Mobile Air Conditioning

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Mobile Air Conditioning

- HFC-134a Emission Estimates
  - Current & Future
- Emission Reduction Options
- Measures of Industry Success
- Summary & Conclusions

Table I - Current HFC-134a Emissions Scenario

Current (1998) Emission Parameters

- **2 Recharges / 12 year lifetime**
- **Systems recharged at 40% charge loss**
- **Average system charge = 0.91 kg**
- **Recycling losses = 6% of original equipment (OE) charge**
- **Charge recoverable at scrap = 40% of OE charge**

Note: Absence of recycling would add 0.5 OE charge to the estimates due to service need to charge (and subsequently vent) empty-to-low-charge systems to find and repair leaks and faulty components.

$$\boxed{\underset{\text{(With Recycling)}}{\textbf{Lifetime Emissions}} = \underset{\substack{\uparrow \\ \text{Initial OE} \\ \text{Charge}}}{\textbf{OE Charge}} + \underset{\substack{\uparrow \\ \text{Service} \\ \text{Recharges}}}{\textbf{(2)(0.46)(OE Charge)}} - \underset{\substack{\uparrow \\ \text{Recovery} \\ \text{at Scrap}}}{\textbf{0.4 (OE)}}}$$

Emissions Estimates

Case 1: No Recycling at Service, No Recovery at Scrap

Lifetime Loss = 0.91 + (2.5)(1)(0.91) - 0 = 3.19 kg HFC-134a

Annual Emissions = 0.266 kg HFC-134a → **346 kg CO_2-equiv.**

Case 2: Recycling at Service, Recovery at Scrap

Lifetime Loss = 0.91 + (2)(0.46)(0.91) - 0.4(0.91) = 1.38 kg HFC-134a

Annual Emissions = 0.115 kg HFC-134a → **150 kg CO_2-equiv.**

Table II - Future HFC-134a Emissions Scenario

Future (~2005) Emission Parameters

- **1 Recharge / 12 year lifetime**
- **Systems recharged at 40% charge loss**
- **Average system charge = 0.80 kg**
- **Recycling losses = 6% of original equipment (OE) charge**
- **Charge recoverable at scrap = 40% of OE charge**

Note: Absence of recycling would add 0.25 OE charge to the estimates due to service need to charge (and subsequently vent) empty-to-low-charge systems to find and repair leaks and faulty components.

$$\boxed{\underset{\text{(With Recycling)}}{\textbf{Lifetime Emissions}} = \underset{\substack{\uparrow \\ \text{Initial OE} \\ \text{Charge}}}{\textbf{OE Charge}} + \underset{\substack{\uparrow \\ \text{Service} \\ \text{Recharges}}}{\textbf{(1)(0.46)(OE Charge)}} - \underset{\substack{\uparrow \\ \text{Recovery} \\ \text{at Scrap}}}{\textbf{0.4 (OE)}}}$$

Emissions Estimates

Case 1: No Recycling at Service, No Recovery at Scrap

Lifetime Loss = 0.8 + (1.25)(0.80) - 0 = 1.80 kg HFC-134a

Annual Emissions = 0.150 kg HFC-134a → **195 kg CO_2-equiv.**

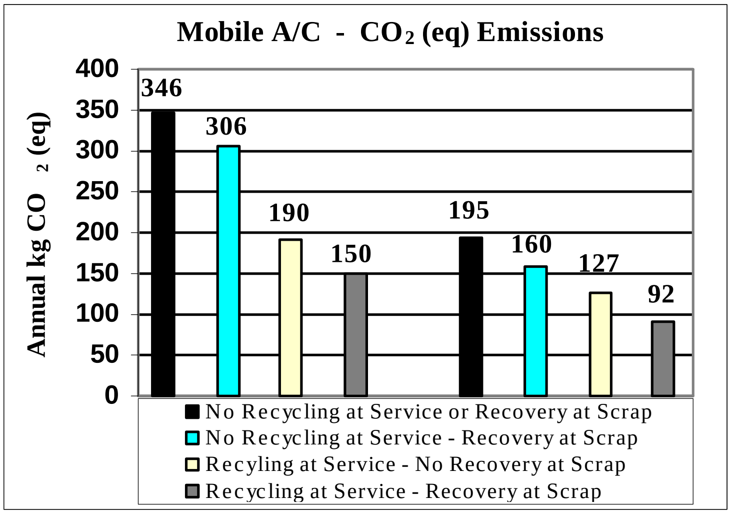
Case 2: Recycling at Service, Recovery at Scrap

