



Fluor & Energy
Materials

New Refrigerants: Purpose and Practice

July 15, 2026

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Refrigerants

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TST Round Table

New Refrigerants: Purpose and Practice

Agenda

New Refrigerants: Purpose

Why new refrigerants?
EPA SNAP Rule 27
Composite refrigerant
overview
Composition rationale

Practice—Case Studies

Ford plug-in hybrid (PHEV)
System mass/cost reduction potential
Ford vapor-injection heat pump (VIHP)
Hyundai Kona testing (AC/HP modes)
LCCP assessment for total carbon
emissions

Practice—Retrofit Process; Service Tools and Equipment

SAE Retrofit Standard J3332
Currently Available Tools & Equipment for
Retrofit/Service
SAE J3374 in process to define RRR for
Composite (Blend) refrigerants

1 | New Refrigerants: Purpose *Composite (blend) refrigerants*

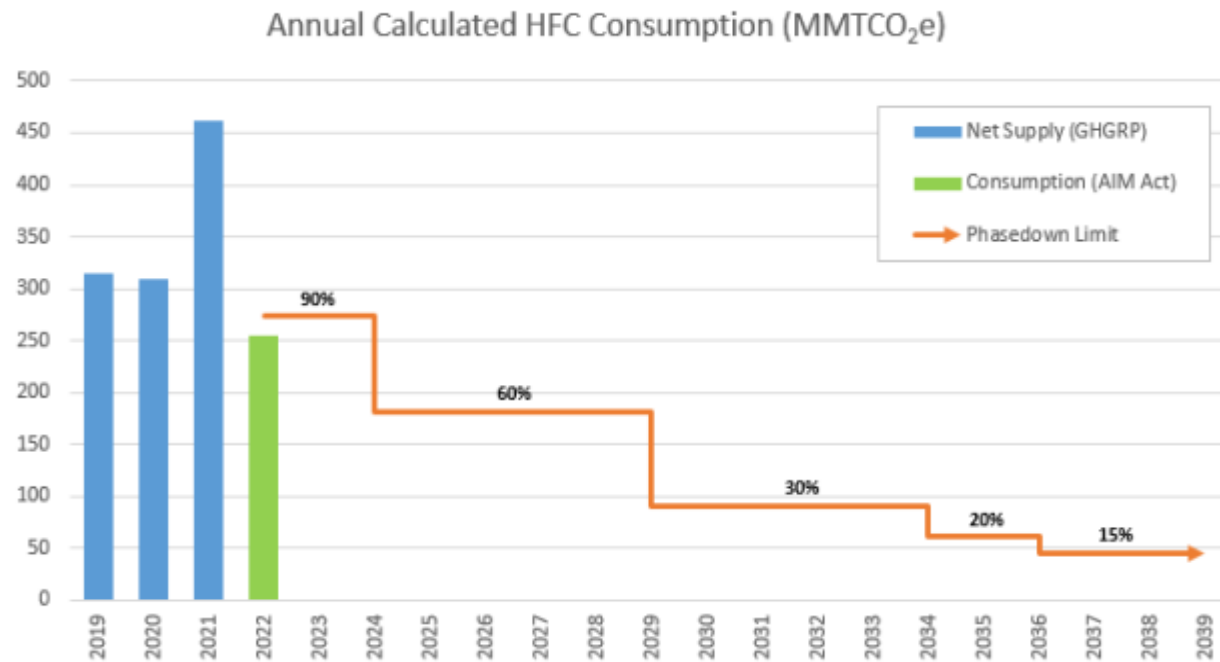
Thermal Management Industry Update

Current Events

- **Regulatory**
 - The EPA has issued proposed SNAP Rule 27; final publication expected Sept 2026
 - R-444A is available in the US under EPA test market arrangement.
 - Allows light duty vehicles to be retrofitted to R-444A and R-456A (456A also approved for on road HD)
 - Allows both 456A and 444A for DIY purchase in less than 2lb cans
- **Future ready**
 - R-444A tested in four OEM systems in various **current and in-development** system architectures
- **Standards**
 - SAE ICCC creating standards for composite (blend) refrigerant purity (J3306), vehicle retrofit, unique fitting definition, and RRR machines—J3332 Retrofit & J3374 Blend RRR Machines
- **Market adoption of Blends**
 - One major packing and distribution company is on the market with R-444A
 - Retrofit fittings and service couplers are available today

New refrigerants

How Can R-456A Extend R-134a Availability?



