10-2010

R1234yf Refrigerant

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R1234yf Refrigerant

PRESENTED BY EUGENE TALLEY
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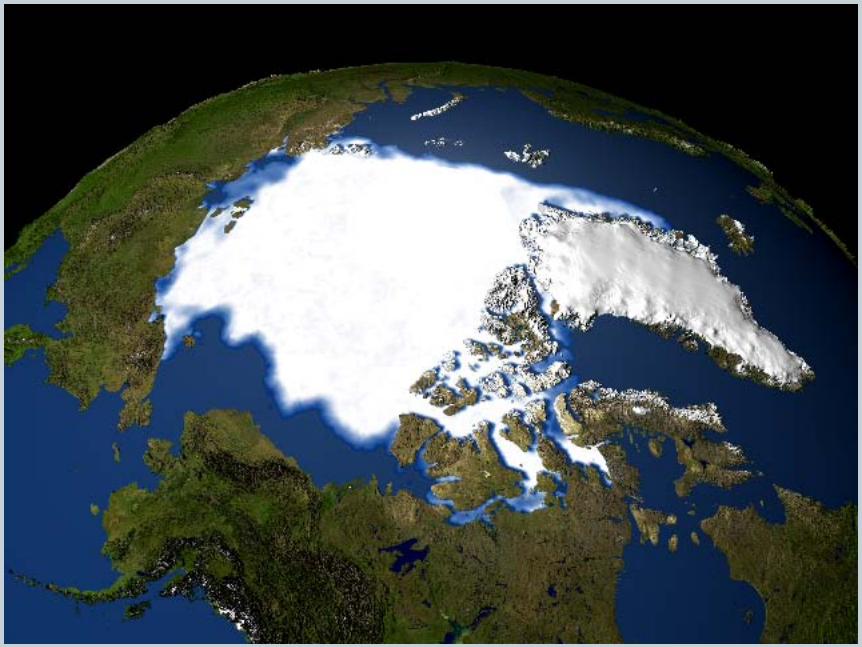
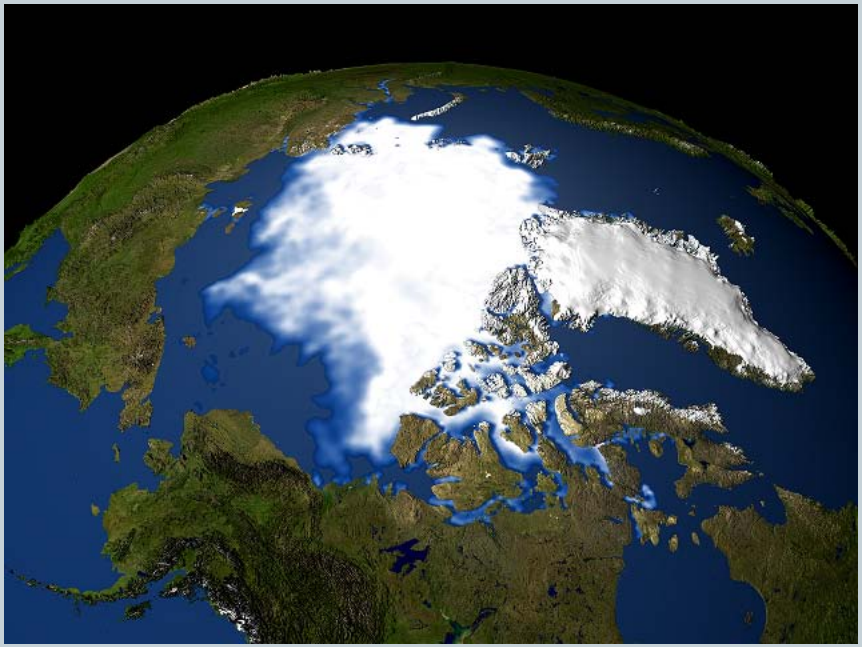
FALL 2010 ICAIA CONFERENCE

Why a new refrigerant?

- The U.S. and European governments are requiring the use of a refrigerant with a Global Warming Potential (GWP) of less than 150



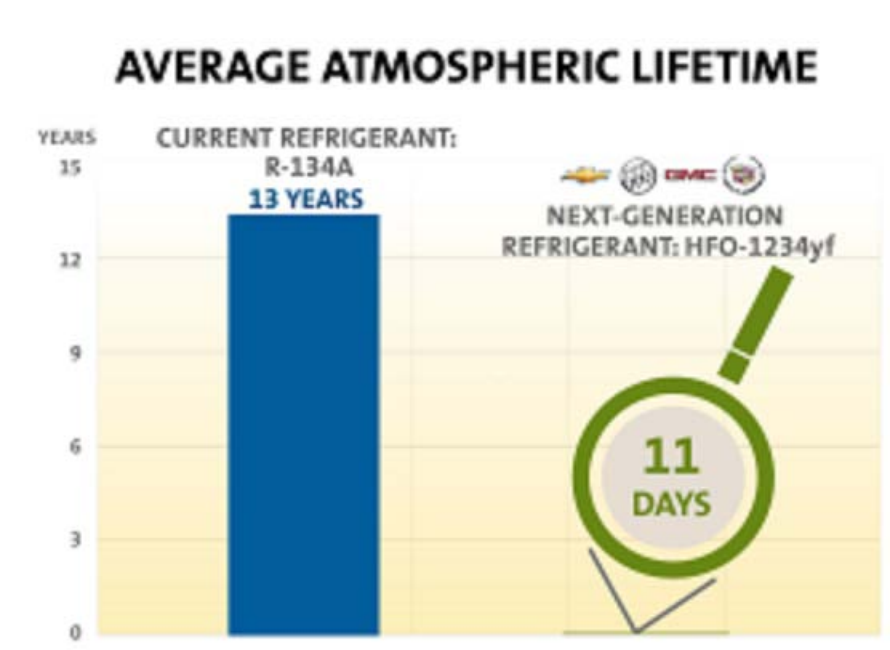
1979



2003

Why not R134A?