Lifetime Loss = 0.8 + (0.46)(0.8) - 0.4(0.8) = 0.85 kg HFC-134a

Annual Emissions = 0.071 kg HFC-134a → **92 kg CO_2-equiv.**

Mobile A/C Emissions vs. Environmental Initiatives

Annual Equivalent Emissions Allocated on a Per-Vehicle Basis



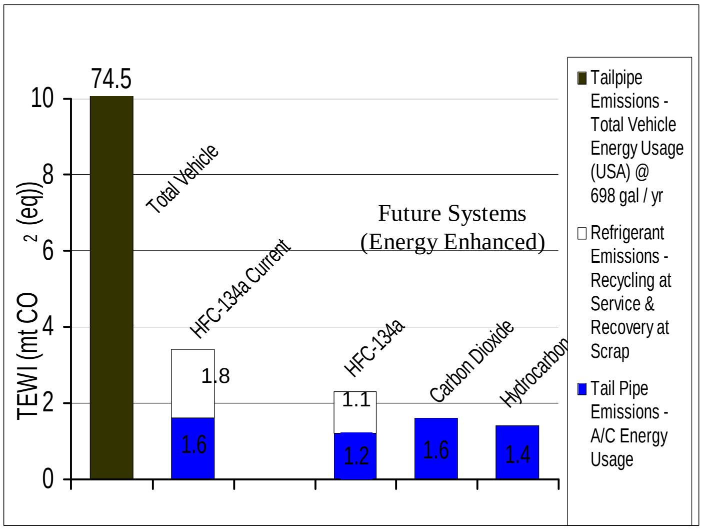
Future HFC-134a Emissions - Expressed as Tailpipe Equivalent Emissions

	Fuel Econ. (mpg)	Fuel Econ. (km/l)	Fuel CO_2 Emission (g/km)	HFC-134a Kilometer Equivalency vs. Recycle/Recover With R&R (km)	No R&R (km)	Average Annual Distance Driven (km)	Average HFC-134a as a % of Tailpipe With R&R (%)	No R&R (%)
USA	25	10.6	225	409	867	21,900	1.9	4.0
Europe (Current)	~30	12.8	186	495	1048	16,100	3.1	6.5
Europe (2008)	~40	17.0	140	657	1393	16,100	4.1	8.7
Japan (2008 ?)	~40	17.0	140	657	1393	16,100	4.1	8.7

% Attributable to HFC-134a Depends on Fuel Economy, Distance Driven and Availability of Refrigerant Recovery & Recycling Equipment

Mobile A/C Systems - Estimated Lifetime Emissions

Average Per-Vehicle Lifetime Emissions (12 Year Life)



Emission Reduction Options

Vehicle Manufacturers - New Vehicles

- Improved Sealing Materials (e.g., HNBR,EPDM)
- Multiple Lip Compressor Shaft Seals
- Low Permeation HFC-134a Hoses
- Improved Joining Processes for Higher Integrity Heat Exchangers and Refrigerant Joints
- Reduced Refrigerant Charge
- Refrigerant Leak Detection Dye
- Encourage Leak Detection & Leak Repair at All Service Facilities

Emission Reduction Options

Service Industry

- Encourage / Require Refrigerant Recycling at Service and Recovery at Scrap
- Implement Refrigerant Recycling & Recovery Equipment and Procedures
- Train Service Technicians in Proper Handling of Refrigerants and to Find and Repair Leaks

