/10/2024



Forane[®] 32 Refrigerant

- Current heat pumps



Forane[®] 516A Refrigerant

- Air-Water heat pumps
- Heat pump water heaters
- Chillers



Forane[®] 457A Refrigerant

- Residential & light commercial heat pumps



Forane[®] 1233zd HTS

- High temperature heat pumps



Conclusion and Questions



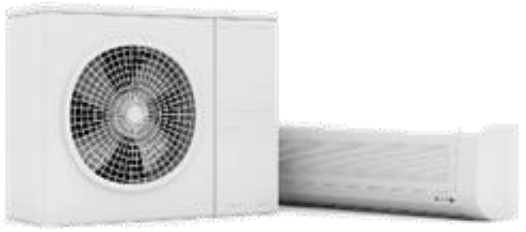
Forane[®] 32

10/10/2024



Forane® 32

- GWP* of 675
- A2L – mildly flammable, low toxicity
- Zero ozone depletion potential
- Non PFAS
- Currently used in heat pumps across the globe



R-32 Properties Relative to R-410A

Capacity	Efficiency	Charge Size	Stability	Compatibility	Cost
+10%	+5%	20% less	Similar	Similar	Less

*Based on AR4 GWP Values



Forane® 516A

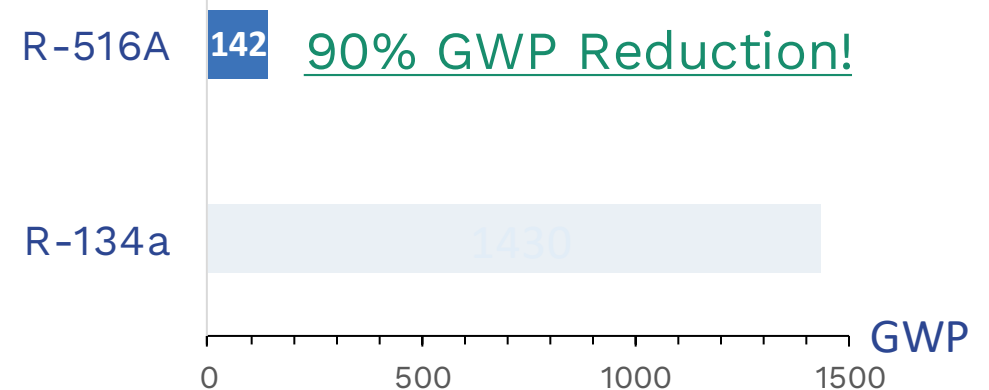
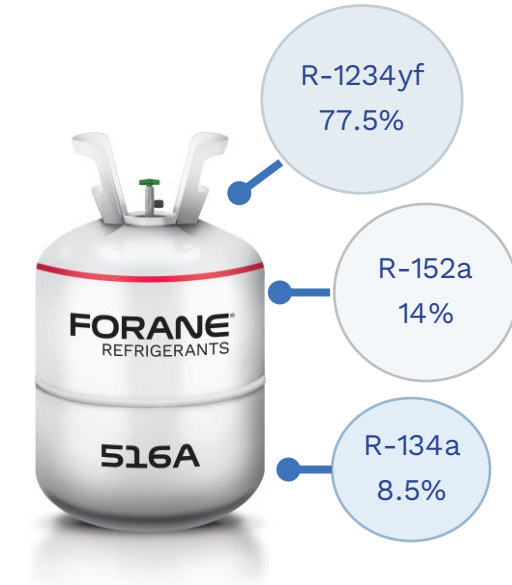
Very-Low GWP Refrigerant

10/10/2024



Forane® 516A

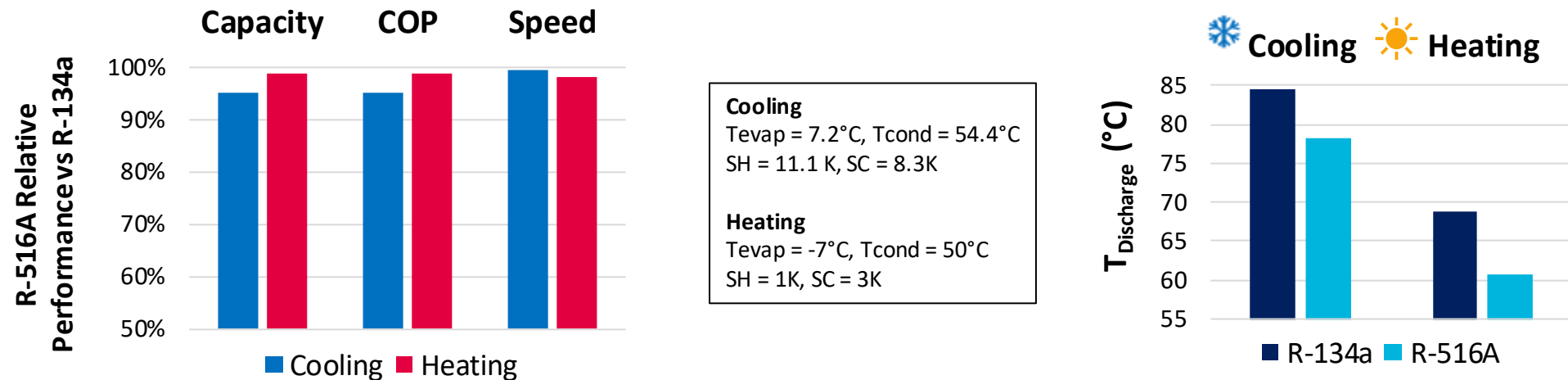
- Very Low GWP – 142*
- Azeotropic blend – ZERO glide
- A2L – Mildly flammable
- Closest match to R-134a properties amongst <150 GWP refrigerants
- Matching thermodynamic properties mean very few R-134a system design changes required



