HFO-1234yf
A Low GWP Refrigerant For MAC
Honeywell / DuPont Joint Collaboration

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• DuPont And Honeywell Have Identified HFO-1234yf (CF₃CF=CH₂) As The Preferred Low GWP Refrigerant Which Offers The Best Balance Of Properties And Performance

• Other Industry Options Have Certain Limitations
  – CO₂: complexity, energy efficiency and requires mitigation
  – 152a / secondary loop: performance, size and weight

Honeywell and DuPont are focused on HFO-1234yf
• **Excellent environmental properties**
  – Very low GWP of 4, Zero ODP, Favorable LCCP
  – Atmospheric chemistry determined and published

• **Low toxicity, similar to R-134a**
  – 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
Excellent Environmental Properties

- ODP = 0
- 100 Year GWP = 4 \( (\text{GWP}_{134a} = 1300) \)
  - Atmospheric lifetime = 11 days
  - Atmospheric chemistry measured
    - Atmospheric breakdown products are the same as for 134a
    - No high GWP breakdown products (e.g. NO HFC-23 breakdown product)
    - Results published in 2008
- Good LCCP
### Significant Toxicity Information Available

<table>
<thead>
<tr>
<th>Test</th>
<th>HFO-1234yf</th>
<th>134a</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Acute Lethality</td>
<td>No deaths 400,000 ppm</td>
<td>No deaths 359,700 ppm</td>
</tr>
<tr>
<td>• Cardiac sensitization</td>
<td>NOEL &gt; 120,000 ppm</td>
<td>NOEL 50,000 ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LOEL 75,000 ppm</td>
</tr>
<tr>
<td>• 13 week inhalation</td>
<td>NOEL 50,000 ppm</td>
<td>NOEL 50,000 ppm</td>
</tr>
<tr>
<td>• Developmental (Rat)</td>
<td>NOAEL 50,000 ppm</td>
<td>NOAEL 50,000 ppm</td>
</tr>
<tr>
<td>• Genetic Toxicity</td>
<td>Not Mutagenic</td>
<td>Not Mutagenic</td>
</tr>
<tr>
<td>• 13 week genomic (carcinogenicity)</td>
<td>Not active (50,000 ppm)</td>
<td>Baseline (50,000 ppm)</td>
</tr>
<tr>
<td>• Environmental Tox</td>
<td>NOEL &gt; 100 mg/L (Pass)</td>
<td>NOEL &gt; 100 mg/L (Pass)</td>
</tr>
</tbody>
</table>

**HFO-1234yf Has Low Toxicity**
ATEL Calculation

- ATEL (Acute Toxicity Exposure Limit) is a value used by standards organizations (e.g. ASHRAE 34) to reduce the risks of acute toxicity hazards in normally occupied spaces.
- It is calculated from the acute toxicity data for a given refrigerant and provides an estimate of the maximum exposure limit for a short time period (e.g. 30 minutes)

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>ATEL (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-12</td>
<td>18,000</td>
</tr>
<tr>
<td>R-134a</td>
<td>50,000</td>
</tr>
<tr>
<td>R-152a</td>
<td>50,000</td>
</tr>
<tr>
<td>CO₂</td>
<td>40,000</td>
</tr>
<tr>
<td>HFO-1234yf</td>
<td>101,000</td>
</tr>
</tbody>
</table>

HFO-1234yf Has a Favorable ATEL Value
• No changes were made to system including TXV; Industry standard test conditions
• Both Capacity and COP are generally within 5% of 134a performance.
  – This was recently confirmed at two outside labs.
• Lower compression ratio, low discharge temperature
  (12°C lower at peak conditions)
• Further improvements likely with minor system optimization, for example:
  – Lower $\Delta P$ suction line and / or TXV optimization to maintain a more optimum superheat.

