SAE International Automotive Alternate Refrigerant Systems Symposium
JUNE 28 - JULY 1, 1999
SCOTTSDALE, ARIZONA

Meeting Summary

This overview covers activities and areas of discussion at the 1999 SAE Automotive Alternate Refrigerant Systems Symposium vehicle evaluations and technical sessions.

NEW SYSTEMS

There were 24 vehicles evaluated during the Symposium including nine demonstration vehicles. Eight of the demonstration vehicles had CO_2 refrigerant systems and one had a secondary cooling loop using two different cooling media. A glycol and water mixture provided the evaporator circuit cooling. The refrigerant used in the engine compartment circuit was not identified at the time of the rides. The secondary loop exchanger was added to a conventional HFC-134a refrigerant system.

Due to a system problem, the Mercedes Benz (C) was replaced with a Behr (Benz) (CO2) vehicle (O) during the evaluation program. The VW CO_2 vehicle (P) had a compressor clutch failure and no data was obtained. Refrigerant control problems also were experienced by the Audi and BMW CO_2 systems.

SYSTEM PERFORMANCE

In general, most demonstration CO_2 vehicles provided a comparable level of comfort to their respective HFC-134a vehicles.

It generally had been believed that a secondary cooling loop system would have reduced cooling performance during soak and cool down, and city traffic operation. However, the occupant-perceived comfort levels in the demonstration secondary cooling loop system were comparable to the base HFC-134a system.

SYSTEM DESIGNS

The major emphasis of the Symposium was to address the technology for alternate refrigerants being considered for mobile air-conditioning systems. However, an efficient refrigerant cycle does not assure that the vehicle will provide an acceptable level of occupant comfort. An overview was presented during the technical sessions on other vehicle systems that influence occupant comfort.

The mobile air-conditioning system is a combination of several systems within the vehicle. To be effective, the total air-conditioning system design must include the refrigerant circuit and all vehicle systems to provide a satisfactory level of occupant comfort. Other vehicle systems that effect the total air-conditioning system performance include the following:

1. Body design; including interior and exterior colors, and the amount and location of vehicle glazing surfaces.

2. The amount of uncontrolled body leakage from body construction sealing, sealing of windows, doors and exterior lighting assemblies. Excess body leakage results in the inflow into the passenger compartment of unconditioned air effecting heating and air-conditioning performance.
3. The design and location of the panel air outlets and the amount of airflow delivered from the outlets into the passenger compartment.

Some of the effects on occupant comfort were identified in comments made by the evaluators over the three-day period.

RIDE COMMENTS

Review of the ride comments sheets invites the following comments:

- Vehicles having leather seating surfaces were rated as being hot and uncomfortable compared to fabric seats.
- Comments included difficulty in identifying the correct control position for (outside or recirculation air mode) resulting in an improper setting for maximum performance during a portion of city traffic in the Benz, Cadillac, GM EV1 and Toyota (Vehicles C, G, X and L).
- Comments were made on panel outlets regarding their, location, ability to control air direction and inadequate airflow. Inadequate rear seat airflow was identified for the Buick, Malibu, Toyota (L) and Volvo. Poor outlets (air quantity or ability to direct) were noted for the Taurus, Malibu and Toyota (L). Comment on the EV1 was the driver's knee blocked airflow.
- Compressor shut off in city traffic or poor low speed performance was noted for the Audi, BMW (B), Toyota (L), Toyota (T), Volvo and VW (N).
- Heat (direct sun) from the rear window caused rear seat discomfort in the Dodge.
- Re-evaporation odor in city traffic was reported in the BMW (A) and dust entry was noted in the Malibu (R).
- Compressor noise was reported in the Audi, BMW (A) and Toyota (T).

SYSTEMS

CO_2 Systems

During the Symposium it was evident that CO_2 systems required additional development. The system problems experienced during the 1998 and 1999 evaluations were related to the refrigerant circuit. This included refrigerant control and the system's high pressures.

Refrigerant containment during normal customer use must be comparable (number of years of operation before adding refrigerant) to that of existing HFC-134a systems.

Management of the refrigerant high and low side circuit pressures is required to prevent accidental discharge. System design should ensure both occupant and service technician safety.

With the initial high cooling demand of soak and cool down, the refrigerant system performance at low-speed city traffic operation should be comparable to HFC-134a. At road speeds, evaporator freeze protection is required to prevent coil surface freeze-up.

Data recorded during the road evaluations indicated that panel temperatures (Graph 3) on one vehicle were below 37 °F. (2.8 °C) an indication of potential evaporator freeze-up conditions. Since this temperature is most likely not achievable on a production system, the demonstrated level of comfort may not be obtainable.