*Based on AR4 GWP Values

R-516A for Heat Pumps

- Application: Low ambient Air to Water Heat Pump (AWHP)
- Tested in system utilizing oil free, centrifugal R-134a compressor ^[1]



- Heating capacity, COP, and compressor speed all very similar to R-134a
- Significantly lower discharge temperatures, which allows broader operation map
- R-516A - Ideal candidate for air-to-water heat pumps ^[2]

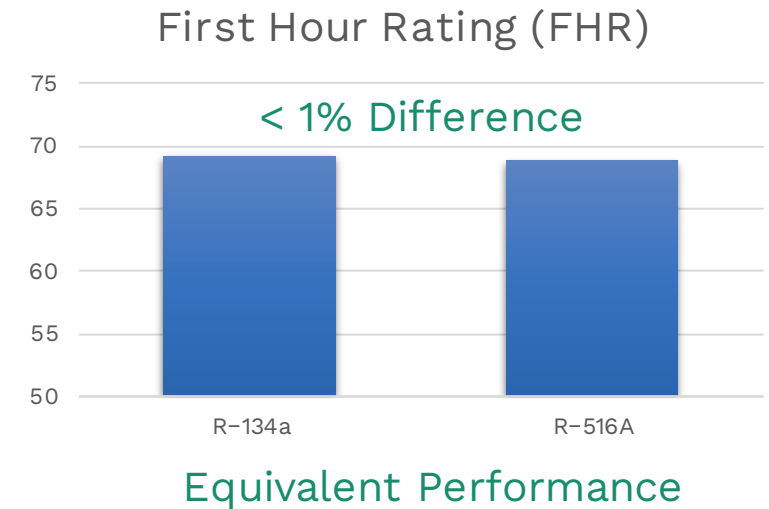
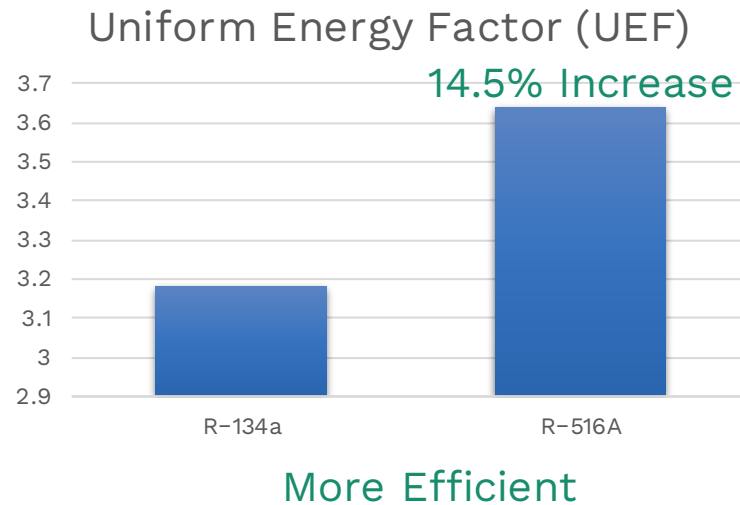
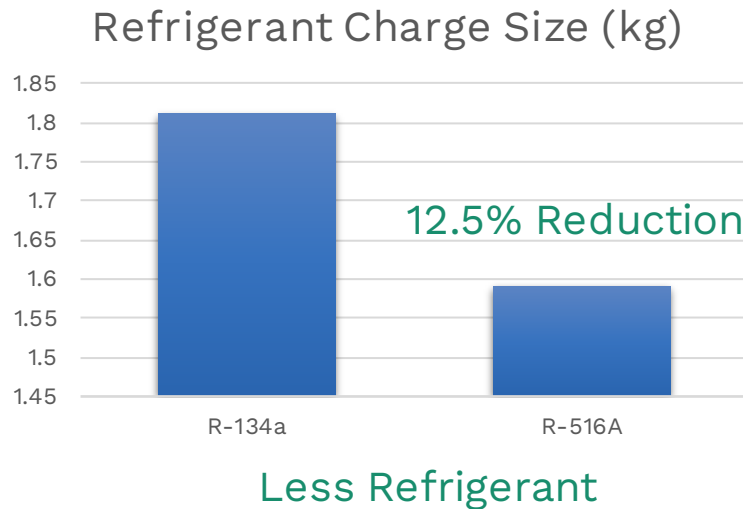
[1] Kim and Turner, IEA HPT Annex 54, Heat Pump Systems with Low-GWP Refrigerants, Progress Annual Report (2019)

