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August 31, 2004

Subject: SAE I-MAC Cooperative Research Program
From: SAE Interior Climate Control Standards Committee

HFC-134a is included in the Kyoto protocol "basket" of global warming gases and regulatory control is anticipated with a planned phase-out date in 2011 for use in new production vehicles and after 2016 for servicing all cars and light trucks offered for sale in the European community.

The international mobile air conditioning industry is actively working to reduce refrigerant leakage and improve system energy efficiency. These changes will reduce the climate impact of current design MAC systems and will help prolong HFC-134a use until alternative refrigerants can surpass, on a sustainable basis, the same high performance of the improved MAC system in all operating environments.

The SAE ARCRP Phase I and II activities evaluated three refrigerant options for system efficiency at equal capacity. It is now necessary to determine how much improvement can be made in HFC-134a systems to cost-effectively reduce the AC system international environmental impact.

In a paper "An Industry Perspective - Lessons Learned And The Cost Of CFC Phaseout" by F. A. Vogelsberg October 1996 the impact of the HFC-134a conversion was identified. The paper indicates that the cost to the U.S. automotive manufacturers and service industry was $8.5 billion.

In should be noted that the change from CFC-12 to HFC-134a was a relative minor change as compared to some current alternate refrigerants being considered and there is an immediate need to have an informed automotive industry to meet this existing challenge.

Under the guidance of this new two year SAE Improved Mobile Air Conditioning Cooperative Research Program (SAE I-MAC CRP), the industry will share the cost to provide comparable technical information for a variety of air conditioning system improvements, the vehicle, and A/C system servicing.

The goals of the project are to identify technologies, informing sponsors of results, that will:

- reduce direct system refrigerant leakage by 50%
- improve system efficiency by 30%.
- reduce system loads by 30%
- reduce the impact of service refrigerant losses by 50%

This 3 million dollar project has already received cash and in-kind funding commitments from the U.S. EPA, vehicle manufacturers and refrigerant suppliers. By this letter we are requesting commitments from A/C automotive industry leaders to support this Cooperative Research Project with funding of $20,000 for calendar year 2005 and for 2006. We are asking that a written commitment be made by the end of October 2004 so the scope of the project can be better defined. Many of your team members are already working on committees to define ways to meet the above targets, but we need your financial commitment if we are going to quantify these improvements over the next two years.

Duane Tiede
2004 SAE President

Ward Atkinson
Chair, ICCC

Background and supplemental information on the I-MAC CRP can be found in the attached "Project Overview" document.

SAE I-MAC Project Overview

August 31, 2004

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HFC-134a is included in the Kyoto protocol "basket" of global warming gases and regulatory control is anticipated with a planned phase-out date in 2011 for use in new production vehicles and after 2016 for servicing all cars and light trucks offered for sale in the European community.

The international mobile air conditioning industry is actively working to reduce refrigerant leakage and improve system energy efficiency. These changes will reduce the climate impact of current design MAC systems and will help prolong HFC-134a use until alternative refrigerants can surpass, on a sustainable basis, the same high performance of the improved MAC system in all operating environments.

The SAE ARCRP phase I activities and II evaluated three refrigerant options for system efficiency at equal capacity. It is now essential and logical to determine how much improvement HFC-134a technology can provide as a near-term, cost-effective environmental benefit.

This new SAE Improved Mobile Air Conditioning Cooperative Research program (SAE "I-MAC" CRP), will provide the industry with technical information adaptable at the assembly plant at a favorable cost-benefit ratio to all stakeholders. This data may provide options to more challenging engineering solutions being considered in some automotive markets.

Since the project plans to identify sponsoring companies in upcoming communications materials, we are providing your company/association the opportunity to officially join us by committing to your share of the funding. Details on requirements are explained in the following.

