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

Agenda

FORANE® REFRIGERANTS

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

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Forane® 32

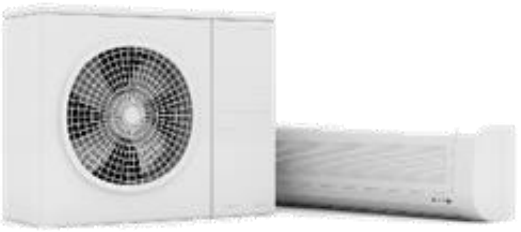
→ GWP* of 675

→ 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

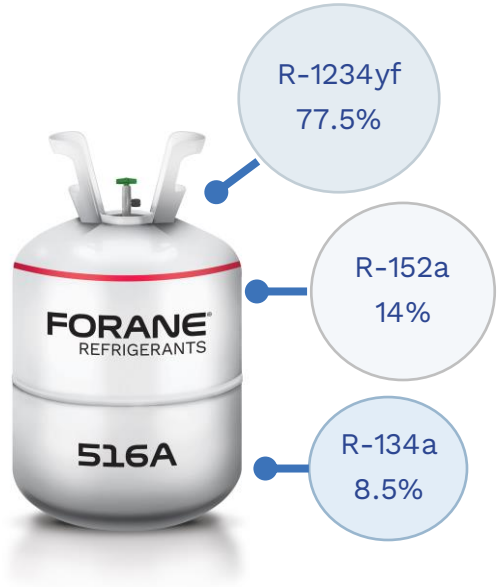
Forane® 516A

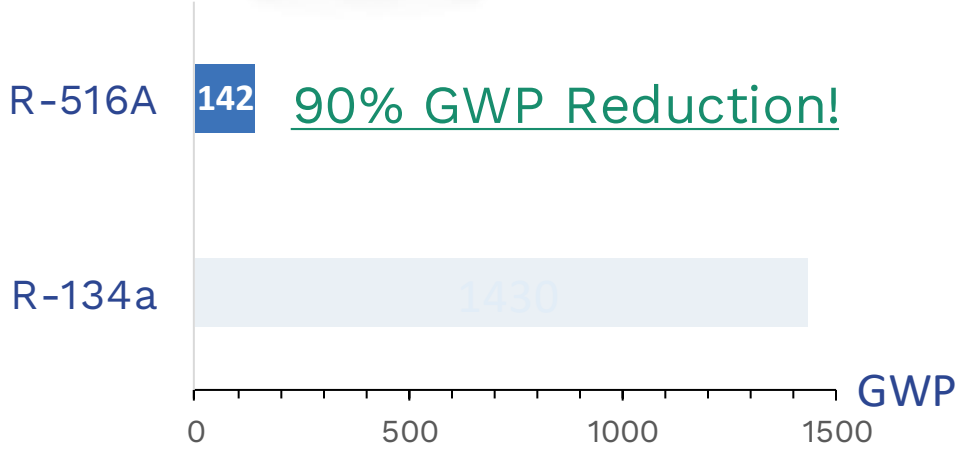
Very-Low GWP Refrigerant

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



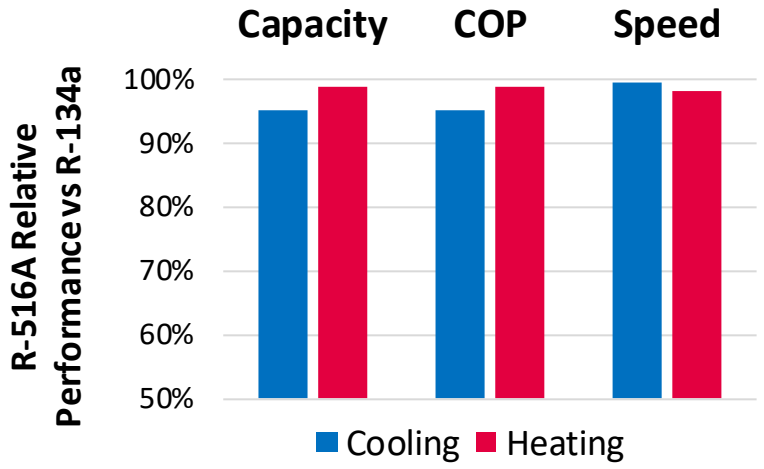


*Based on AR4 GWP Values

R-516A for Heat Pumps

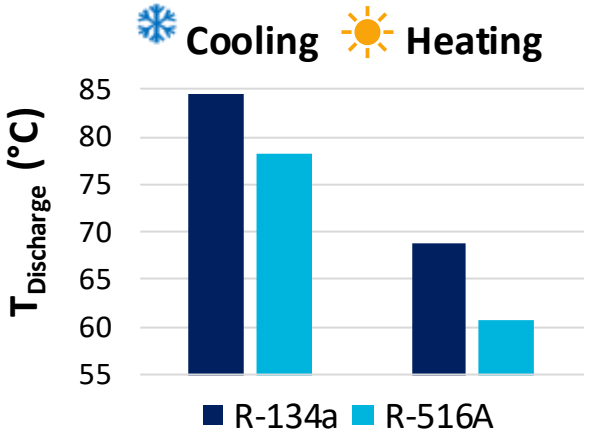
→ Application: Low ambient Air to Water Heat Pump (AWHP)

- Tested in system utilizing oil free, centrifugal R-134a compressor [1]