MATERIALS

CO_2 Systems

Refrigerant circuit seal materials used for HFC-134a systems are not compatible with CO_2. Development of new seal designs for refrigerant circuit connections and compressor shaft seals are required. New designs including metal seals are being considered.

Existing flexible hose assemblies used for HFC-134a systems are not usable with CO_2. New smaller flexible hose assemblies with internal metal surfaces must be evaluated for long-term durability and their effect on noise and vibration into the passenger compartment.

SERVICE

With higher CO_2 system pressures, the system service ports must be multi-purpose having a minimum restriction for charging the system and be restricted for reduced flow when removing refrigerant. During system servicing, safety considerations must be addressed when the technician connects service equipment to the system. There also is the question if technicians should be certified to service high-pressure systems.

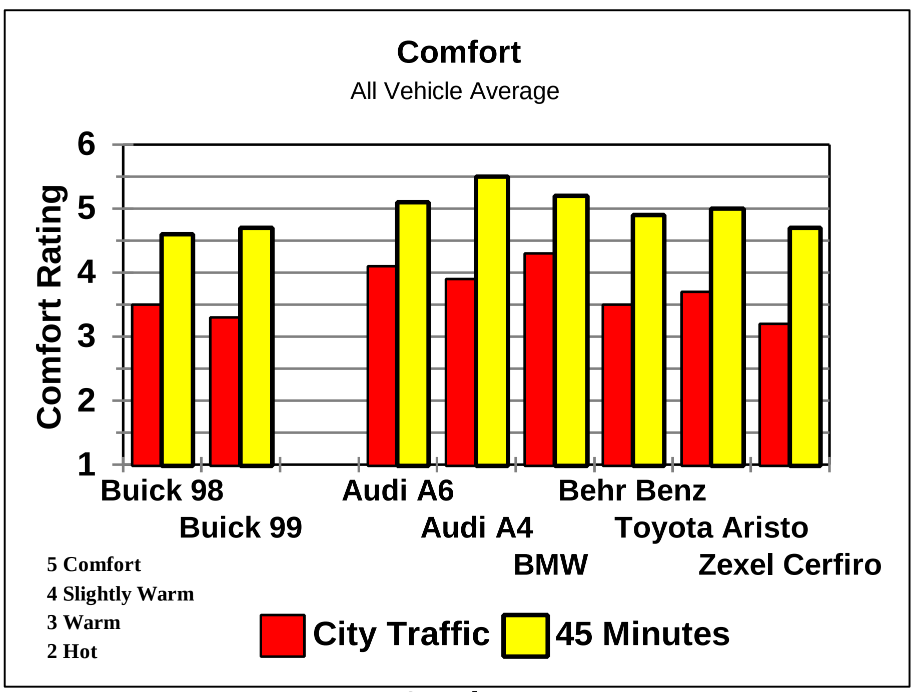
Worldwide, untrained personnel such as in developing countries, and DIY's (Do it Yourself) currently service mobile air-conditioning systems. This may pose personal safety concerns if they attempt to service flammable refrigerant or high-pressure systems.

RESULTS OF 1998 AND 1999 PHOENIX MEETINGS

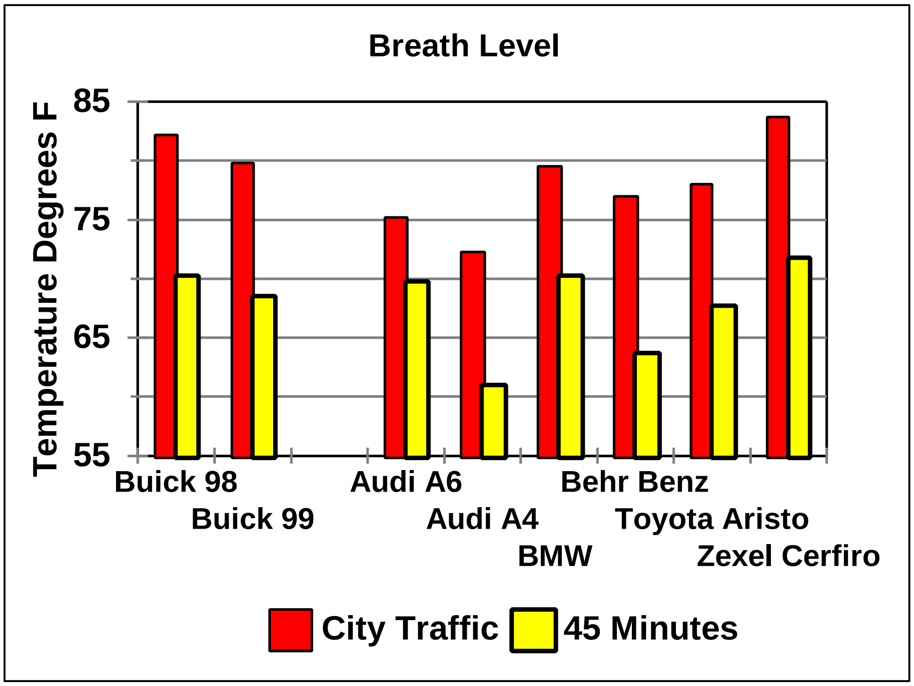
The weather conditions experienced between the 1998 and 1999 are compared in the chart below.

