Alternate Refrigerant
—Scope of Work—

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With HFC-134a being included in the Kyoto Protocol "basket" of global warming gases, the international mobile air conditioning industry is actively working to reduce refrigerant emissions and lower the amount of refrigerant required by the system. In addition, two naturally occurring materials, carbon dioxide and propane, are being investigated as potential replacements for HFC-134a.

Much of the work on carbon dioxide systems is centered in Europe, particularly within the German auto industry association, VDA. VDA members, who are also on the SAE Alternate Refrigerants Task Force, had requested that a test procedure and program be established for evaluation of these different technologies. This test program focuses on the comparative fuel usage of these systems, which is expected to form part of the decision-making process.

Since the three refrigerant options can provide suitable occupant comfort, it is necessary to determine which technology provides the best and most cost-effective environmental and consumer benefits.

Under the guidance of the SAE Cooperative Research Program, a shared industry cost will provide the industry with comparable technical information at least cost.

When the mobile air-conditioning industry phased out the use of CFC-12 refrigerant, its replacement, HFC-134a, required development of new lubricants and modification of compressors. In addition, more efficient condensers were developed for retaining similar system performance during low speed operating conditions.

In general, the mobile air-conditioning system changeover from CFC-12 to HFC-134a, although time consuming, used existing system components and technology. The conversion expense for the automobile and service industry was extensive, resulting in higher costs for the consumer.

Currently, to address the environmental issue, two refrigerant replacements are being considered by the industry along with the enhancement of existing HFC-134a systems.

Over the last three years, the Phoenix Alternate Refrigerant Symposiums have demonstrated that the technologies will provide occupant comfort. However, the costs for development and tooling for production and relative cost for the service industry is currently unknown and a wide variance is expected.

Since these refrigerant options provide occupant comfort, it is necessary to determine which technology provides the best environmental and consumer benefit at optimal cost.

When installed in a vehicle, the A/C system consumes energy that results in the release of carbon dioxide over the life of the vehicle. This carbon dioxide equivalent includes the 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 refrigerant to the atmosphere also occurs and is referred to as equivalent carbon dioxide emissions.

SAE Cooperative Research Program

SAE has established an Alternate Refrigerant Cooperative Research Program. The program will provide a directly comparative engineering evaluation of the existing HFC-134a systems and other refrigerant technologies.

Program Structure

The program is structured as noted in Figure 1.

The activity allows for international automobile and A/C system manufacturers and component suppliers to participate in the program.

Since vehicles have space limitations, the test procedure provides that a specific size heat exchanger be used for comparisons between each refrigerant. A specific set of test parameters is run for comparison and the results will identify system performance and energy requirements on a common engineering basis. This direct type of comparison has not been done to date by an objective / independent laboratory.

Currently, preliminary bids have been requested to provide the engineering test setup and conduct the required tests. After these initial bids have been received, the U.S. Core Group will evaluate the facilities and complete the final program budget.

VDA vehicle makers have indicated that they expect to make a decision as to the type of future refrigerant system they will use in new vehicles during calendar year 2001. Testing new technologies in a cooperative effort of this nature affords the opportunity for all vehicle makers to learn more about potential future systems as a concerted industry effort supported by industry stakeholders. To this end, funding contributions are being sought to support this effort.

If the automotive industry wants to make an informed choice, it is imperative that this project be funded and started in the last quarter of the year 2000. Should this project not be funded and the environmental issues not identified, a wide variety of solutions could be developed and applied around the world.

If each automobile manufacturer / system and component supplier has to fund an alternate refrigerant program to make an engineering judgement the cost and time period will be prohibitive. Therefore, funding of the SAE Cooperative Research Program makes good economic sense for vehicle manufacturers, system suppliers and component suppliers.

Currently Environmental Canada and the U.S. EPA have committed some funding for this project.

Test Program
The test program will compare the following mobile A/C systems for cooling performance and energy requirements:

- Baseline HFC-134a system
- Carbon Dioxide system
- Hydrocarbon secondary loop system
- Enhanced HFC-134a system

Project Organization
To provide the most direct flow of information, the three core groups will have direct interface with vehicle and A/C system manufacturers and component suppliers. The Asian and European groups will each have direct contact and input from interested parties in their specific part of the world. They, in turn, will be a member of the U.S. "Core" Group through JAMA and VDA.

The U.S. Core Group will coordinate the test program requirements, the identification of the test facility and the budget.

The Expert Advisors will be responsible for all testing and reporting of data to the Core Group.

To assure that the tests are properly conducted, the "Expert Advisor Group" will have one person to oversee the test facility for procedures, operation and instrumentation.

A second person in the "Expert Advisor Group" will oversee the data and provide the written reports to the "Core Group". These two people will directly work with the test facility and the specific refrigerant expert, as noted below, when they use the facility.

To assure that the latest refrigerant technology is tested and that the specific system meets the requirements, one person will be assigned for each refrigerant type. This will limit the number of people in direct contact with system component suppliers should there be any proprietary components used in the testing.

Baseline R134a Systems
This system would represent a typical mid-size current production HFC-134a system with no enhancements. It will be used to establish some of the test parameters for comparison of the other proposed systems.

Carbon Dioxide Systems
Existing laboratory data indicates that carbon dioxide can be more efficient than the baseline HFC-134a system when the A/C system is operated under weather conditions with an ambient below 92° F (33°C). When the temperatures exceed this point the carbon dioxide system is less efficient when compared to existing HFC-134a systems.

