

HFO-1234yf

Industry Update

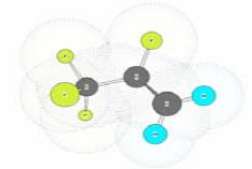
February 6, 2009

Dr. David P. Wilson, Honeywell
Mary Koban, DuPont

- Most Auto OEMs continue strong support of HFO-1234yf as the leading MAC alternative
- Major milestones have been achieved through cooperative industry effort and open sharing of results
 - Toxicity/Environmental testing (Independent world class labs)
 - Risk assessments for flammability and health (SAE CRP-1234), (JAMA, European Alliance,)
 - System performance/LCCP evaluations (OEMs, JAMA, SAE CRP-1234)
 - Materials compatibility/durability testing (SAE CRP-1234-2, JAMA, OEMs, Tier 1s and 2s)
 - Registration (REACH, SNAP, ASHRAE, etc)

- Recently completed developmental and reproductive studies have shown that HFO-1234yf will not be classified a developmental or reproductive toxin.
- HFO-1234yf has recently been approved as a Class A refrigerant by ASHRAE.
- HFO 1234yf WEEL was adopted at 500 ppm (8-hr TWA) by the AIHA WEEL Committee. AIHA Standards expects this assignment to be published in the 2009 set of WEELs.
- **After independent review of all toxicology test results, DuPont and Honeywell have concluded that HFO-1234yf is safe to commercialize for use in MAC.**
- Furthermore, industry risk assessments of various potential exposure scenarios have also concluded HFO-1234yf is safe for use in mobile AC applications.

- 2,3,3,3-tetrafluoroprop-1-ene (Cas 754-12-1)
 - Registered under REACH Directive 67/548/EEC (Elincs) , VII-A status
 - EC #: **468-710-7**
 - Threshold 10 MT p.a. (50 MT cumulative)
 - Honeywell REACH Registration #: 01-0000019665-61-0000
 - Notification is company specific
 - DuPont has been granted access to Honeywell notification
- Update required once next tonnage threshold is reached (inform only)
- 1000+ T Update registration file is complete - submit February 2009
- ECHA has three weeks to conduct completeness check of each registration



*HFO-1234yf Registered Under REACH;
Data Threshold is 10 MT p.a.*

- HFO-1234yf SNAP application submitted to EPA and Letter of completeness issued July 8, 2008.
- If EPA has no significant issues, next steps are:
 - Draft a "Proposed Rule of Law" statement on HFO-1234yf and identify any conditions of use
 - Have the US OMB review and approve the Proposed Rule
 - Publish the Proposed Rule in the Federal Register
 - Have a public comment period for interested parties to make comments
 - Complete final EPA SNAP approval through publication of a Final Rule
- US EPA Industry Update
 - EPA found no significant regulatory barriers to use of flammable refrigerants in Europe, Japan, or other countries when investigating use of HFC-152a.
 - Sixteen US states removed ban on flammable refrigerants in MAC, 3 remain.
 - Alliance of Automobile Manufacturers is working with support of EPA to remove those barriers for SNAP listed refrigerants.

- ASHRAE SSPC 34 voted (1/09) to approve R-1234yf with Safety Classification A2 and requested immediate publication upon approval by ASHRAE Standards. Expect publication about March-April.
- ASHRAE SSPC 34 Flammability Subcommittee recommended publication public review of new 2L flammability classification group to be added to the Standard.
- ISO 817 draft Standard incorporating new 2L flammability classification approved at DIS stage and will be going out for p-member country vote in 2009. Expect publication as ISO standard in late 2010, HFO-1234yf ISO classification assignment afterwards.
- SAE ICCC Committee developing Safety Standards for HFO-1234yf.
- New ISO Working Group (ISO/TC22/WG14) started to develop an ISO safety requirements standard for use of HFO-1234yf and CO2 for MAC; final publication targeted for 1st Half 2011.

Summary

- HFO-1234yf flammability characteristics are much more favorable than those of hydrocarbon gases or HFC-152a.
- US Codes for storage and handling of flammable liquefied gases provide specific treatment for hydrocarbon gases; need to develop guidelines for mildly flammable gases.
- US Electrical Codes exempt ammonia due to its mild flammability and high MIE.
- SAE working with UL to determine electrical equipment specifications for HFO-1234yf.
- Guidance from existing US Codes such as NFPA 58, NPFA 59A and NFPA 1 may be overly conservative with regard to HFO-1234yf on storage and handling.