Source: <https://www.epa.gov/climate-hfcs-reduction/frequent-questions-phasedown-hydrofluorocarbons>

- **30% CO₂e phasedowns in 2024 and 2029**
 - Baseline set in early 2010s
- All segments (HVAC, commercial refrigeration, automotive, etc) draw from the same pool of CO₂e
- EVs and heat pumps will continue to drive refrigerant **demand** while allowances are **reduced** over time
- GWP limits and timing – Technology Transition
 - Light-duty: GWP ≤ **150** by model year 2025
 - Med.-duty passenger, HD pickups, HD vans, non-road HD: GWP ≤ **150** ~2028

Global phasedowns limit refrigerant availability, especially after 2029

New Refrigerants

The New Options For Service: R-456A & R-444A

Non-flammable systems (ASHRAE A1 safety class.)

R-456A (Replaces R-134a)

- Composition (wt%)
 - R-1234ze(E) – 49%
 - R-134a – 45%
 - R-32 – 6%
- Benefits
 - Extends useful life of 134a vehicles
 - 2x refrigerant availability for same quota
 - Line-on-line performance match with 134a
 - R-134a direct replacement (same oil, same system components)
 - In use today in **>1M EU vehicles**

Mildly-flammable systems (ASHRAE A2L safety class.)

R-444A (Substitute for R-1234yf)

- Composition (wt%)
 - R-1234ze(E) – 83%
 - R-152a – 5%
 - R-32 – 12%
- Benefits
 - Alternative to 1234yf
 - 5-10% enhanced performance over R-1234yf
 - Better fuel economy or EV range
 - Very low TFA production
 - R-1234yf direct replacement (same oil, same system components)