**HFO-1234yf performance is comparable to 134a; further improvement possible with minor optimization**
Preliminary LCCP Analysis

GM Model Using Bench Test Performance Results
Relative to R-134a

Average 15% Better LCCP Values; Up to 27% in Europe
JAMA and FIAT Obtained Similar Results
Summary

- Low Charge, High Pressure, Heated Compressor Environment, 2000 RPM, 400 hour test
- No change detected in either refrigerant or lubricant chemistry
  - Initial and final oil sample TAN < 0.1
  - Refrigerant purity remained at 99.8% with no change in trace impurities.
- Wear is same as in a 134a system
- Polishing is seen on the Front and Rear Shaft Bearings & Rear Thrust Bearing
- Swash-plate polymer coating is intact and shows only minor wear
- Results confirmed in compressor tests by Sanden

Compressor Wear Same as 134a
**Results**
HFO-1234yf shows lower permeability values toward Veneer hoses compared to R134a.

**Remarks**
With the same gas concentration (0.6g/cm³) the inner pressure with HFO-1234yf is lower (e.g: at 90°C was -20%)
Refrigerant Flammability Tests

• Is it flammable? If yes, Flame Limits will exist.
  – LFL – lower flammability limit
  – UFL – upper flammability limit

• What is the probability of an ignition source being present of sufficient energy to cause an ignition?
  – Autoignition temperature
  – Minimum ignition energy (MIE)

• What is the impact (damage potential) if an ignition occurs?
  – Heat of combustion
  – Burning velocity
HFO-1234yf Flame Limits

LFL Values
- Ammonia 15 vol.%
- HFC-32 13.3 vol.%
- HFO-1234yf 6.5 vol.%
- Methane 4.6 vol.%
- HFC-152a 3.9 vol.%
- Ethylene Oxide 3.0 vol.%
- Acetylene 2.5 vol.%
- Propane 2.1 vol.%
- Gasoline 1.6 vol.%

- HFO-1234yf flame limits measured using ASTM E681-04 T= 21°C : 6.5 vol.% to 12.3 vol.%
- Low LFL value → more flammable
- Wider UFL – LFL → more flammable

ASTM E681 Apparatus
- Air In
- Refrigerant In
- Spark Ignition
- Stirrer

- ASTM E-681 in US
  - 2004 version cited by ASHRAE (12 liter flask, spark ignition)
  - Flame must reach the wall and exhibit > 90 degree angle
  - 1985 version cited by SAE (5 liter flask, match ignition)

- A11 in EU
  - 5 cm x 30 cm Vertical tube
  - Spark ignition
  - Flame travels up the tube

HFO-1234yf Is Less Flammable Than 152a
Burning Velocity Measurements

- Measurements performed in 3 liter spherical apparatus
- Experimental result for HFO-1234yf: 1.5 cm s⁻¹
- ISO 817 Flammability Classification is 2L (lowest flammable class classification)
Minimum Ignition Energy

- 12-liter glass sphere used in ASTM E681 flammability limit tests was modified for MIE testing in order to eliminate potential wall quenching effects seen in standard 1 liter vessel

- Materials Tested:
  - HFC-32 from 16-22% (v/v) in 1% increments at 30 and 100 mJ nominal
  - HFO-1234yf from 7.5-11% (v/v) in 0.5% increments up to 1000 mJ nominal
  - Ammonia at 22% (v/v) at 100 and 300 mJ nominal

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>No Ignition Occurred</th>
<th>Ignition Occurred</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFC-32</td>
<td>30 +/- 12 mJ</td>
<td>100 +/- 30 mJ</td>
</tr>
<tr>
<td>Ammonia¹</td>
<td>100 +/- 30 mJ</td>
<td>300 +/- 100 mJ</td>
</tr>
<tr>
<td>HFO-1234yf</td>
<td>5,000 +/- 350 mJ</td>
<td>10,000 +/- 350 mJ</td>
</tr>
</tbody>
</table>

*HFO-1234yf Is Very Difficult To Ignite With Electrical Spark*
HFO-1234yf Mild Flammability Properties