Location	Date	Ambient °F.	Ambient °C.	Wet Bulb °F.	% R.H.	Grains Moisture lb. Dry Air	Enthalpy B.T.U./lb
1999							
Phoenix	6-29-99	108	43	75.5	21	78	38.8
Phoenix	6-30-99	111	44	74	17	68	38
Phoenix	7-1-99	112.5	45	72	13	53	35.8
1998							
Phoenix	7-16-98	118	48	75	12	62	38.5
Phoenix	7-17-98	115.5	46	76	16	71	39.6
Phoenix	7-18-98	113	45	77	19	79	40.5
Dallas	7-26-98	104	40	75	24	82	38.6
Dallas	7-27-98	101	38.5	75	30	90	38.6
Dallas	7-28-98	103	39.5	76	29	92	39.6
Dallas	7-29-98	101	38.5	74.5	28	86	37.3

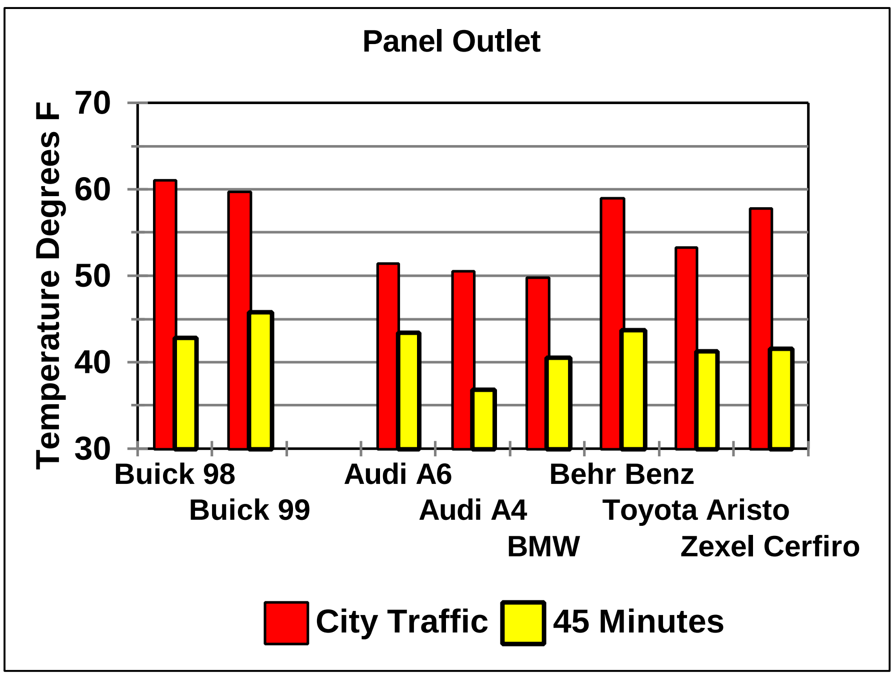
In the 1998 Phoenix program, Delphi furnished a Buick that had extensive refrigerant system data from tunnel and road testing. For comparison, this same vehicle was included in the 1999 program. The data found in graphs 1, 2 and 3 compare the Buick in the 1998 and 1999 evaluations and the 1999 CO_2 systems. The Buick did not have the highest comfort ratings of the vehicles evaluated in 1998 and 1999. However, the similar level of performance allows comparison between other vehicles in the evaluation programs.



Graph 1



Graph 2



Graph 3

FUTURE DEVELOPMENT

It is the intent of the SAE Interior Climate Control Standards Committee to support the mobile air-conditioning industry in the development of new technologies. This support includes future meetings, establishing Task Force and Working Groups for the development of SAE procedures and standards.