[2] Stoll, Danfoss Climate Solutions, From components to solutions, source to supply, a value chain approach on heat pumps for a decarbonized tomorrow, Chillventa Specialist Forum (2022)

R-516A for Heat Pumps

→ Application: Residential Heat Pump Water Heater

- Drop-in tested in a residential integrated heat pump water heater designed for R-134a

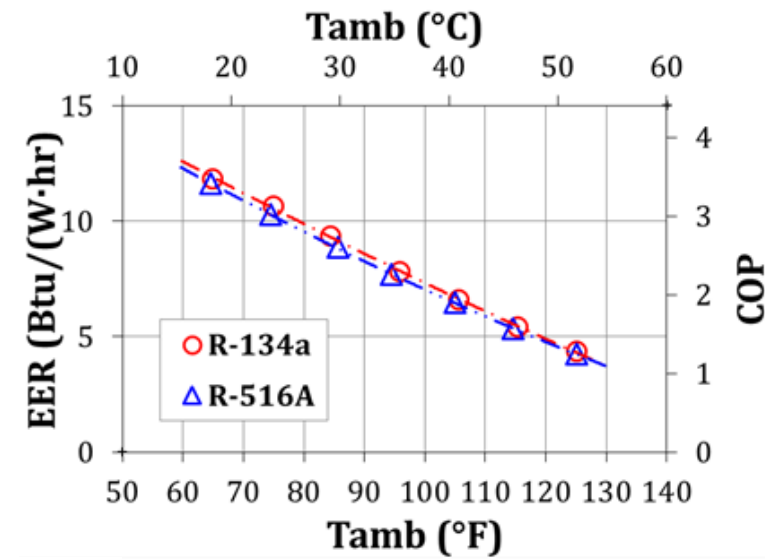
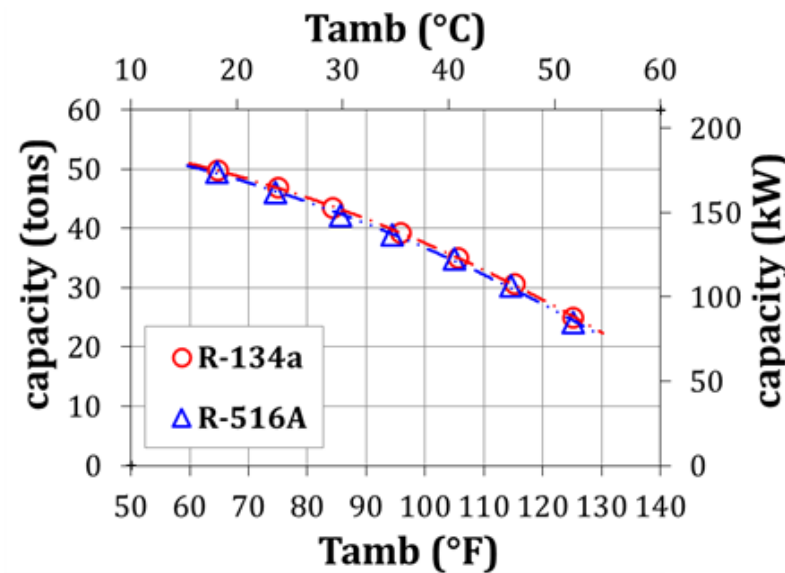


→ R-516A - Ideal replacement for R-134a in heat pump water heaters

R-516A in Chillers

→ Medium Pressure Chiller Evaluation

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



TChWo = 44°F (6.7°C)

- R-516A showed comparable performance to R-134a
- Provides strong performance for heat pump models