- The 100 year GWP for R134A is 1300
- Governments are looking for any and all ways to reduce greenhouse gasses and global warming



Why not R134A?

- By 2016 the EPA is requiring a corporate fleet average of less than 250 g/mile of CO_2 requirement
- A lower GWP refrigerant equals emissions credit for the manufacturer's fleet

What are the options?

R744

R1234yf

What about R744?

- The GWP is 1
- CO_2 is a part of the normal human respiratory process
- There is no recycling required
- Sounds good right?

What about R744? - The Downsides

- Operating pressures
  - May need to be in excess of 5x to 8x that of 134
  - Low pressures of 300-400 psi
  - High pressures around 1800 psi (normal operation)
- Due to pressures, completely new systems need to be designed
- The high pressures will require additional power to generate cooling. This can offset the GWP and CO_2 g/mile gains

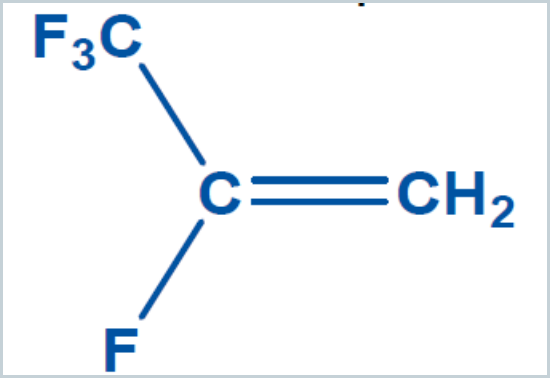
But what about R744? - The Downsides

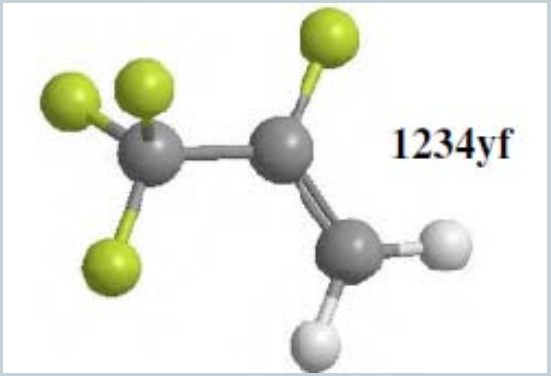
- How do you find a leak in a system where the gas leaking occurs naturally in the atmosphere
- An odorant would likely be required to ensure passengers stay safe
- If a leak were to occur in the evaporator, the CO_2 in the passenger compartment may become toxic to the passengers due to excessive quantities of CO_2

Carbon Dioxide is a powerful cerebral dilator. At concentrations between 2 and 10%, Carbon Dioxide can cause nausea, dizziness, headache, mental confusion, increased blood pressure and respiratory rate. Above 8% nausea and vomiting appear. Above 10%, suffocation and death can occur within minutes.