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Practice: Case Studies

Vehicle Tests with R-444A

Key Takeaways

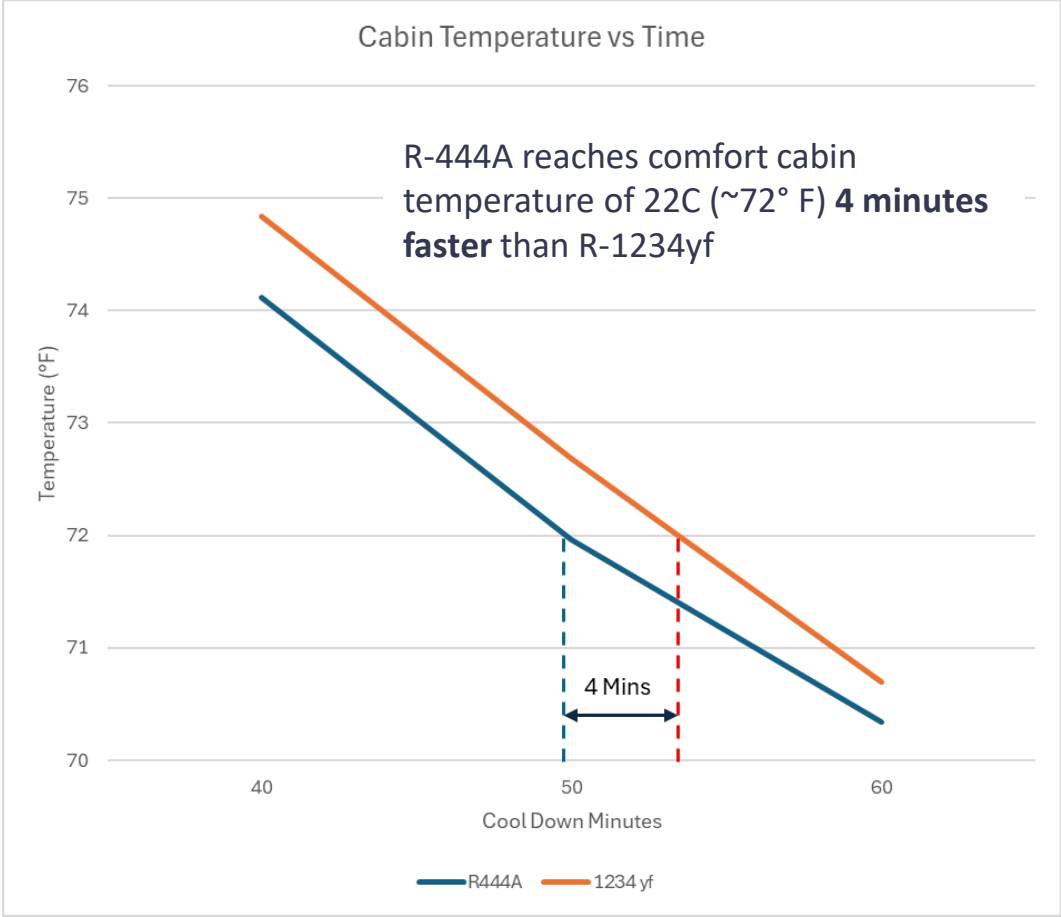
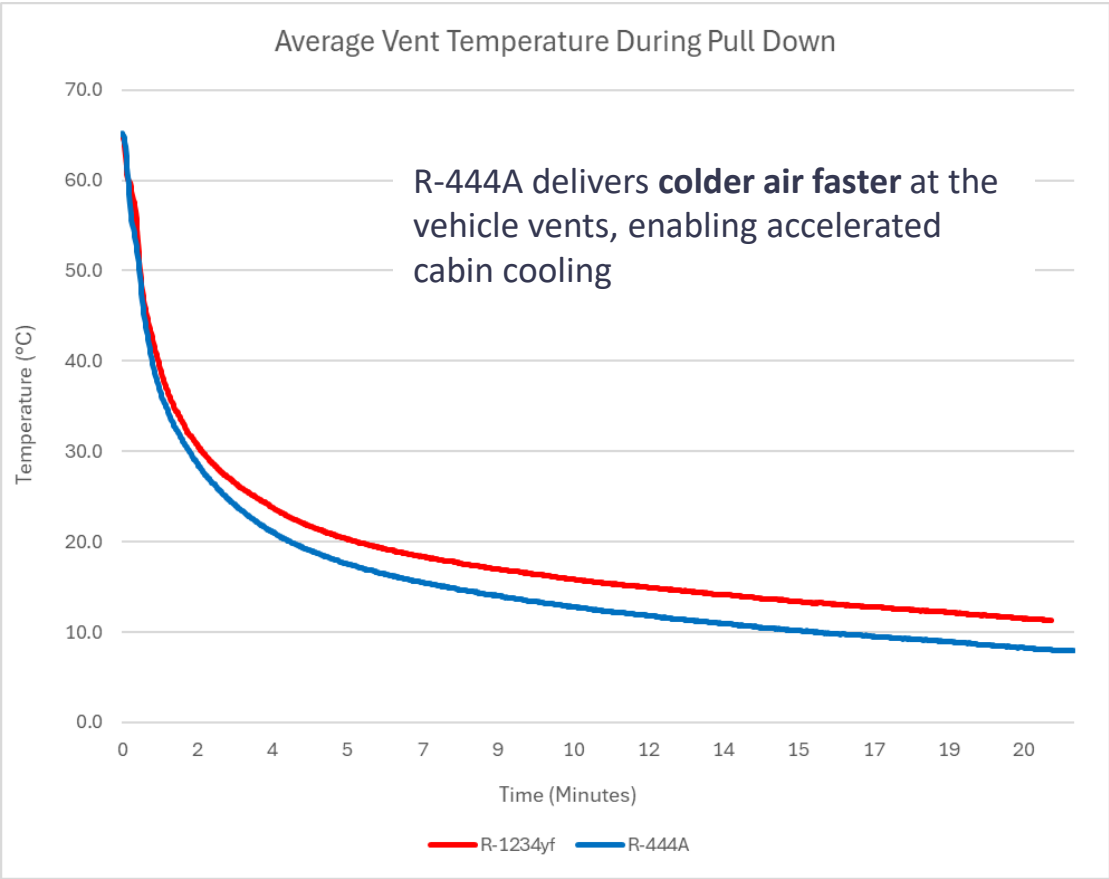