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



→ 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]

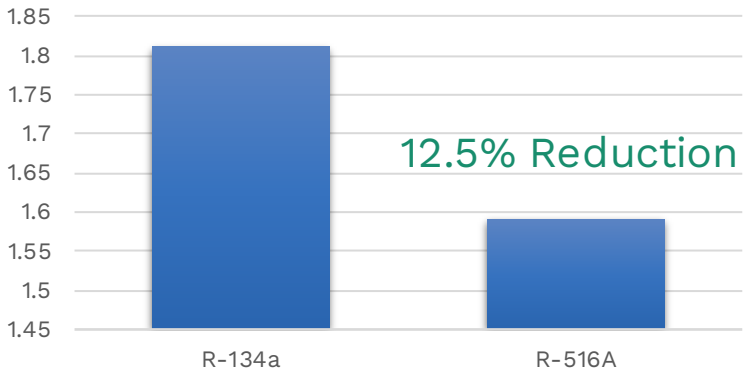
[1] Kim and Turner, IEA HPT Annex 54, Heat Pump Systems with Low-GWP Refrigerants, Progress Annual Report (2019)
[2] Stoll, Danfoss Climate Solutions, From components to solutions, source to supply, a value chain approach on heat pumps for a decarbonized tomorrow, Chillventa Specialist Forum (2022)

R-516A for Heat Pumps

→ Application: Residential Heat Pump Water Heater

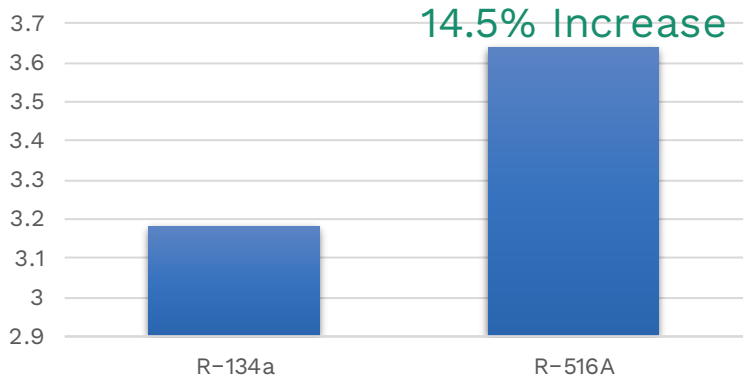
- Drop-in tested in a residential integrated heat pump water heater designed for R-134a

Refrigerant Charge Size (kg)



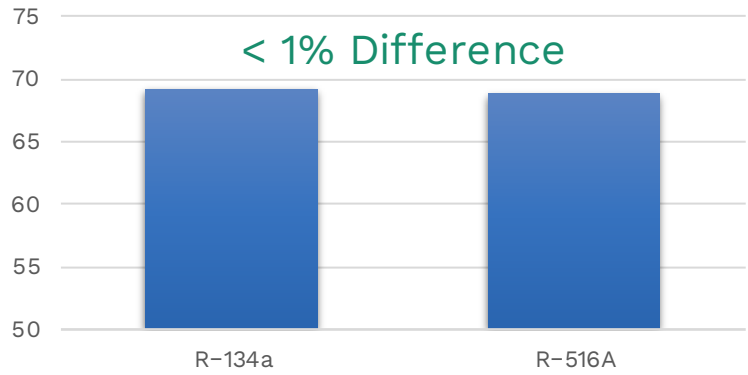
Less Refrigerant

Uniform Energy Factor (UEF)