How about HFO-R1234yf

- HFO or Hydro-Floro-Olefin
  - 2,2,2,3 Tetrafluoropropene

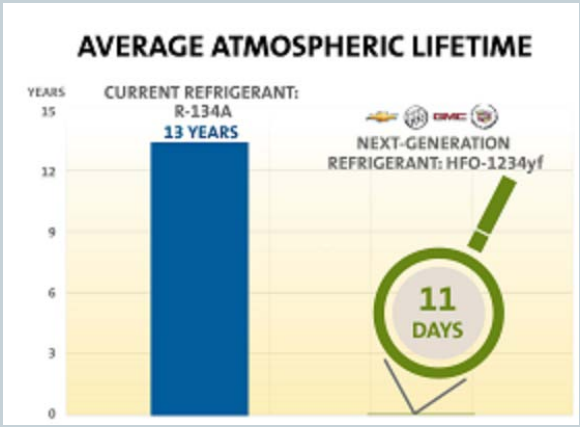




- May also be called Tetrafluoropropene

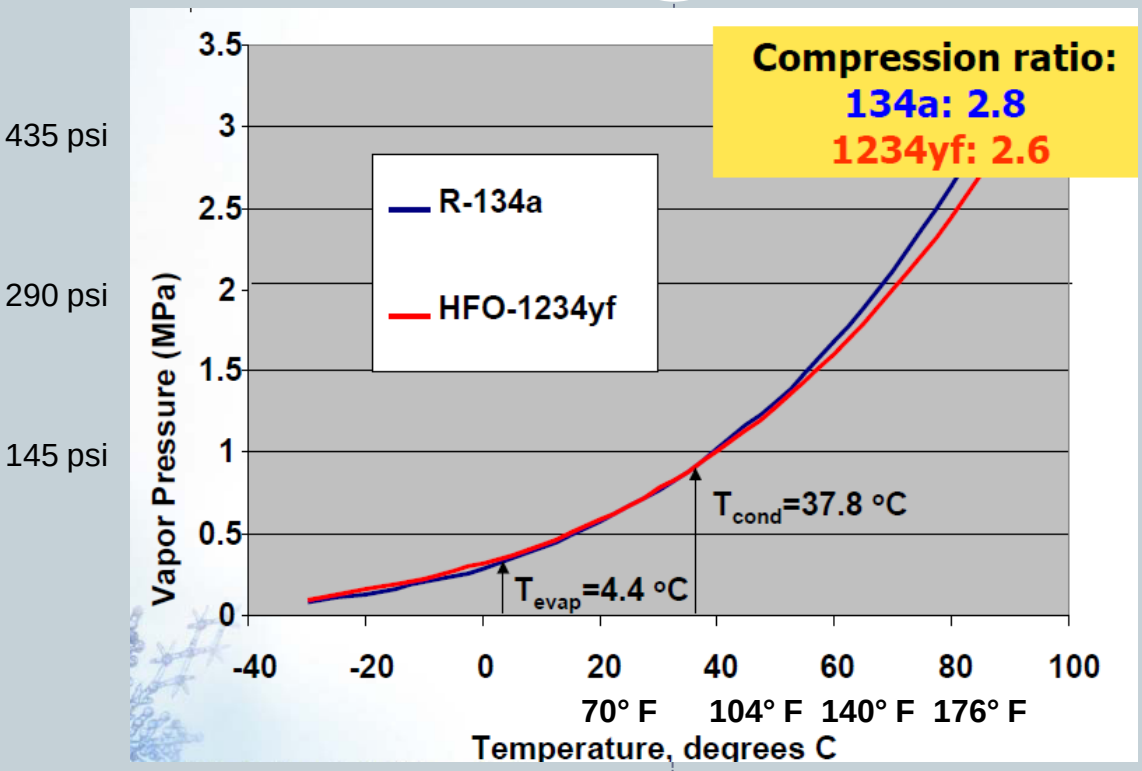
How about R1234yf

- The GWP for R1234yf is only 4 !



- Similar procedures and processes for R134A
  - Reduced training time
  - In some cases reduced need for new equipment

How about R1234yf



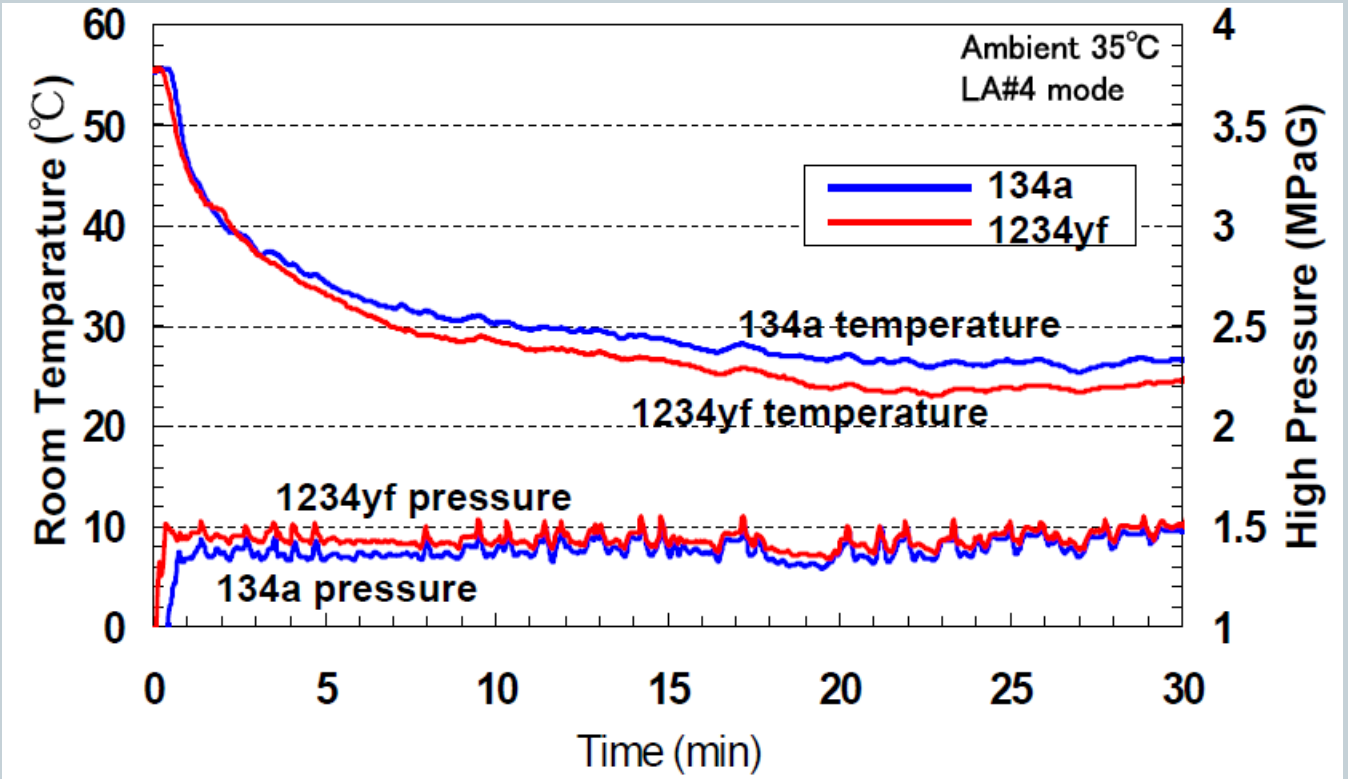
Cooling characteristics similar to R134A