What's Next?

- Work with NFPA, the refrigerants industry, and auto industry to properly incorporate mildly flammable refrigerant, HFO-1234yf
- SAE J-Standards in various stages of completion to meet 2011 deadline
- ASHRAE 34 and ISO 817 Classification standards for A2L refrigerants under development

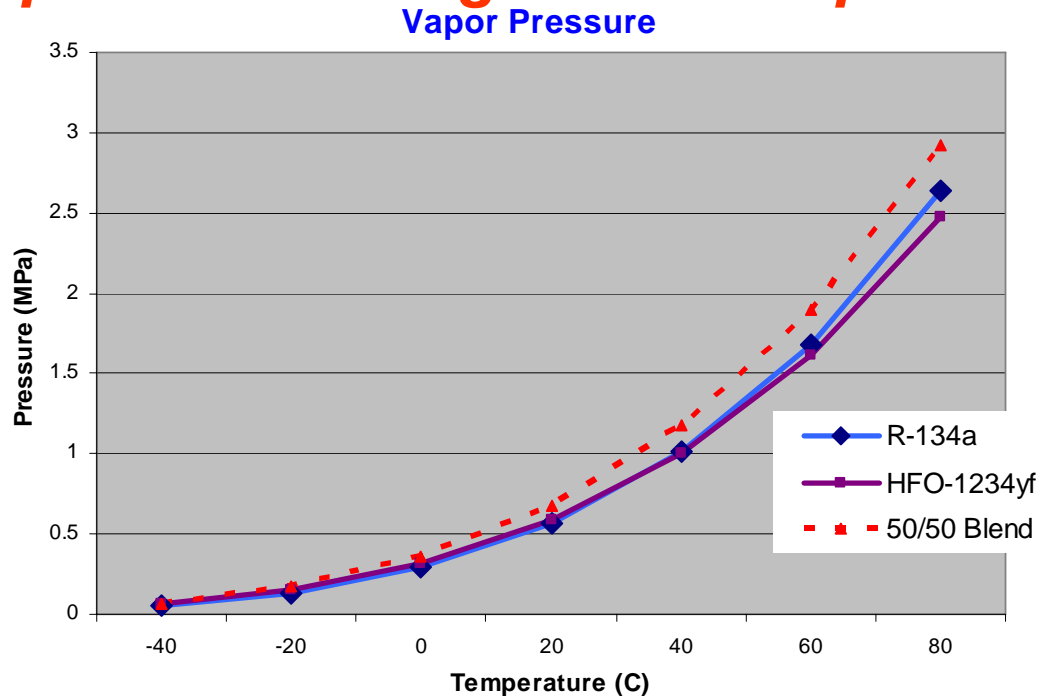
HFO-1234yf Will Be Handled Similar to R-134a

- Distribution of HFO-1234yf along supply chain similar to R-134a
- Minor changes to plant charging equipment and procedures
- Can be recovered, recycled and reused on site at service shops
- Leaks can be detected with same equipment as R-134a
- Unique fittings will be used ensure no cross contamination with R-134a

Recovery Networks/Service Shops

- Third party recovery networks expected to function similar to HFC-134a
- HFO-1234yf can be reclaimed/recycled on site.
- Slightly modified R/R/R equipment, same procedure.