The goals of the project are to identify technologies that will:

1. reduce direct system refrigerant leakage by at least 50%
2. improve system efficiency by at least 30%.
3. reduce system cooling loads by at least 30%
4. reduce the impact of service refrigerant losses by at least 50%

Funds to start this project have already been committed by the U.S. EPA, global refrigerant suppliers, and others. It is anticipated that a total of US$3 million or more will be contributed in cash and in-kind contributions to support the 2-year project.

Since mobile systems provide occupant comfort and safety throughout the world, it is now imperative that HFC-134a systems be designed to operate efficiently over the entire global weather spectrum. It is also necessary to determine which technology or technologies provide the best environmental and consumer benefit at optimal cost.

The Phoenix Alternate Refrigerant Symposiums have demonstrated that carbon dioxide, hydrocarbon, and HFC-152a refrigerant technologies will provide occupant comfort and the SAE CRP has demonstrated that these systems can be designed to provide comparable energy efficiency in North American and North Europe climates. However, the total costs for development, tooling for production, and service infrastructure is currently unknown, and a wide variance among refrigerants is expected.

Any vehicle A/C system consumes additional fuel energy that results in the release of carbon dioxide equivalent emissions over the life of the vehicle. This carbon dioxide equivalent includes the fuel consumption impact of the total mass of the A/C system as carried on the vehicle, the system electrical requirements for controls and airflow, and energy to drive the compressor.

Leakage and/or release of the greenhouse gas refrigerants to the atmosphere during vehicle operation, service, and disposal also occur and can be converted to equivalent carbon dioxide emissions. Losses of refrigerant during service are handled in the same manner.

SAE Cooperative Research Program

SAE has established the I-MAC Refrigerant Cooperative Research Program. The program has established a Project Organization (Figure 1) consisting of four working group teams, their goals (Figure 2), and identified interested members from the vehicle manufactures, tier 1 and tier 2 suppliers.

The main goal is to establish the system leakage reductions that can be achieved, and the system energy efficiency improvements. A core group will coordinate these activities as well as those of the service team and the vehicle load reduction team.

System efficiency will be measured under controlled laboratory conditions and potential areas for investigation include:

- Compressor performance and control
  - This should focus on the lower evaporator loads that are typical of the most common driving conditions.
- Refrigerant systems controls
- Improved heat exchangers
- Management of system inlet loads (OSA –Rec)
- Reduction of System lubricant circulation
- Smart AC controls (e.g. comfort at least energy use; regenerative cooling on deceleration)

Reduction of system capacity requirements potential areas for investigation include:

- Vehicle body sealing
- Vehicle glazing
- Heat content and mass of interior materials
- Soak temperature reductions

Service activity will address:

- Service procedures
- Service equipment
- Containment of refrigerant in all service sectors

Program Time Table

Task	Who	2004				2005				2006			
		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Secure Project Approval	MD/WH												
Determine Expert Team members	WH												
Define Detail Project Plan	NREL												
Analysis of Current Literature	NREL												
Leakage Team													
Survey suppliers for alternatives	Team												
Test Procedure development	Team												
Evaluation	Ind. Lab												
Build System	NREL												
Vehicle Demonstration	NREL												
Efficiency Team													
Survey suppliers for alternatives	Team												
Test Procedure development	Team												
Build System	NREL												
Lab Evaluation	Ind. Lab												
Vehicle Demonstration	NREL												
Apply Lessons Learned	NREL												
Vehicle Demonstration	NREL												