How about R1234yf

- To compare R134A to R1234yf
  - The boiling point of R134A is -26° C (-14.4° F)
  - The boiling point for R1234yf is -29° C (-20.2° F)
- From a customer perspective there should be very little difference between the 2 refrigerants

How about R1234yf

Toyota 1234yf Drop-In Vehicle Test



1234yf pulls down to cooler temperature than R134a indicating higher cooling capacity. Pressures are similar.

R1234yf Components

- R1234yf may require about a 5% increase in refrigerant vs. R134A
- This is according to Fiat, who is going to be using it in Europe

R1234yf Components

- R1234yf will NOT be backwards compatible to R134A systems

- Current indications are that the current R134A compressors will not work with R1234yf
- However the new R1234yf compressors can be used on R134A systems

R1234yf Components

- Information released to date indicates use of “re-tuned” TXVs
- Orifice tubes have not shown up in any of the test studies (JAMA, Visteon, DuPont)

R1234yf Components

- Testing to date has found that the same desiccant type and quantity works with R134A and R1234yf

R1234yf Components

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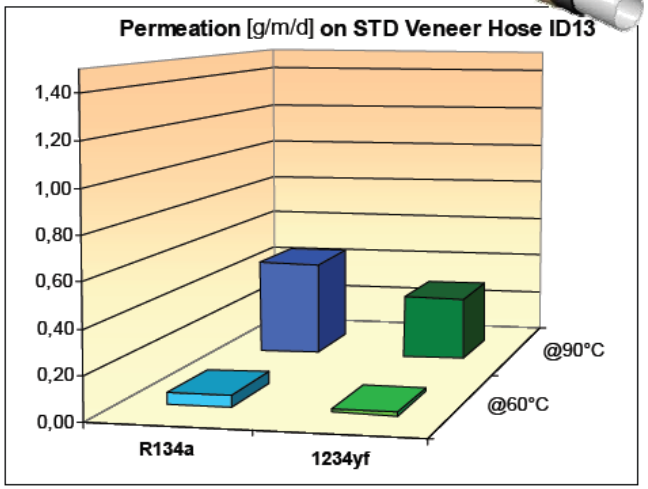
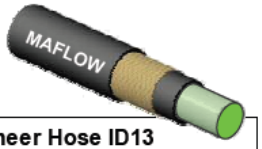
Permeation HFO-1234yf vs R-134a

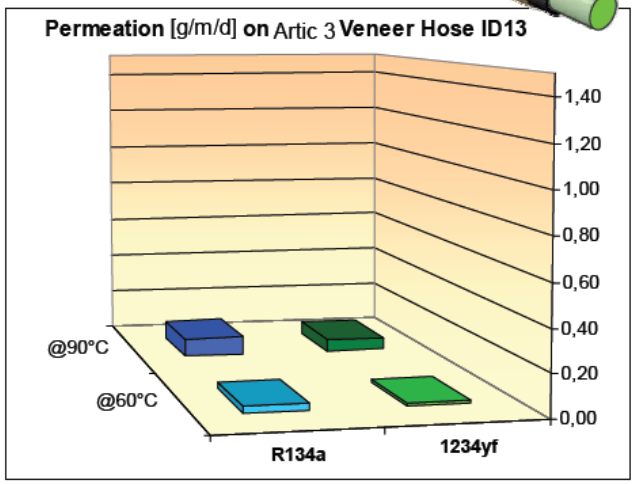
Honeywell

Standard Veneer Hose



ULEV Veneer Hose





Results

R1234yf shows lower permeability values toward Veneer hoses compared to R134a.

Remarks

With the same gas concentration (0.6g/cm³) the inner pressure with R1234yf is lower (e.g: at 90°C was -20%)

MAFLOW

R1234yf Components

HFO-1234yf: Excellent Plastics Compatibility

ND8 PAG at 100°C for two weeks

Refrigerant	Plastics	Rating	24 h Post Weight Chg. %	Physical Change
HFO-1234yf	Polyester	1	4.4	0
"	Nylon	1	-1.5	1
"	Epoxy	1	0.3	1
"	Polyethylene Terephthalate	1	2.0	0
"	Polyimide	0	0.2	0

Refrigerant	Plastics	Rating	24 h Post Weight Chg. %	Physical Change
R134a	Polyester	1	5.6	0
"	Nylon	1	-1.4	1
"	Epoxy	1	0.3	1
"	Polyethylene Terephthalate	1	2.8	0
"	Polyimide	0	0.7	0

Rating 0 = best when weight gain < 1 and physical change = 0
1 = borderline when weight gain > 1 and < 10 and/or physical change upto 2
2 = incompatible when weight gain > 10 and/or physical change = 2