Modest pressure change does not pose safety risk



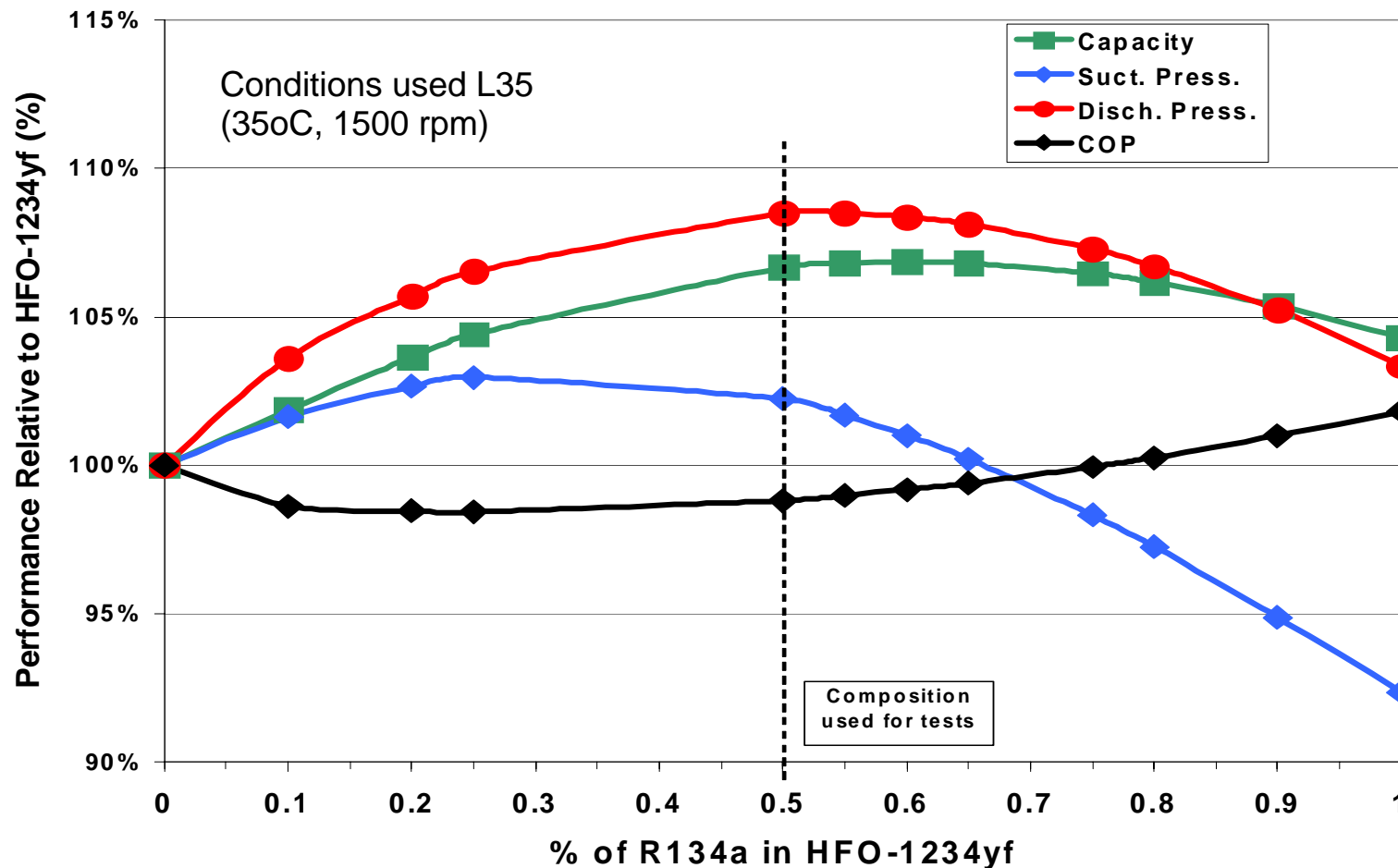
What will happen if HFO-1234yf is accidentally mixed with HFC-134a?

- Minimal pressure effect, but will alter P-T relationship for servicing
- Potential impact on R/R/R segments (ease of separation, ARI 700 purity specs)
- Resulting blend will have small glide and may still be flammable

Regulations, training, industry Standards needed to prevent mixing of HFC-134a and HFO-1234yf during servicing

Performance Impacts of Mixing HFC-134a with HFO-1234yf

- System simulations conducted at various compositions
- Experimental verification also done for severe case of 50/50 composition



- **Results show pressures increase, but less than R12/R134a mixtures**
- **Slight shifts in capacity, COP**

