September 22, 2003

To: Automotive Air Conditioning Industry

Subject: Status of SAE Phase II Alternate Refrigerant Cooperative Research Program

From: Ward Atkinson, Chair SAE Interior Climate Standards Committee

cc SAE Alternate Refrigerant Cooperative Research Program Members
SAE Interior Climate Control Standards Committee

On September 3, 2003 a letter was sent to the industry regarding a supplementation of the SAE ARCRP.

The Expert Team was at the U of I last week and has reviewed the need and test matrix for the proposed Phase II ARCRP supplemental refrigerant evaluation program.

The following comments from industry sponsors were received during reports of the original ARCRP activity.

- The face area of the heat exchangers tested was above the average size in current production vehicles. The condenser/gas cooler was 25% and the evaporator/cooling core was 10% above the average.
- System controls cannot be optimized for both COP and capacity. This may result in compromises in both COP and capacity values. Capacity may be more important than COP at high ambient conditions.
    - For system capacity higher ambient conditions are most important for occupant comfort.
    - For annual energy analysis the moderate and lower ambient temperatures are more important because they have higher weighting factors.
- Ambient test conditions do not reflect operation in re-circulation mode at high ambients.
- Compressor speeds are higher on some vehicles than tested in the original ARCRP

With the Brussels MAC Summit overview of refrigerant emissions, performance and efficiency of MAC systems were at issue. The Commission Of The European Communities, Brussels, 11.8.2003 has issued a Regulation Of The European Parliament And Of The Council on certain fluorinated greenhouse gases that addresses refrigerant leakage. In this document, there is also reference to concerns for the fuel consumption related to the AC system.

In order to address these issues and the comments received from industry, a revised Phase II evaluation program is proposed by the Expert Team.

- Revised heat exchanger sizes
- Comparison of HFC-152a, HFC-134a and R744 (CO_2)
- An abbreviated test matrix with higher speeds and revised load conditions
    - o High load conditions
    - o Low load conditions

The program is scheduled to start in October 1, 2003 and will be completed by May 1, 2004.

The reports and complete test data from this program will only be available to the Phase II funding sponsors and will be not be publicly released until June 2005.

Test Budget

Since engineering budgets generally have a fiscal year ending, to complete this project in the needed time frame we need a written funding commitment from sponsors by **October 17, 2003** with the funds payable to SAE in the 1st quarter of 2004.

Depending upon the number of sponsors the budget request has been established at US$15,000.00 per corporate sponsor and US$50,000 from government sponsors. If insufficient sponsors are confirmed, the testing program will be reduced based on those who respond.

Please indicate your interest and support as soon as possible by contacting Gary Pollak at SAE so that this project can move forward in meeting this industries' need to make an informed technology choice.

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Objectives of the Phase II ARCRP:

- Evaluate potential of R152a as an alternative refrigerant in the mobile air conditioners.
- Evaluate for direct comparison R134a as a refrigerant in the same system (last) used for the R152a system evaluation.
- Evaluate potential of R744 as an alternative refrigerant in the mobile air conditioners.
- Determine COP (Coefficient of Performance) and Q (refrigeration capacity) for the matrix of steady state operating conditions similar to in SAE ARCRP.
- This program will utilize smaller heat exchanges than original SAE ARCRP. Proposed changes:
  1. Condenser/gas-cooler face area: 0.25 m^2
  2. Evaporator face area: 0.058 m^2
  3. Compressor speed 900; 1500, 2500; 4000 rpm
  4. Test Matrix is shown in Table I [We will accept comments from the sponsors on this new matrix.]

Organization:

The Expert Team will solicit the following basic components for the systems: [comments from the sponsors are welcomed.]

R152a:

- Two compressors,
- Two evaporators,
- Two condensers,
- One internal heat exchanger
- One oil separator

R134a:

- System will use identical optimized components chosen from the R152a system. Refrigerant will be replaced with R134a.

R744:

- Two gas coolers,
- One compressor,
- One internal heat exchanger
- One evaporator

ACRC team will evaluate equipment options to identify the best system in a short test matrix (two ambient conditions and two compressor speeds).

Once the best system and control strategy is determined, with these components, and approved by Expert Team, the final runs over entire test matrix will be performed as identified in Table I.

Test Matrix Phase II ARCRP Table I

Ambient temp. [°C/ °F]	Compressor speed [rpm]	Condenser		Evaporator		Simulated air selection	RH [%]
		Inlet air temp. [°C/ °F]	Flow rate [l/s/CFM]	Inlet air temp. [°C/ °F]	Flow rate [l/s/CFM]		
45/113	*900*	*60/140*	*342/725*	**35/95**	**90/190**	*Recirc*	*25*
	1500		685/1460		**100/212**		
	2500		1065/2260		**100/212**		
	4000				**100/212**		
35/95	900	50/122	*342/725*	35/95	90/190	*OSA*	40
		35/95			90/190		
	1500		685/1460		**100/212**		
	2500		1065/2260		**100/212**		
	4000				**100/212**		
25/77	*900*	*40/104*	*342/725*	*25/77*	*90/190*	*OSA*	*80*
		25/77			*90/190*		
	1500		685/1460		60/127		
	2500		1065/2260				
	4000						
25/77	*900*	*40/104*	*342/725*	*25/77*	*90/190*	*OSA*	*50*
		25/77			*90/190*		
	1500		685/1460		60/127		
	2500		1065/2260				
	4000						
15/59	*900*	*30/86*	*342/725*	*15/59*	60/127	*OSA*	*80*
		15/59					
	1500		685/1460				
	2500		1065/2260				
	4000						
	900		*342/725*		*28/60*	*OSA*	*80*
	1500		685/1460				
	2500		1065/2260				
	4000						