R1234yf Components

HFO-1234yf: Excellent Elastomers Compatibility

ND8 PAG at 100°C for two weeks

Refrigerant	Elastomers	Rating	24 h Post Linear Swell %	24 h Post Weight Gain %	24 h Post Delta Hardness
HFO-1234yf	Neoprene WRT	0	0.0	-0.3	1.0
"	HNBR	0	1.6	5.5	-7.0
"	NBR	0	-1.2	-0.7	4.0
"	EPDM	0	-0.5	-0.6	4.0
"	Silicone	1	-0.5	2.5	-14.5
"	Butyl rubber	0	-1.6	-1.9	0.5

Refrigerant	Elastomers	Rating	24 h Post Linear Swell %	24 h Post Weight Gain %	24 h Post Delta Hardness
R134a	Neoprene WRT	0	-0.6	-1.3	2
"	HNBR	0	2.1	8.6	-5.5
"	NBR	0	0.0	3.0	-3.5
"	EPDM	0	-1.1	-0.4	-2
"	Silicone	0	-1.4	1.4	-2.5
"	Butyl rubber	0	-1.1	-1.6	-3.5

Rating

0 < 10% weight gain and < 10% Linear swell and < 10 hardness unit change
1 > 10% weight gain or > 10% Linear swell or >10 hardness unit change
2 > 10% weight gain and > 10% Linear swell and > 10 hardness unit change

Oil required for R1234yf

- The current indications are that a PAG oil will be used
- The current R134A PAG oils will not work with R1234yf

Oil required for R1234yf

- Sanden is developing 2 new PAG oils to be used with R1234yf
  - SP-A1 will be used with mechanical compressors
  - SP-A2 will be used with mechanical and electrical compressors

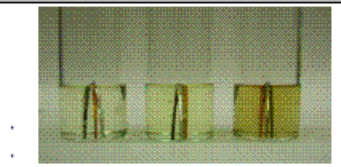
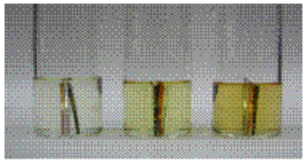
Oil required for R1234yf

- A study by JAMA, found that the use of POE (Ester) oils with R1234yf caused a increased level of acidity in the system when moisture was present

Oil required for R1234yf

- **Stability Test Result** Oil:POE2 (Serial POE for Stationary AC) Temperature:175 , 200 °C

ANSI/ASHRAE97-1999 Proposed Spec <3.3

Refrigetant		R134a			1234yf		
Moisture	ppm	<10	1000	10000	<10	1000	10000
Temperature	°C	175					
Oil appearance photograph							
Oil appearance		Maize	Maize	Maize	Maize	Maize	Maize
Sludge		Not Co.	Not Co.	Not Co.	Not Co.	Not Co.	Not Co.
Total Acid Number (mgkoh/g)		0.00	0.10	21.4	0.05	1.18	21.1
Temperature	°C	200					
Oil appearance photograph							
Oil appearance		colorless	Maize	Maize	Colorless	Maize	Maize
Sludge		Not Co.	Not Co.	Not Co.	Not Co.	Not Co.	Not Co.
Total Acid Number (mgkoh/g)		0.00	0.21	22.3	0.06	2.84	21.2

Oil required for R1234yf

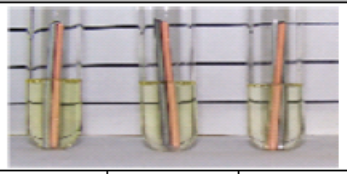
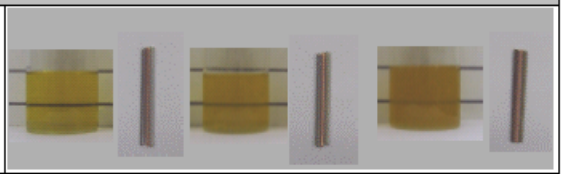
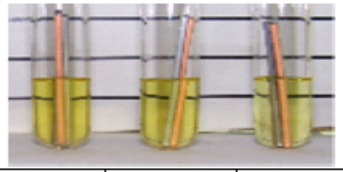
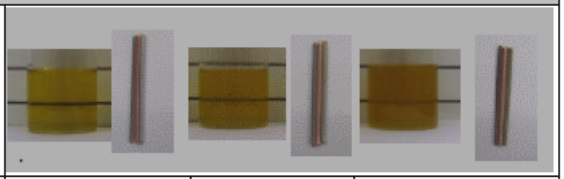
Stability Test Result

Oil:PAG1 (Serial PAG for MACs)

Temperature:175 , 200 °C

Proposed Spec <3.3

ANSI/ASHRAE97-1999

Refrigetant		R134a			1234yf		
Moisture	ppm	<10	1000	10000	<10	1000	10000
Temperature	°C	175					
Oil appearance photograph							
Oil appearance		Maize	Maize	Maize	Yellow	Yellow	Yellow
Sludge		Not Co.	Not Co.	Not Co.	Not Co.	Not Co.	Not Co.
Total Acid Number (mgkoh/g)		0.03	0.82	1.75	1.40	2.44	3.04
Temperature	°C	200					
Oil appearance photograph							
Oil appearance		Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Sludge		Not Co.	Not Co.	Not Co.	Not Co.	Not Co.	Not Co.
Total Acid Number (mgkoh/g)		1.28	1.15	2.19	2.88	3.49	3.22

For Hybrid Use

- Based on Honeywell's own study R1234yf has nearly the same electrical properties as R134A