Service Shops

- Service technicians need additional information on proper use/storage/handling of mildly flammable refrigerants
 - HFO-1234yf MSDS
 - Honeywell/DuPont Safe Handling Guidelines
 - SAE J Standards
 - Appropriate industry certification according to local/regional/country guidelines
 - As part of process, working with industry organizations to develop appropriate material for use in training/certification programs
 - **MACSW will give an update on this process later today**
 - Recovery machines will need to be rated for flammables (non-sparking controls).
 - Several companies already have products in development
 - Refrigerant identifiers need to be modified for use with HFO-1234yf
 - Several companies already have products in development



The miracles of science

Refrigerant Material Compatibility



HFO-1234yf Plastics Compatibility

ND8 PAG at 100°C for two weeks

Refrigerant	Plastics	Rating
HFO-1234yf	Polyester	1
"	Nylon	1
"	Epoxy	1
"	Polyethylene Terephthalate	1
"	Polyimide	0

Refrigerant	Plastics	Rating
HFC-134a	Polyester	1
"	Nylon	1
"	Epoxy	1
"	Polyethylene Terephthalate	1
"	Polyimide	0

Rating

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

HFO-1234yf Elastomers Compatibility

ND8 PAG at 100°C for two weeks

Refrigerant	Elastomers	Rating
HFO-1234yf	Neoprene WRT	0
"	HNBR	0
"	NBR	0
"	EPDM	0
"	Silicone	1
"	Butyl Rubber	0

Refrigerant	Elastomers	Rating
HFC-134a	Neoprene WRT	0
"	HNBR	0
"	NBR	0
"	EPDM	0
"	Silicone	0
"	Butyl Rubber	0

Rating

0 <10% wt gain and <10% linear swell and <10 hardness change
 1 >10% wt gain or >10% linear swell or >10 hardness change
 2 >10% wt gain and >10% linear swell and >10 hardness change

Honeywell and DuPont Utilize State of the Art, World-Class Manufacturing Processes :

- Latest State of the Art Process Control Technology– will minimize process upsets that could result in unnecessary emissions
- Leak Detection and Repair Program – Quantitative, scheduled leak detection from valves, flanges, and seals to identify and reduce fugitive emissions
- Eliminate point source vents of organic materials
- Zero leak waste philosophy

Additional Steps to Minimize Environmental Impact of HFO-1234yf Production

- Utilize State of the Art Computer Modeling in Plant Design – Will Ensure design minimizes energy consumption
- Continuous Waste Minimization Program – DuPont and Honeywell plants maintain numerous projects to reduce wastes for continuous improvement
- Comprehensive Raw Material Yield monitoring program – Identifies And Corrects potential operating inefficiencies on a daily basis

- HFO-1234yf met all key technical customer criteria to be adopted for MAC
 - Safety (Toxicity/Flammability)
 - **Toxicity (DuPont – Honeywell)**
 - **Risk Assessments (SAE CRP, JAMA)**
 - System performance
 - **SAE CRP 1234yf evaluations, OEMs, and some Tier 1s**
 - Environmental/LCCP evaluations (OEMs, JAMA, SAE CRP-1234)
 - **Various LCCP evaluations done showing LCCP benefit of HFO-1234yf compared to HFC-134a and CO2**
 - Materials compatibility/durability testing
 - **SAE CRP-1234-2, JAMA, OEMs, Tier 1s and 2s**
 - Regulatory approvals underway (REACH, SNAP, ASHRAE, etc)

- **Excellent environmental properties**
 - Very low GWP of 4, Zero ODP, lowest LCCP
 - Atmospheric chemistry determined and published
- **Low toxicity**
 - Low acute and chronic toxicity
 - Significant testing completed
- **System performance very similar to R-134a**
 - Excellent COP and Capacity, no glide
 - From both internal tests and OEM tests
 - Thermally stable and compatible with R-134a components
 - Potential for direct substitution of R-134a
- **Mild flammability (manageable)**
 - Flammability properties significantly better than 152a; (MIE, burning velocity, etc)
 - Potential for “A2L” ISO 817 classification versus “A2” for 152a based on AIST data
 - Potential to use in a direct expansion A/C system - better performance, lower weight, smaller size than a secondary loop system
- **Global Solution**
 - Good performance in all climates
 - Compatibility with current technology allows for rapid global adoption

For further information on HFO-1234yf please visit:

- www.genetron.com
- www.1234facts.com
- www.refrigerants.dupont.com
- www.SmartAutoAc.com

Thank you!

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