- **Ford**
 - PHEV testing confirmed improved cooling performance and significantly ~50% improved COP vs. YF in most conditions; IHX may be able to be removed (~30% higher COP vs. YF)
 - No evidence of meaningful composition variation throughout flow path (0-2°C in most conditions)
 - VIHP testing showed 14.5% improved capacity at -18C through increased heat transfer into coolant
 - COP is similar to YF at -18°C; system component and control strategy modification may be needed to optimize
- **Hyundai**
 - AC: 444A performance matches or exceeds YF with higher COP at equal capacity
 - HP: 444A performance matches or exceeds YF with 10% higher COP
 - Operates well at -20°C ambient
- **BMW**
 - 444A performance ~ YF
 - No negative impact due to evaporator glide by 444A to date
 - ZE showed significant performance shortfall vs. YF (15-25% lower)
- **Tesla**
 - +2% gain in peak cooling capacity under drop-in conditions, with 1% higher COP when replacing YF
 - At low load, COP ~ 10-15% lower than YF, supporting future testing and optimization

R-444A has demonstrated expected performance and efficiency gains, with future opportunities to optimize for future OEM systems

Vehicle Test with R-444A

R-444A: Faster comfort vs. R-1234yf



Source: Horiba Mira 3rd party pull down testing, Ford Kuga.



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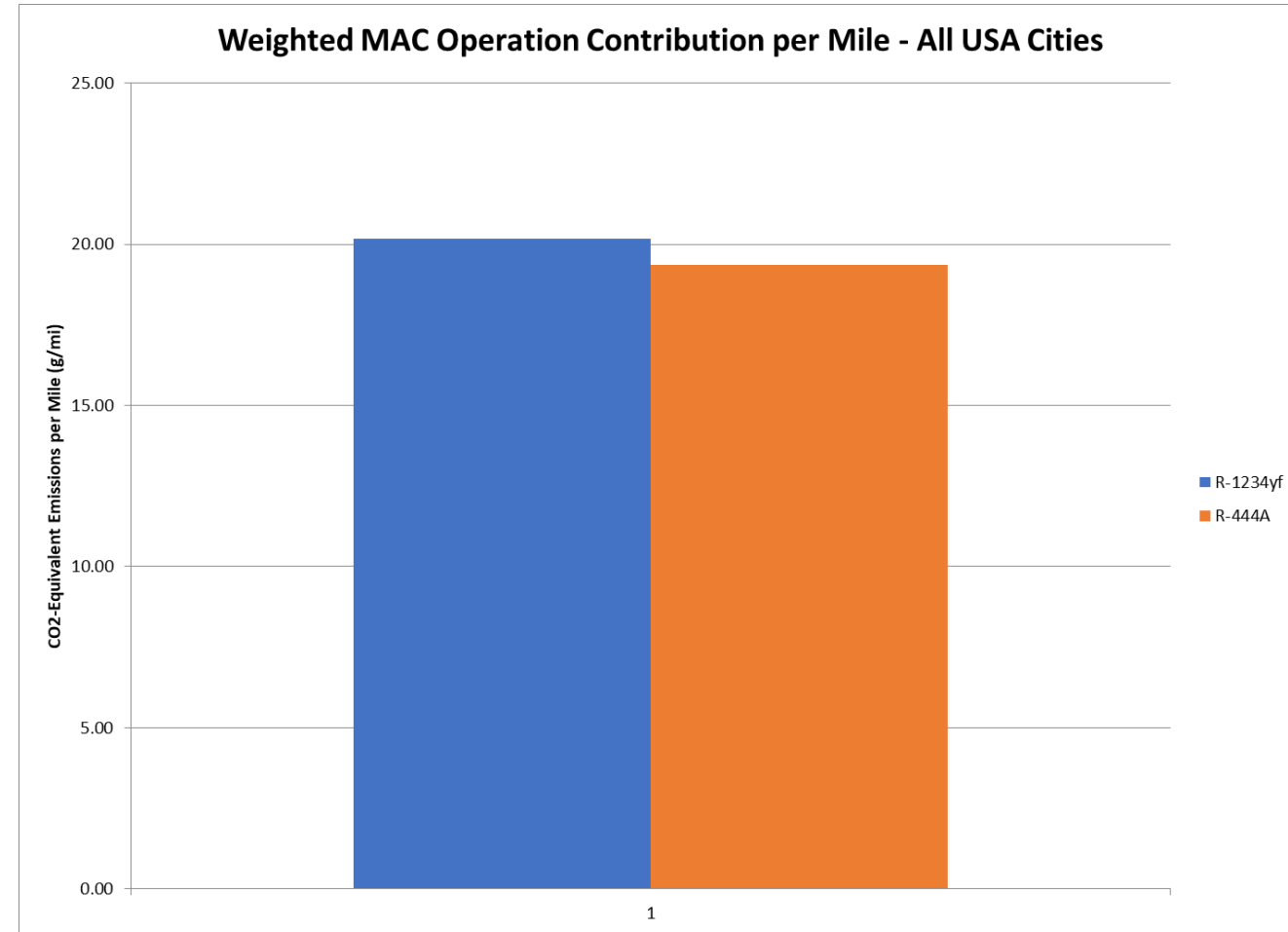
Quicker Comfort – Pull Down Test Results