Electrical Properties

	R-134a	HFO-1234yf
Liquid Dielectric Constant @ 21.3°C	9.8 (1), 9.0 (2), 9.2 (3)	7.7 (1)
Resistivity, MOhms.m	9.6(1) 7.3 (2)	3.4 (1)

Data References:

1. Honeywell measurements
2. A. Sekiya & S. Misaki, Journal of Fluorine Chemistry; 101 (2000) pp 215-221
3. C. Meurer, G. Pietsch & M. Haacke, International Journal of Refrigeration, 24 (2001) pp 171-175

R1234yf Toxicity

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Acute Toxicity Exposure Limit

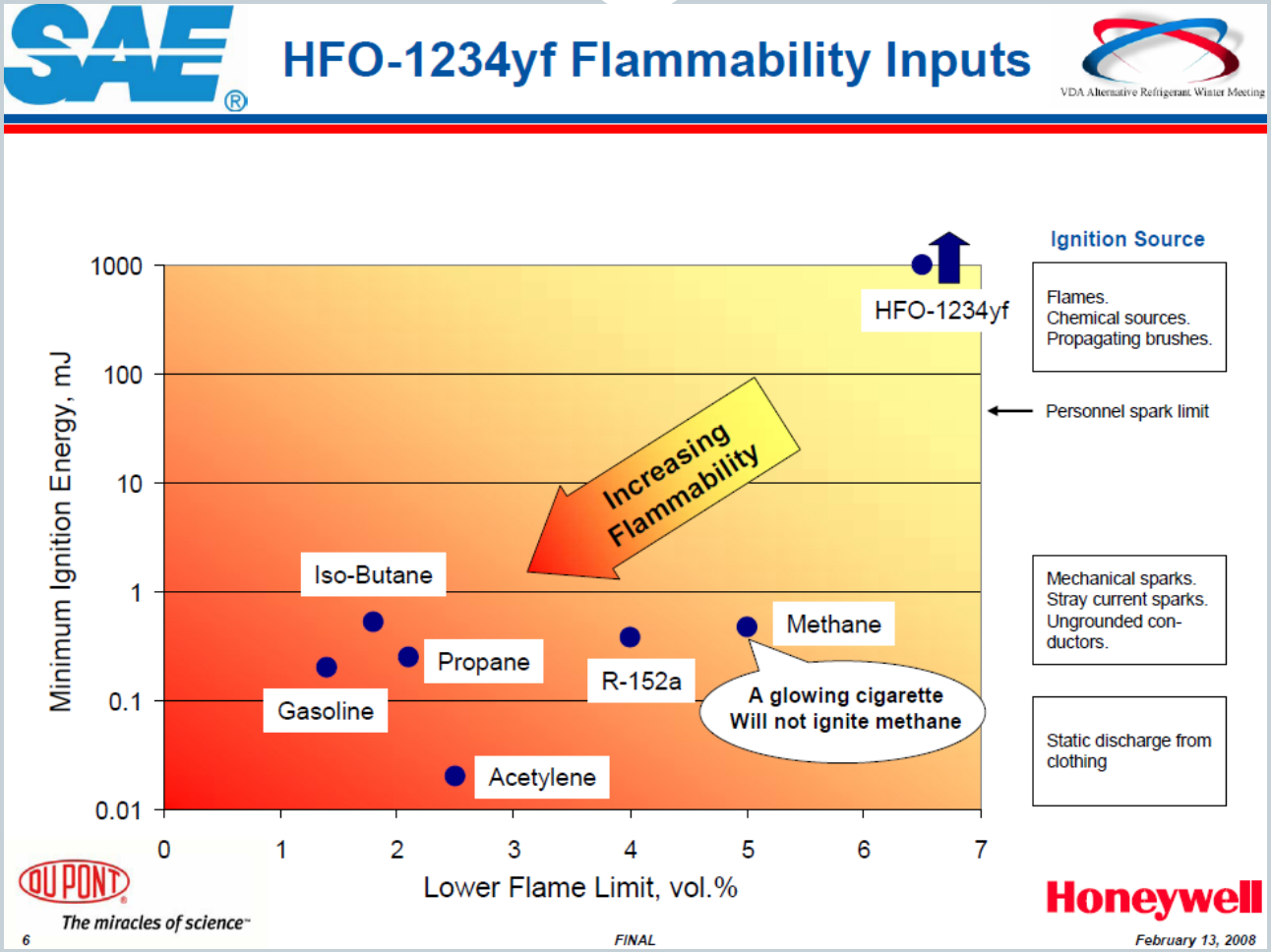
- It provides an estimate of the maximum exposure limit for a short time period (≤30 minutes) with no adverse health effects.
- HFO-1234yf developmental test results have no impact on ATEL value.

Refrigerant	ATEL (ppm)
R-12	18,000
R-134a	50,000
R-152a	50,000
CO_2	40,000
HFO-1234yf	101,000

HFO-1234yf Has a Favorable ATEL Value – Short Term Tox Exposure Not an Issue for Collisions, Accidental Releases

The Acute Toxicity Exposure Limit (ATEL) is a value used by Standards organizations (e.g., ASHRAE 34, ISO 817) to establish the maximum refrigerant concentration limit for a refrigerant in air. It is calculated from the acute toxicity data using methods determined in accordance with the Standards.