### Flammability Properties

<table>
<thead>
<tr>
<th></th>
<th>LFL&lt;sup&gt;a&lt;/sup&gt; (vol%)</th>
<th>UFL&lt;sup&gt;a&lt;/sup&gt; (vol%)</th>
<th>(\Delta) (vol%)</th>
<th>MIE (mJ)</th>
<th>BV&lt;sup&gt;c&lt;/sup&gt; (cm/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propane</td>
<td>2.2</td>
<td>10.0</td>
<td>7.8</td>
<td>0.25</td>
<td>46</td>
</tr>
<tr>
<td>R152a</td>
<td>3.9</td>
<td>16.9</td>
<td>13.0</td>
<td>0.38</td>
<td>23</td>
</tr>
<tr>
<td>R32</td>
<td>14.4</td>
<td>29.3</td>
<td>14.9</td>
<td>30-100&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.7</td>
</tr>
<tr>
<td>Ammonia</td>
<td>15</td>
<td>28</td>
<td>13</td>
<td>100-300&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.2</td>
</tr>
<tr>
<td>HFO-1234yf</td>
<td>6.5</td>
<td>12.3</td>
<td>5.8</td>
<td>&gt;1,000&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.5</td>
</tr>
</tbody>
</table>

<sup>a</sup>Flame limits measured at 21 C, ASTM 681-01

<sup>b</sup>Tests conducted in 12 litre flask to minimize wall quenching effects

<sup>c</sup>Burning Velocity ISO 817 (HFO-1234yf BV measured by AIST, Japan)

### Flammability Index

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>F</th>
<th>RF</th>
<th>RF2</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFO-1234yf</td>
<td>0.97</td>
<td>0.27</td>
<td>3.6</td>
<td>0.6</td>
</tr>
<tr>
<td>32</td>
<td>1.31</td>
<td>0.33</td>
<td>4.6</td>
<td>2.3</td>
</tr>
<tr>
<td>152a</td>
<td>1.78</td>
<td>0.5</td>
<td>16.6</td>
<td>17.9</td>
</tr>
<tr>
<td>Propane</td>
<td>1.99</td>
<td>0.55</td>
<td>56.7</td>
<td>37.2</td>
</tr>
</tbody>
</table>

\[
R = \frac{Cst}{LFL}
\]

\[
F = 1 - \sqrt[2]{\frac{LFL}{UFL}}
\]

\[
RF = \left[ \frac{UFL}{LFL} - 1 \right] × \frac{Q}{M}
\]

\[
RF^2 = \left( \sqrt{UFL × LFL} - LFL \right) × Qst × Su × M
\]

\[Cst = \text{Stoichiometric composition in air, vol.\%}\]

\[Q = \text{Heat of Combustion per one mole}\]

\[Qst = \text{Heat of Combustion per one mole of the Stoichiometric mixture, kJ/mol}\]

\[Su = \text{Burning speed in Meters/Second}\]

\[M = \text{Molecular weight}\]
• The autoignition temperature of HFO-1234yf was determined at Chilworth Technology in UK.
  – Uniformly heated 500 ml glass flask, observed in dark for 10 mins.
  – Autoignition temperature for HFO-1234yf determined to be 405°C.

• Note that the air refrigerant mixture must be at this temperature for ignition to occur.

• Experiments were conducted to evaluate the ignition potential of hot surfaces (up to 800°C) to cause ignition.
  – 6 mm steel plate heated from behind with propane-oxygen torch
  – No ignition seen

• HFO-1234yf vapor sprayed onto the plate
• Infrared Thermometer measured temperature.
  • Three “dots” seen are to aim the thermometer
• Occasional red circles are diffraction rings from the camera lens reflecting the red plate through the refractive index gradient (caused by hot air / cold refrigerant).
## Summary of Hot Plate Tests