More Efficient

First Hour Rating (FHR)



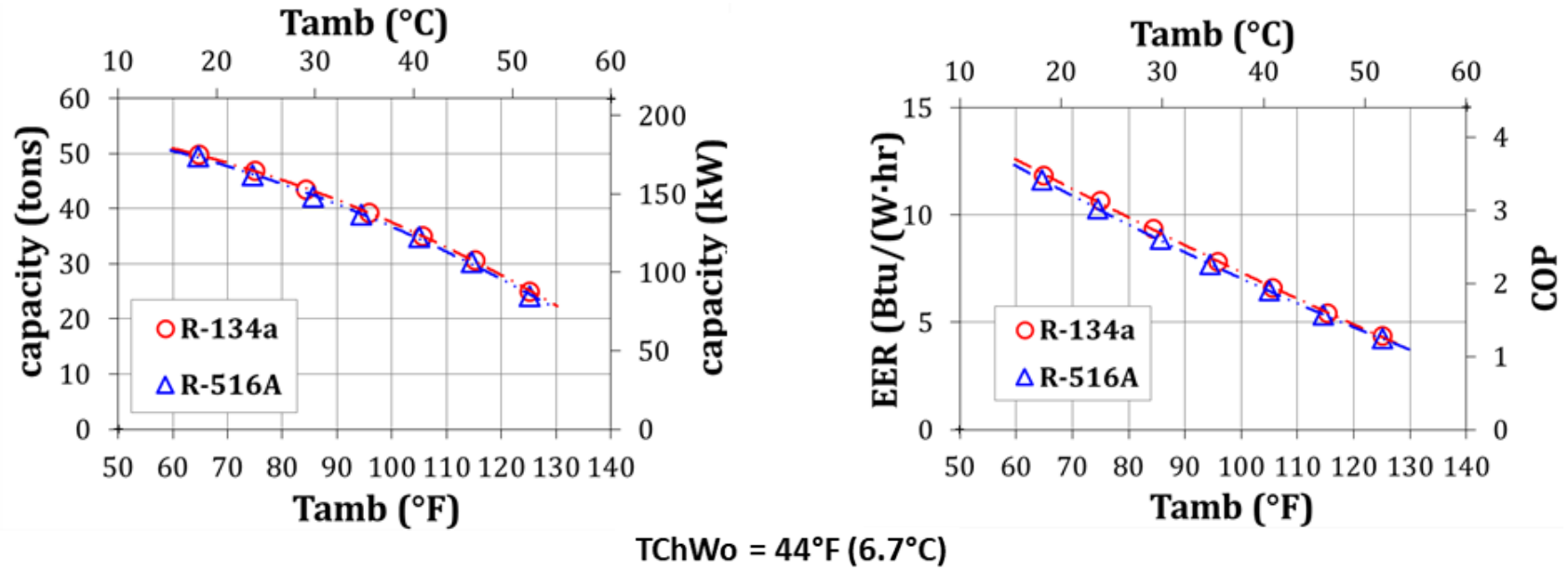
Equivalent Performance

→ 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

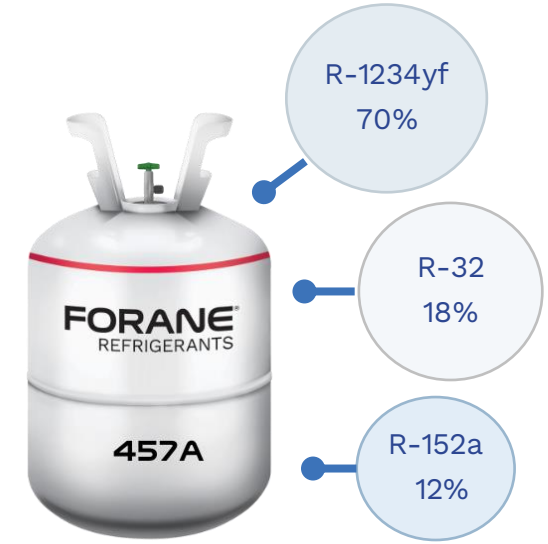
Forane® 457A

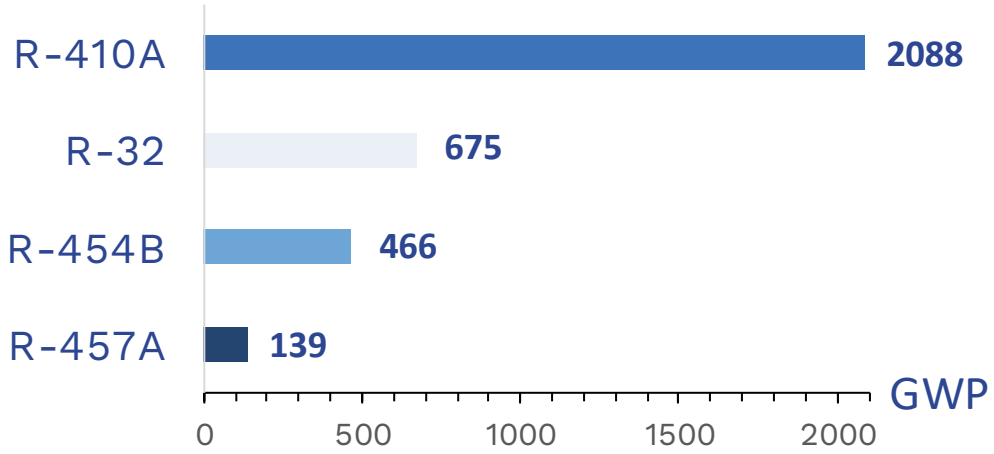
Very-Low GWP Refrigerant

10/10/2024

Forane® 457A

- → Very Low GWP – 139*
- → A2L - Mildly flammable
- → SNAP listed in US