The operating pressures of a carbon dioxide system can be 10 times higher on the low side and 5 times higher on the high side compared to existing HFC-134a systems. To utilize carbon dioxide as a refrigerant no existing mobile A/C system components or technology can be used. Therefore, this requires complete retooling of still unknown and undeveloped components. In addition new system service procedures and equipment are required.

Hydrocarbon Systems
For safety reasons it is not advisable to simply replace the refrigerant in today's existing systems with a flammable hydrocarbon. By considering a secondary loop cooling system, a reduced charge amount of flammable refrigerant operating at similar pressure to HFC-134a can be contained in the engine compartment. Using existing mobile A/C technology and adding an

additional heat exchanger, cooling to the passenger compartment can be provided with a non-flammable liquid.

Enhanced HFC-134a System

The enhanced HFC-134a system concept includes reduced system refrigerant charge, reduced emission rates from hoses and refrigerant connections, improved heat exchangers (evaporator/condenser) and a more efficient compressor and potentially including oil separators and/or suction line heat exchangers similar to CO_2 systems.

Funding

For additional information regarding funding and function of the SAE Cooperative Research Program contact Anthony Androsky at 724.772.8557; e-mail: androsky@sae.org.

SAE Alternate Refrigerant
Cooperative Research Program

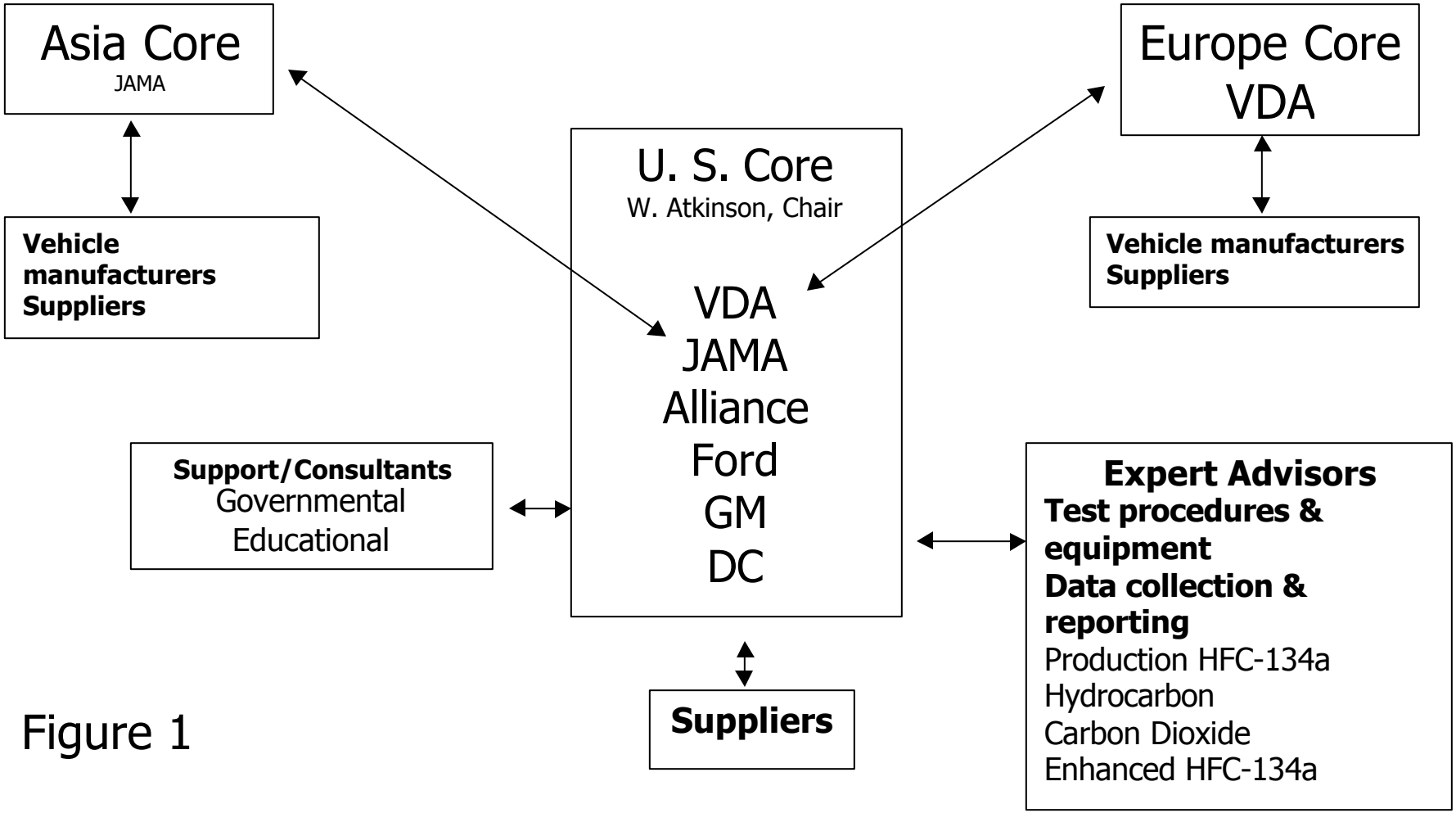

Figure 1

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