Project Organization

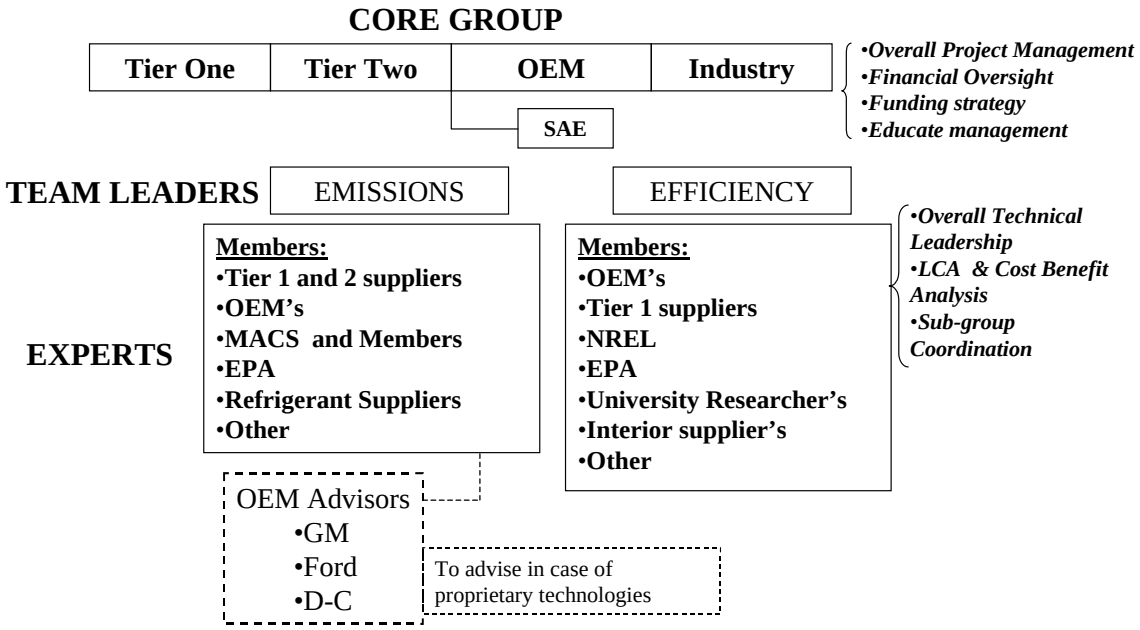

Figure 1

Working Group Teams

	Team1	Team2	Team3	Team4
Team Name:	**Refrigerant Leakage Reduction**	**AC System Efficiency Improvement**	**Vehicle Load Reduction**	**Service refrigerant loss Reduction**
Number of Team Members:	**23**	**17**	**6**	**6**
OEM's:	**3**	**6**	**2**	**2**
Tier1's:	**13**	**7**	**2**	**2**
Others:	**7**	**4**	**2**	**2**
Goals:	**50% Reduction in leakage**	**30% Improvement in COP**	**30% Load Reduction**	**50% Reduction in refrigerant losses**

Figure 2

Project Scope Organization

Deliverables

- SAE J-standards on R134a System Components leakage procedure/method
- SAE J-Standards on Measurement and Testing of HVAC energy/power consumption/efficiency
- Develop a ranking of cost/benefits for various technologies that will enable reduced leakage
- Demonstrate technologies with laboratory results
- Quantify the Service impact on the overall emissions situation with R134a
- Demonstration vehicles in 2005 and 2006
- Communication and education materials
- Others?

Roles and Responsibilities OEM

- Joint Industry leadership with Government partners
- Vehicles, test design, and evaluation
- Climate control system design(s)
- A/C system design(s)
- Test facility or facilities (For vehicle F/E confirmation of test results of MAC system)
- Funding
- Others?

Roles and Responsibilities Other Corporate Suppliers

- A/C system components
- Assemble MACs
- Bench tests for capacity and leakage
- Funding
- Others?

Roles and Responsibilities Government

- Consumer Education
- Certification, Labeling and Promotion
- Funding
- Complementary Regulation and Voluntary Incentives
- Others?

