HFO-1234yf
Industry Update
February 6, 2009

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Mary Koban, DuPont
Industry Update

• 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.**

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
Handling/Recyclability

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/R equipment, same procedure.
Accidental Mixing

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 Readiness

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
### HFO-1234yf Plastics Compatibility

**ND8 PAG at 100°C for two weeks**

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>Plastics</th>
<th>Rating</th>
</tr>
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<tbody>
<tr>
<td>HFO-1234yf</td>
<td>Polyester</td>
<td>1</td>
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<tr>
<td>&quot;</td>
<td>Nylon</td>
<td>1</td>
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<tr>
<td>&quot;</td>
<td>Epoxy</td>
<td>1</td>
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<tr>
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**Rating**

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

### HFO-1234yf Elastomers Compatibility

**ND8 PAG at 100°C for two weeks**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>HFO-1234yf</td>
<td>Neoprene WRT</td>
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<tr>
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<td>EPDM</td>
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<tr>
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<td>Silicone</td>
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<tr>
<td>&quot;</td>
<td>Butyl Rubber</td>
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**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 Technology and Regulatory Summary

• 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](http://www.genetron.com)
- [www.1234facts.com](http://www.1234facts.com)
- [www.refrigerants.dupont.com](http://www.refrigerants.dupont.com)
- [www.SmartAutoAc.com](http://www.SmartAutoAc.com)
Thank you!

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