R1234yf Flammability



R1234yf Flammability

HFO-1234yf FTA Scenarios Outputs

VDA Alternative Refrigerant Winter Meeting

- Risk of potentially adverse exposure associated with a small/medium/large leak into passenger compartment
- Risk of potentially adverse exposure associated with a leak due to vehicle collision
- Risk of potentially adverse exposure associated with a leak during vehicle repair
- Risk of fires due to refrigerant release under these conditions
  - with a small/medium/large leak into passenger compartment
  - with a leak in engine compartment
  - with a leak during vehicle repair by professional service technicians
  - with a leak during vehicle repair by DIYers

R1234yf Flammability

Passenger Compartment Vehicle Ignition Test

VDA Alternative Refrigerant Winter Meeting

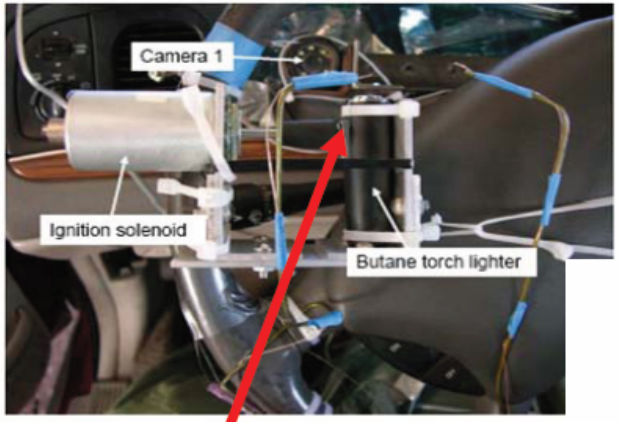


Figure 12 Close-up view of butane torch lighter assembly

Ignition source: butane lighter

No Ignition!

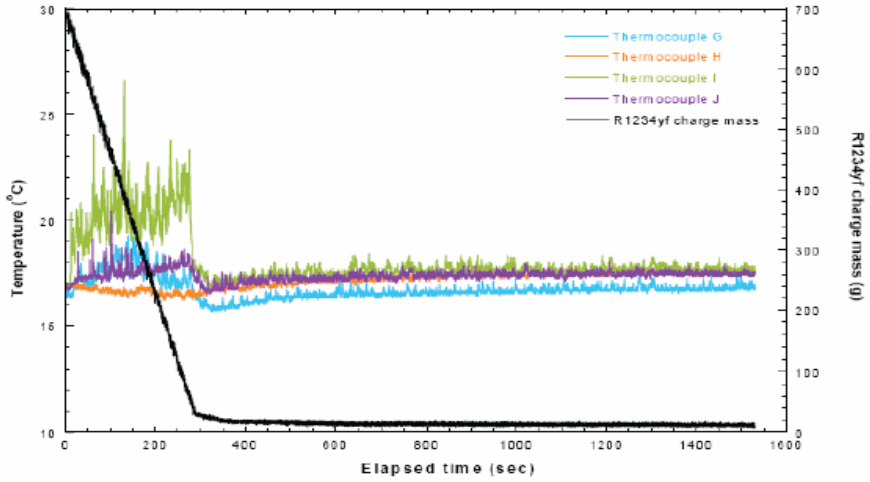


Figure 23 Passenger compartment ignition test (PCI Test 1) Temperature and R1234yf discharge mass versus elapsed time

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R1234yf Flammability

Engine Compartment Ignition Test

VDA Alternative Refrigerant Winter Meeting

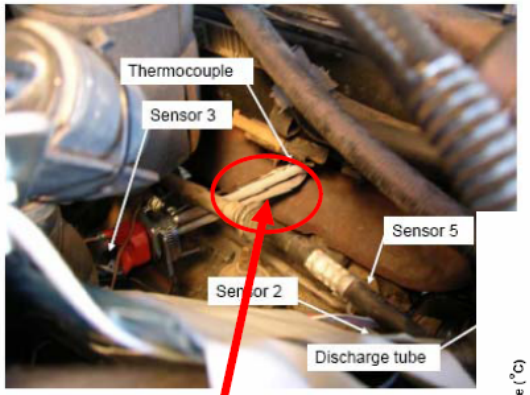

Figure 13 Heating element ignition source in engine compartment

No Ignition!

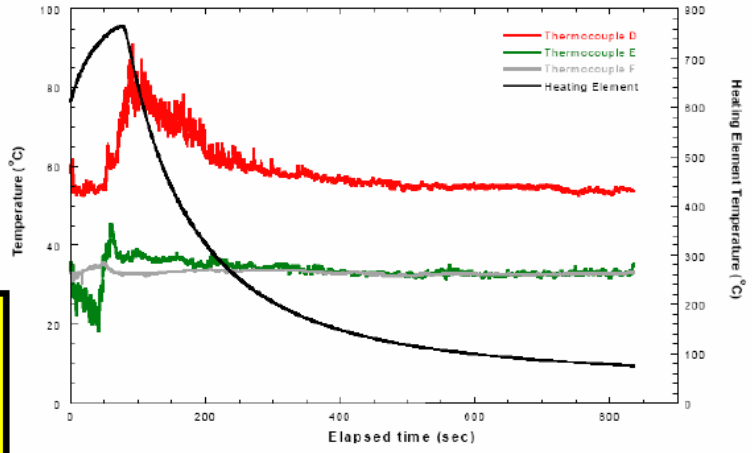

Figure 32 Engine compartment ignition test (ECI Test 1) – Thermocouple and heating element temperature versus elapsed time