General Team Expectations

- Monthly conference calls/meetings
    - Take assignments and complete on schedule
- Assist in laboratory/vehicle testing
- Provide component level testing
- Prepare quarterly report to the "Board"
- Decisions by consensus [if consensus cannot be reached, it is acceptable to report the alternatives]

Leakage Team Plan

2004

- Literature Search on Leakage Studies [submit to team leaders]
    - Identify alternatives for leakage procedure
    - Identify differences [Pros/Cons] of different methods
- Decide on baseline system/vehicle [discuss alternatives]
- Identify a test facility [discuss alternatives]
- Gather detail descriptions of technical alternatives [breakout]
    - Drawings/sketches
    - Component leakage data
    - Identify top 3 for demonstration in 2005
- Pareto of leakage sources [MACS]
- Set reasonable targets for improvement of components
- Review proposed SAE/CARB spreadsheet
- Check on ways to share internal information with this team [Core Team]

2005

- Decide on parts for demonstration vehicle
    - Request parts for lab/vehicle evaluations
- Develop lab leakage test procedure
- Conduct Lab Tests on baseline vs "top 3" technologies selected in 2004 per procedure
- Install technologies on demonstration vehicle for Phoenix
- Phoenix report/presentation
- Investigate next "Top 3" for 2006 evaluation
- Identify how assembly variation affects the results

2006

- Finalize laboratory test procedure [SAE Standard]
- Consider vehicle leakage test procedure
- Decide on parts for evaluation and prepare parts for test
- Test parts in lab and in vehicle
- Demonstrate/present in Phoenix

Efficiency Team Plan

2004

- Literature Search on Efficiency Studies [submit to team leaders]
    - Identify alternative procedures
    - Compare Assumptions
        - Identify differences [Pros/Cons] of different methods
- Decide on baseline system/vehicle [discuss alternatives]
- Identify a test facility [discuss alternatives]
- Gather detail descriptions of technical alternatives [breakout]
    - Drawings/sketches
    - Identify "Top 3" for demonstration in 2005
- Pareto of Various sources of losses
- Set reasonable targets for improvement
- Select demonstration vehicle

2005

- Request hardware for demo vehicle
- Build Vehicle
- Develop procedure for evaluation
- Conduct Lab Tests on baseline vs improved system
- Install system on demonstration vehicle for Phoenix
- Phoenix demonstration/presentation
- Decide on next "Top 3" improvement items
- Select second vehicle

2006

- Finalize laboratory test procedure [SAE Standard]
- Consider vehicle test procedure
- Request parts for second vehicle
- Build and test second vehicle
- Phoenix demonstration

Plans for the Service Team and the Vehicle Load Reduction Team are under development.

Proposed 2005 Sponsor Meetings

- SAE VTM Toronto, Canada May 10-12-2005
    - I-MAC CRP Sponsor meeting Monday May 9, 2005
        - Working Groups Teams 8:00 am – noon
        - Working Lunch (Buffet)
        - Joint Session 2:00 pm –5 pm

- CARB/EPA/SAE MAC Summit 2005

- I-MAC-CRP Phoenix Member Meeting Demonstration Project Vehicle
  July 12-13, 2005
    - Meeting Agenda
        - Morning Sessions
            - Project Overview
            - Establishing Standards
    - Afternoon Sessions
        - Ride Evaluations
            - Project Demonstration Vehicle
            - Production HFC-134a Vehicles

Funding

- In 2004, primarily "in-kind" from Industry to establish plan.
    - EPA and some Refrigerant suppliers have provided initial funds to "jump start" the program
- In 2005/2006, all corporate sponsors will be expected to contribute a fee [$20,000 /yr] estimated payable in first quarter of each calendar year] to support independent lab testing and other miscellaneous expenses. Government and chemical sponsors may contribute more. **Your commitment to this funding must be received in writing by COB October 31, 2004.**
- Additional Industry Funding will include "in-kind" contributions such as parts/vehicle/testing time, labor/Engineering time/travel expenses [Target is to match to cash contribution or greater]
- "associate," non-voting, non-funding membership will be considered on a case-by-case basis.

General Information

The U.S. Core Group will coordinate the overall project budget, provide periodic updates to industry leaders, and support the project teams as necessary.
The "Team Leaders, together with their respective teams, will be responsible for all testing and reporting of the data to the "Core Group". The various teams will determine test program requirements, identify and recommend the test facility, and the required budget.

Funding Contact

For additional information regarding funding and function of the SAE Cooperative Research Program contact: Gary Pollak 724.772.7196 gary@sae.org

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