<table>
<thead>
<tr>
<th></th>
<th>Hot Manifold</th>
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<tbody>
<tr>
<td></td>
<td>550°C</td>
</tr>
<tr>
<td></td>
<td>Faint Red</td>
</tr>
<tr>
<td></td>
<td>800°C</td>
</tr>
<tr>
<td></td>
<td>Cherry Red</td>
</tr>
<tr>
<td></td>
<td>&gt;900°C</td>
</tr>
<tr>
<td></td>
<td>Orange</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Compound</th>
<th>Spray No oil</th>
<th>Premixed with air no oil</th>
<th>Premixed with air PAG oil</th>
<th>R-134a</th>
<th>Spray no oil</th>
<th>Premixed with air no oil</th>
<th>Premixed with air PAG oil</th>
<th>HFO-1234yf</th>
<th>Spray No oil</th>
<th>Premixed with air no oil</th>
<th>Premixed with air PAG oil</th>
<th>R-134a</th>
<th>Spray no oil</th>
<th>Premixed with air no oil</th>
<th>Premixed with air PAG oil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No ignition</td>
<td>Not tested</td>
<td>No ignition</td>
<td>No ignition</td>
<td>No ignition</td>
<td>No ignition</td>
<td>No ignition</td>
<td>Ignition</td>
<td>No ignition</td>
<td>No ignition</td>
<td>No ignition</td>
<td>No ignition</td>
<td>Ignition</td>
<td>No ignition</td>
<td>No ignition</td>
</tr>
<tr>
<td>HFO-1234yf</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-134a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

*HFO-1234yf shows same flammability behavior as R-134a - Ignition due to presence of oil*
A potential ignition source for potentially flammable refrigerant/air leaks in passenger compartment of cars is a spark caused by a short circuit from a 12-V battery located under the seat.

The purpose of these tests is to determine whether such a spark is capable of igniting an ‘optimum’ concentration of HFC1234yf in air.

Follow procedures from ASTM E681 to prepare a well-blended refrigerant/air mixture of a known concentration in a sealed 12-l spherical flask; add moisture equivalent to 50% RH at 23°C.

Create a short-circuit in the mixture by discharging a high-capacity 12-V automotive battery (1020 cranking amps) across 9.5 mm diameter copper electrodes located in the sphere.

Perform tests for 8.13, 8.5, and 9.0% HFC-1234yf concentrations at 20°C, 60°C and 80°C; non-ignitions to be confirmed by nine (9) additional trials.
Battery Ignition Apparatus

12-l Sphere Containing 1234yf/Air

9.5 mm Stationary Copper Electrode

Moveable 9.5 mm Copper Electrode

Automotive Cables

High Current 12-V Switch

12-V/1020 CA Battery
Battery Ignition Results

- **No ignitions** observed at 8.13, 8.5, and 9.0% HFC-1234yf at either 20°, 60° or 80°C (10 trials per concentration)
- For comparison the ignitability of ammonia, a refrigerant of relatively low flammability, was tested at a 20% v/v concentration at 20°C and 60° C; positive test was obtained on the first trial
Passenger Compartment Evaluations

• As shown in the previous charts, the flammability parameters were conducted under very tightly controlled conditions.
  – Well mixed, uniform concentration of refrigerant and air.
  – Stagnant, not flowing environment.
  – Fixed conditions (e.g. temperature)

• In actual applications these conditions do not exist.

• Evaluations both experimental and with computer simulations were conducted to try to more closely approximate real world conditions.
• Good agreement between prediction and measurements.

• No increase in flame length from butane lighter.

• No flame from Electrical Arc.

<table>
<thead>
<tr>
<th></th>
<th>60 sec</th>
<th></th>
<th>360 sec</th>
<th></th>
<th>600 sec</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CFD</td>
<td>Test</td>
<td>CFD</td>
<td>Test</td>
<td>CFD</td>
</tr>
<tr>
<td>Vent</td>
<td>1.0</td>
<td>0.2</td>
<td>3.5</td>
<td>3.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Floor</td>
<td>1.5</td>
<td>1.4</td>
<td>4.1</td>
<td>3.6</td>
<td>4.5</td>
</tr>
<tr>
<td>Butane Lighter</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Elec. Arc</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>
Extreme Leak Results: No Ignition with Arc Welder

- With simulated ruptured tube leak
  - No ignition with arc welder on floor (simulating battery ignition source)
  - No ignition with arc welder at vent outlet (simulating PTC heater ignition source)
## Results of Mock-up Flammability Tests