Ignition source: heating element at 600-750°C

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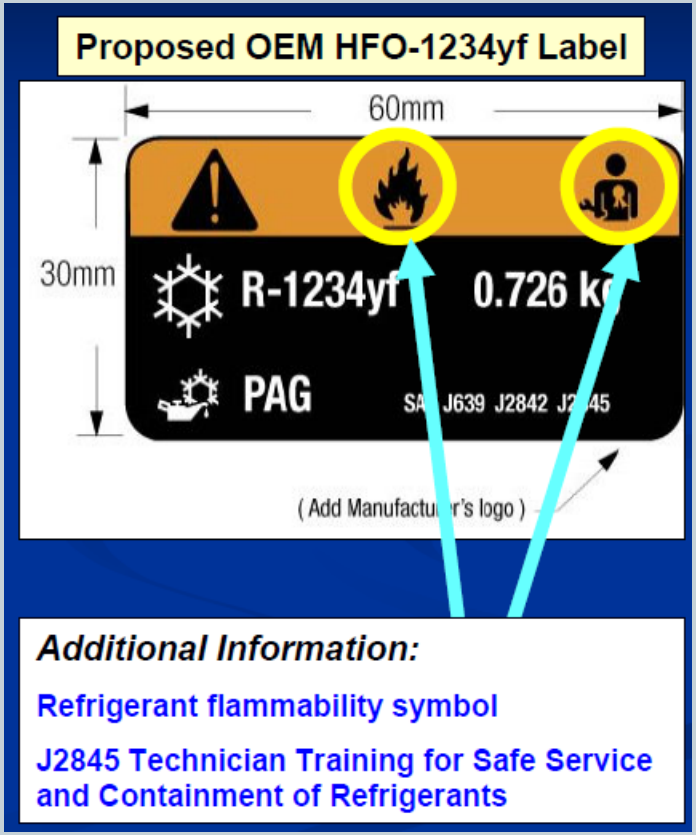
R1234yf Flammability



Equipment for R1234yf

- Yes, you will need a new Recovery/Recycle/ Recharge machine
- R1234yf can be recycled in the same manner R134A has been in the past

Equipment for R1234yf

- Refrigerant Identifiers
  - Some Neutronics equipment will work with a software update
  - In some cases new equipment will be required

Equipment for R1234yf

- Leak detection equipment that meets the J2791 standard will work with R1234yf

Equipment for R1234yf

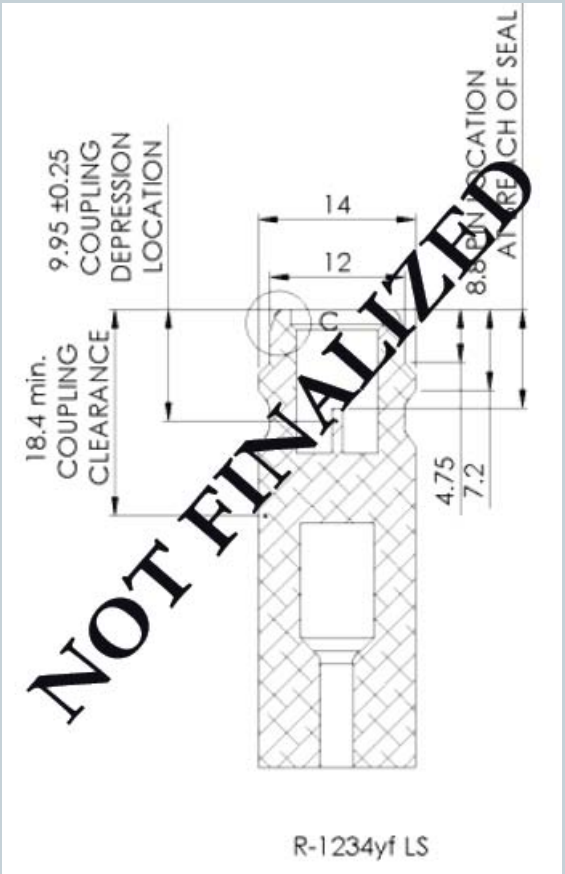
- Dye will be an acceptable method for leak detection, however the dye required will not be the same as the one you use with R134A today

R1234yf Handling

- Similar size containers compared to R134A
- Possible disposable and returnable containers
  - Disposable containers limited to approximately 2 lbs
- Returnable container sizes may be 2, 5, 10, 20, and 30 lb sizes

R1234yf Handling

- Quick disconnects used on European models are similar to R134A, however smaller in size



Costs

- Current cost estimates for R1234yf are approximately $35-40 a pound
- Future R134A supplies may be taxed to a rate equal to R1234yf
- This is to prevent the use of R134A in R1234yf systems

Timeline

Europe	United States
• Usage to begin in 2011 • Must be used on any “new” vehicle • Phase in complete by 2017	• GM announced a 2013 launch • Most manufacturers will shoot for 2016 when the new fleet fuel economy regulation starts

Suggested websites

- www.MACSW.orgwww.org
- www.refrigerants.dupont.comwww.com
- www.SmartAutoAC.com
- www.genetron.com
- www.arkema-inc.com
- www.1234facts.com

Conclusion

This presentation will be posted at:

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Questions, Comments: etalley@siu.edu