- → Favorable critical temperature for heat pumps (90.2 ºC)
- → 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

10/10/2024

Forane® 1233zd HTS

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

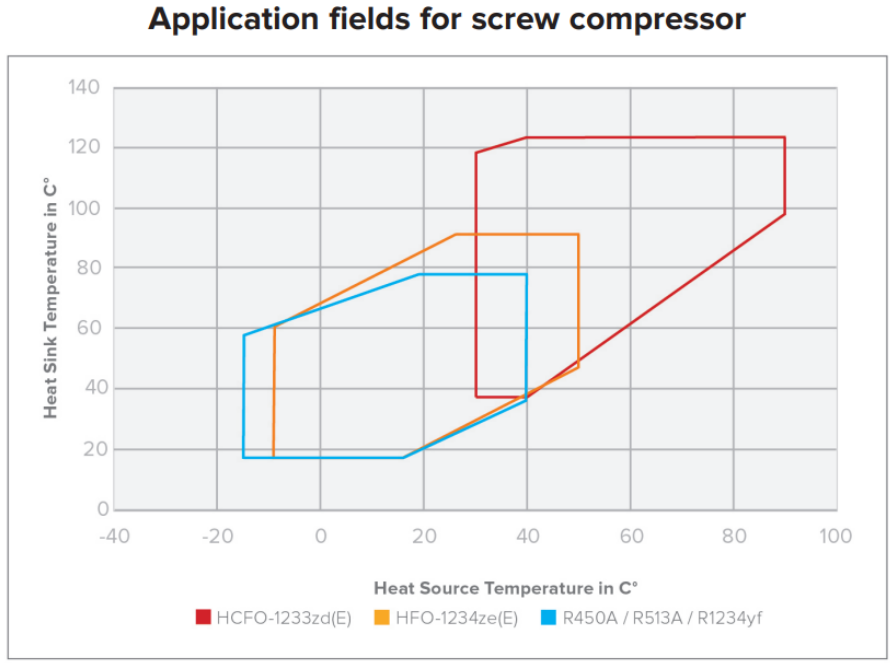
*Based on AR5 GWP Values

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



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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