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Test Description</th>
<th>Ignition Source</th>
<th>Time of Ignition</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Large Corrosion Leak (0.5 mm diameter)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Cigarette lighting at breath level</td>
<td>Butane lighter</td>
<td>After leak starts</td>
<td>No Ignition - only flame color change noted</td>
</tr>
<tr>
<td>2</td>
<td>Pooling Test- no blower operation</td>
<td>Arc welder on floor</td>
<td>Four minutes after end of leak</td>
<td>No Ignition</td>
</tr>
<tr>
<td>3</td>
<td>Cigarette Lighting at Vent Outlet</td>
<td>Butane lighter</td>
<td>After leak starts</td>
<td>No Ignition - only flame color change noted</td>
</tr>
<tr>
<td></td>
<td><strong>Ruptured Tube Leaks (6.4 mm diameter)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Cigarette lighting at breath level</td>
<td>Butane lighter</td>
<td>After leak starts</td>
<td>Butane lighter failed to light.</td>
</tr>
<tr>
<td>5</td>
<td>Simulation of battery short</td>
<td>Arc welder on floor</td>
<td>After leak starts</td>
<td>No ignition</td>
</tr>
<tr>
<td>6</td>
<td>Simulation of PTC heater short</td>
<td>Arc welder at vent outlet</td>
<td>After leak starts</td>
<td>No ignition</td>
</tr>
<tr>
<td>7</td>
<td>Cigarette Lighting at Vent Outlet</td>
<td>Butane lighter</td>
<td>After leak starts</td>
<td>Butane lighter failed to light.</td>
</tr>
<tr>
<td>8</td>
<td>Cigarette lighting at breath level</td>
<td>Butane lighter</td>
<td>At start of leak for entire leak event</td>
<td>Minor flame extension</td>
</tr>
<tr>
<td>9</td>
<td>Cigarette Lighting at Vent Outlet Lighter held on for typ lighting time</td>
<td>Butane lighter</td>
<td>At start of leak for 5 secs</td>
<td>No flame extension</td>
</tr>
</tbody>
</table>
CFD Modeling & Flammability Testing Conclusions

• CFD Modeling
  – Good agreement for refrigerant concentration profiles between CFD and mock-up tests

• Mock-up test results
  – Ignition of HFO-1234yf did not occur, even with:
    • worst case leak representing evaporator rupture where LFL was exceeded
    • high energy ignition sources (butane lighter and arc welder)
  
• Results of hot surface tests at 800 C simulating engine compartment hot manifold showed no ignition.
  – Consistent with engine compartment test results from the CRP-1234 program

• No ignition occurred from 12V battery spark

• This is likely due to low burning velocity and high MIE of HFO-1234yf which makes it difficult to sustain and propagate a flame

**HFO-1234yf Flammability Risk is Very Low**
For most fires to happen, fuel and air at the right concentration, and an ignition source, with a sufficient energy level must co-exist at the same place and in the same time.

Several risk assessments have been completed or are in progress in US (SAE CRP-1234), Japan (JAMA) and Europe utilizing inputs of modeling and leak experiments.

- Release Experiments
  - Cabin and underhood
  - Normal operation and crash condition
  - Service (Professional and DIY)

- CFD modeling to visualize concentration distribution for various scenarios.
## Table 26. Risks of Injury or Fatality from Various Events Compared to Risks Associated with Leaks of HFO-1234yf