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



Forane® 457A

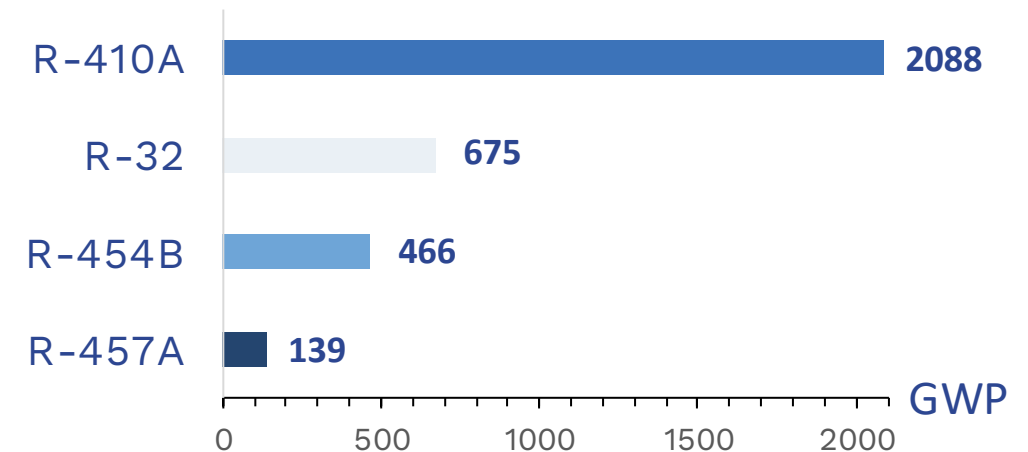
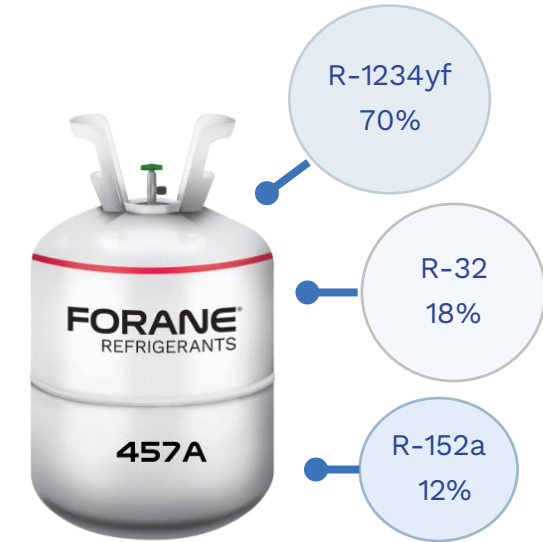
Very-Low GWP Refrigerant

10/10/2024



Forane® 457A

- Very Low GWP – 139*
- A2L - Mildly flammable
- SNAP listed in US
- Favorable critical temperature for heat pumps (90.2 °C)
- Capacity and efficiency competitive amongst <150 GWP refrigerants



*Based on AR4 GWP Values

Forane® 457A

- Chosen by Oak Ridge National Laboratory for “Residential Split Heat Pump Using <150 GWP Refrigerant” DOE funded research project ^[1]
- Project goal: Develop low cost, direct expansion heat pump using long term refrigerants with GWP < 150 and suit mainstream building and equipment structure
 - Achieve seasonal cooling performance of SEER (season energy efficiency ratio) > 16.0
 - Achieve seasonal heating performance of HSPF (heating seasonal performance factor) > 9.0



[1] Shen, B. (2023). Residential Split Heat Pump Using <150 GWP Refrigerant with High Temperature Glide. DOE CRADA.

Forane® 457A

- Exceeded the HSPF goal: 10.1 HSPF (Goal: 9.0)
- Met the SEER goal within allowed tolerance: 15.7 (Goal: 16.0)
- Met Rated capacity: 3.2 Ton (Goal: 3.0 Ton)
- R-457A compressor isentropic efficiency at 8 °C heating condition: 70% - comparable to R410A scroll compressor



[1] Shen, B. (2023). Residential Split Heat Pump Using <150 GWP Refrigerant with High Temperature Glide. DOE CRADA.



Forane[®] 1233zd HTS

Near Zero GWP Refrigerant



Forane® 1233zd HTS

- GWP* of 1
- Single molecule refrigerant
- A1 – non-flammable, low toxicity
- \$60m+ investment in Calvert City, KY
- Production beginning in 2024



*Based on AR5 GWP Values

Forane® 1233zd HTS

- Ideal properties for high temperature heat pumps
 - 18 °C boiling point
 - 166 °C critical temperature
- Can utilize waste heat from many sources
- Applications across many sectors
 - Pharmaceuticals
 - Paper Mills
 - Industrial Dryers & Ovens
 - Low Temperature Steam
 - Food Production

Application fields for screw compressor



Conclusions

→ Forane® 32

- Current refrigerant for heat pumps across many applications

→ Forane® 516A

- < 150 GWP refrigerant for air-to-water heat pumps, heat pump water heaters, and chillers

→ Forane® 457A

- < 150 GWP refrigerant for residential and light commercial heat pumps

→ Forane® 1233zd HTS

- GWP=1 refrigerant for high temperature heat pumps and waste heat recovery

FORANE®
REFRIGERANTS

Thank You

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