Case Study: LCCP R-444A v R-1234yf

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GWP is only part of the story

- Life Cycle Climate Performance (LCCP) analysis sums direct emissions (GWP), indirect emissions (efficiency), and embodied emissions
- Below GWP 150, indirect emissions overtake direct as GWP is sufficiently low
- Analysis comparing R-444A with R-1234yf LCCP was conducted by Optimized Thermal Systems (OTS),
 - Cities analyzed were mix of US locations with various climates
 - E.g. Chicago, Houston, Phoenix, Anchorage
 - Due to lower boiling (bubble) point vs. YF, 444A showed a bigger advantage in colder climates



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Retrofit and Service

Service Equipment

Readiness by desired service participation level

Level 1 – Readiness for servicing vehicles having had a composite refrigerant installed ~\$1.5-1.8k

- Recovery pump meeting local standards (US standard is either J2843 or J3264)
- Recovery cylinder meeting local standards. If you want to keep known refrigerants separated for future in field recycling, dedicate one tank for each refrigerant
- R-444A ROI: $\$1.5k/\$400=3.75$ services; 20% of services are yf; Easily paid back if performing more than 19 A/C services/year

Level 2 – Level 1 readiness plus providing retrofit to composite refrigerants~\$2-2.5k

- Vacuum Pump (2+ CFM)
- Charging scale (with charging solenoid preferred)
- Gauge manifold set
- Service couplers for each composite refrigerant (US Only)
- Service fittings and adapters needed to connect to the retrofitted vehicle and to refrigerant cylinders or small cans
- R-444A ROI: $\$2k/\$400=5$ services; 20% of services are yf; Easily paid back if performing more than 25 A/C services/year

Level 3 – Ready to retrofit and service composite refrigerants using recover, recycle and recharge equipment~\$4-6k

- One “RRR” machine meeting local standards for **each** composite refrigerant to be serviced. Dual gas machines can be an option. SAE Standard J3374 development in process
- If repurposing a machine with a built-in refrigerant identifier, check with the manufacturer to see if the machine can be programmed to th composite refrigerant. If it cannot, you will need to disable the refrigerant identifier function.
- R-444A ROI: $\$6k/\$400=15$ services; 20% of services are yf; Easily paid back if performing more than 75 A/C services/year



All in one recover & recharge



Dual gas RRR machine

Retrofit & Service

Serviceability

Tools & Equipment

Service Equipment Needed

New Refrigerant	Old Refrigerant	*J2851 Recovery	J2788 RRR	J2843 RRR	*Vacuum Pump/Scale
R-456A	R-134a	X	X		X
R-444A	R-1234yf	X		X	X
R-480A	R-134a	X	X		X
R-1234yf	R-134a	Optional	X	X	
<i>* These can be used for multiple refrigerants as long as hoses and tanks are dedicated to the selected refrigerants</i>					