<table>
<thead>
<tr>
<th>Risk</th>
<th>Risk per year</th>
<th>Citation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk of stroke</td>
<td>$2.7 \times 10^{-3}$</td>
<td>Rhys Williams, 2001</td>
</tr>
<tr>
<td>Fatal accident in the home</td>
<td>$1.1 \times 10^{-4}$</td>
<td>Wilson and Crouch, 1987</td>
</tr>
<tr>
<td>Fatal accident while climbing mountains (if mountaineer)</td>
<td>$6 \times 10^{-4}$</td>
<td>Wilson and Crouch, 1987</td>
</tr>
<tr>
<td>Risk of being injured as a pedestrian</td>
<td>$2.1 \times 10^{-5}$</td>
<td>NSC, 2004</td>
</tr>
<tr>
<td>Fatal injury at work (all occupations)</td>
<td>$3.6 \times 10^{-5}$</td>
<td>NSC, 2004</td>
</tr>
<tr>
<td>Injury from lightning strike</td>
<td>$1 \times 10^{-6}$</td>
<td>NWS, undated**</td>
</tr>
<tr>
<td>Risk of being fatally injured in an elevator ride</td>
<td>$2 \times 10^{-7}$</td>
<td>McCann and Zalesky, 2006</td>
</tr>
<tr>
<td><strong>Risk of exposure to HFO-1234yf above health based limits resulting from a collision</strong></td>
<td>$1 \times 10^{-10}$</td>
<td>CRP1234 Analysis</td>
</tr>
<tr>
<td><strong>Risk of being injured by an HFO-1234yf ignition resulting from a collision</strong></td>
<td>$2 \times 10^{-11}$</td>
<td>CRP1234 Analysis (updated since VDA mtg.)</td>
</tr>
</tbody>
</table>

*Risk cited is 1 in 10,000 over the next century

# Injury sufficiently serious to require hospital visit. Based on number of injuries per year divided by total U.S. adult population.

§ Total number of injuries requiring hospital visit per year divided by the total U.S. population.

** Total number of documented injuries from lightning strikes per year, divided by total U.S. population.

& FTA risk multiplied by the number of estimated drivers in the U.S.
### Some Key SAE Standards Relevant to HFO-1234yf
#### Under Development

<table>
<thead>
<tr>
<th>Standard Title</th>
<th>Status</th>
<th>SAE Representative</th>
<th>Working Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Standards for Motor Vehicle Refrigerant Vapor Compression Systems</td>
<td>Revise J639 - separate different refrigerants into different sections - reviewed in Orlando and sent for ballot</td>
<td>Bill Hill</td>
<td>4</td>
</tr>
<tr>
<td>New Ref 152a - 1234yf Refrigerant Purity and Container Requirements Used in Mobile Air-Conditioning Systems</td>
<td>Revise J2776</td>
<td>Bill Hill</td>
<td>4</td>
</tr>
<tr>
<td>R1234yf Service Standards for Mobile Air Conditioning Systems</td>
<td>Revise J2770</td>
<td>Paul Weissler</td>
<td>5</td>
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<tr>
<td>New Ref 152a - 1234yf Refrigerant Recovery Equipment for Mobile Automotive Air Conditioning Systems [Superseding J1732]</td>
<td>Revise J2210</td>
<td>Gary Murray</td>
<td>1</td>
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<tr>
<td>New Ref 152a - 1234yf Refrigerant Minimum Performance Criteria for Electronic Leak Detectors</td>
<td>Revise J2791</td>
<td>Bill Williams</td>
<td>2</td>
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<tr>
<td>New Ref 152a - 1234yf Ultraviolet Leak Detection minimum requirements for Mobile Air-Conditioning Systems</td>
<td>Revise J2775 or J2297</td>
<td>Phil Trigiani</td>
<td>3</td>
</tr>
<tr>
<td>Recommended Service Procedure for the Containment of HFC-152a and HFO-1234yf</td>
<td>Revise J2211</td>
<td>Paul Weissler</td>
<td>5</td>
</tr>
</tbody>
</table>

- First drafts of new Standard Revisions targeted for discussion at SAE ICCC Meeting in April
- Safe Evaporator Standard under consideration.
Next Steps

• Support OEM property/performance testing
  – Vehicle cooling performance/optimization
  – Compatibility, stability and durability

• Complete toxicity testing
  – Rabbit Developmental exposures complete
    • analysis and final report by August ‘08
  – Reproductive (preliminary results by August ’08)

• Complete regulatory registrations (REACH, SNAP etc)

• Achieve industry consensus on HFO-1234yf as global industry solution by mid’08 and put plans in place to meet 2011 EU MAC Directive.
• Excellent environmental properties
  – Very low GWP of 4, Zero ODP, Favorable LCCP
  – Atmospheric chemistry determined and published
• Low toxicity, similar to R-134a
  – 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
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