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Measures of Success

- Recharge Frequency
  - Vehicle Makers and Their Dealerships
  - Third Party Aggregation of Industry Data
- Refrigerant Usage
  - Actual Use Estimates Via IPCC Programme for National Greenhouse Gas Inventories Methodologies
  - January 1999 Industry Experts Meeting

Estimated Actual Mobile A/C HFC-134a Emissions

Annual HFC-134a Emissions = (Total Annual - Virgin HFC-134a Sold to MAC Industry) (0.995)(Total Annual Virgin HFC-134a for First Fill of New Systems)

[+ (Vehicle Annual Scrap Rate) (Total A/C Vehicle HFC-134a Fleet) (Average HFC-134a Charge)] - (Annual HFC-134a Destroyed from MAC Systems)

IPCC Experts Meeting Jan ‘99

Summary & Conclusions

- MACS HFC-134a Contribution To Total GHG Emissions Expected to be Small (~ 0.1%)
- Cost-Effective Improvements Are Provided for HFC-134a Systems (Implementation Underway)
- Potential Replacement Systems Identified
  - Energy Use and Commercialization Issues Remain
- A/C System is One of Many Systems on a Vehicle
- Vehicle Makers Must Decide Whether Change to a Non-HFC-134a A/C System is a Cost-Effective Means of Managing <u>Total</u> Vehicle GHG Emissions

UNEP Technology and Economics Advisory Panel's
Presentation to the Joint IPCC/TEAP Expert Meeting
Petten, NL May 26-28, 1999

TEAP TASKFORCE FINDINGS

PRESENTED BY:

Radhey Agarwal, Stephen Andersen, James Baker, Paul Ashford, Nick Campbell, Suely Carvalho,, Mohinder Malik, Thomas Morehouse, Barbara Polak, Wiraphon Rajadanuraks, and Sally Rand

Motor Vehicle A/C Presented By James Baker

- Global Choice of HFC-134a
  - Early CFC-12 Phaseout Protected Ozone Layer and

    Reduced Global Warming Impact
- Future Systems
  - Reduced Emissions HFC-134a Systems
  - CO_2 & HC Systems Under Development
    - Lower Energy Efficiency Systems
- Electric, Hybrid, Fuel-Cell Vehicles
  - Demand Ultra-High Efficiency Systems
  - Invite Hermetically Sealed Systems, Insulation,

    and Comfort Engineering

“Joint IPCC/TEAP Expert Meeting on Options for the Limitation of Emissions of HFC’s and PFC’s” Petten, NL {May 26-28, 1999}

- First Technical Input to Climate Change Process
- Montreal and Kyoto Protocol Parties Requested Joint Meeting
- Jointly Chaired by UNEP’s TEAP and IPCC
- Assessments Made By Usage Sector
- Mobile A/C Working Group

Mobile A/C Working Group

- Members
  - Stephan Sicars (Sitec) *Co-Chair*
  - Holger Koenig (Bitzer) *Co-Chair*
  - James Baker (Delphi)
  - Ewart Preisegger (Solvay)
  - Yoshiyuki Tsujibayashi (Nissan/JAMA)
  - Yoshido Makoto (Nissan/JAMA)
  - Ian Maclaine-cross (U of NSW)

MACS Working Group Assessment

Current

- Minimize System Leakage
- Minimize Refrigerant Charge
- *Encourage* Recovery & Recycling
- Restrict Small Disposable Cans
- Reduce Overall Emissions to ≤ 80g/yr/vehicle

Future

- Potential Future Options Include Use of Carbon Dioxide and Hydrocarbons
  - Pending Development and Acceptance
  - Higher Costs and Energy Use Expected

Summary & Conclusions

- MACS HFC-134a Contribution To Total GHG Emissions is Small
- Cost-Effective Emission-Reduction Improvements Are Being Implemented for HFC-134a Systems
- Potential Replacement Systems Identified
  - Energy Use and Commercialization Issues Remain
- Vehicle Makers Must Decide Whether Change to a Non-HFC-134a A/C System is a Cost-Effective Means of Managing Total Vehicle GHG Emissions