Internal Orbia testing indicates in field recycling is feasible for R-444A and R-456A



Refrigerant Retrofit SAE J3332

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Retrofit Steps

1. Using certified Refrigerant Recovery Recycling device for the refrigerant to be replaced, remove the refrigerant from the vehicle per proper device operation. Note the amount of oil removed
2. Adapt low and high side service port to those designed for the new refrigerant (as regionally required)
3. Place label for new refrigerant on or adjacent to the SAE J639 label per regional regulations
4. Complete any needed system repairs
5. Add specified oil based upon amount removed during recovery—This step can also be done with pressurized injector after charging



Vehicle service ports adapted for R-444A



Refrigerant Retrofit SAE J3332

6. Using dedicated equipment for the new refrigerant, connect to vehicle and vacuum system for 10 minutes
7. Vacuum leak test for 5 minutes. Continue to (8) if vacuum drops by less than 3 in/Hg (770 mm/Hg), otherwise, repeat step 7.
8. Using same equipment charge vehicle with new refrigerant by weight:
 - a. Set charging scale to 95-100% of either the R-134a or R-1234yf weight indicated on the J639 label or directed by OEM service information. Charge from R-444A or R-456A cylinder in **liquid state**. Start vehicle and turn A/C on Max. Observe pressures and ensure center vent temperature meets specification. Close high side coupler and allow the pressures to stabilize. Close low side coupler and disconnect from the vehicle.



Service Procedures

Composite Refrigerants – R-444A & R-456A

1. Assuming refrigerant is to be removed to effect repair, connect R444A or R456A Service Station to the vehicle.
2. Set for recovery*. The recovery process should remove oil and particulates from the refrigerant, condense the refrigerant and store in a standard recovery tank. Label tank with refrigerant name and refrigerant state--“Recovered R-XXXXA.”
3. Complete A/C system repair and leak check.
4. Using refrigerant specific Service Station, connect to high and low side service ports; set vacuum time to 10 minutes, or until it holds vacuum for 5 minutes dropping less than 3 in Hg/770 mm Hg.

*If during recovery, your RRR machine returns an error or contamination warning, follow these steps:

- 1) Determine if you plan to dedicate this machine to R444A.
- 2) If so, contact the equipment manufacturer for instructions to disable the refrigerant identifier.
- 3) The equipment manufacturer may also have a replacement identifier available for your current refrigerant identifier.
- 4) Additional options for recovery are repurposing an existing R134a machine or acquiring recovery only equipment.



Service Procedures

Composite Refrigerants – R-444A & R-456A

5. Set scale on Service Station to desired charge weight per J639 label or OEM repair information. Charge from liquid port.
6. Start vehicle and observe high and low side pressure and confirm desired center vent temperature is achieved. Close high side coupler allowing the pressures to stabilize. Close low side and remove couplers. Check for leaks.

Special Note: Best practice is to keep refrigerants separate. However, R-444A is compatible with R-1234yf, and the lubricants used in R-1234yf systems and R-456A is compatible with R-134a, and the lubricants used in R-134a systems. Vehicle warranties and local regulations should be consulted.



Field Trial Opportunity

Orbia is setting up field trials to get 444A and 456A to the street

- To meet near-term demand for lower cost, low-GWP alternatives, Orbia is setting up field trials with professional service partners
- 444A and 456A can be offered as service alternatives to 1234yf and 134a (respectively)
 - **Out of warranty vehicle focus**
- The allows pro service shops to offer a differentiated solution to their customers that saves them money and creates multiple consumer benefits:
 - 444A improves vehicle driving range and cooling performance over 1234yf and costs less
 - 456A allows 134a vehicles to remain in use longer
- Field trial provides the ability for marketing and PR materials with the [expected] positive consumer feedback

**Field trial positions partners at a leading position in the market
for next-generation composite refrigerants**



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