MEETING SUMMARY

Prepared by Ward Atkinson, President, Sun Test Engineering

The 2000 SAE Automotive Alternate Refrigerant Systems Symposium, July 11-13, in Scottsdale, Arizona, hosted 200 world industry representatives. Attendees included fifteen vehicle manufactures, nineteen air-conditioning system component suppliers and various governmental and educational institutions.

This overview covers vehicle comfort evaluations and areas of discussion during the symposium.

Unfortunately, the weather conditions resulted in lower ambient temperatures and considerable cloud cover during the test periods. This resulted in vehicle breath level temperatures being lower during soak conditions and heat input during some of the road evaluations. Not all vehicles had a formal ride evaluation. In order to offset the variable weather conditions the data for the limited formal rides have been averaged. The individual vehicle data is provided so that a separate comparison can be made under similar weather conditions.

- **New Systems**
  There were 8 vehicles evaluated during the Symposium including 6 demonstration vehicles. Four of the demonstration vehicles had CO2 refrigerant systems, one had a low pressure CO2 (mixture) system and one was an enhanced HFC-134a system. Two were production HFC-134a systems. (Table 2)

- **System Performance**
  In general most demonstration CO2 vehicles provided a comparable level of comfort to their respective HFC-134a vehicles. Again, as in prior years, the system performance varied due to system airflow and panel outlet air temperature.

- **Extended Idle**
  An addition test was included after the formal ride comparing panel outlet air temperature during an extended idle period. The vehicles were idled for 15 minutes on outside air and recirculated air. The panel outlet air temperature was recorded every 3 minutes. Data for the outside air idle was not available on all vehicles.

- **Ride Comments**
  The major comment due to weather conditions was that vehicle soak conditions did not reach a very high temperature. The average breath level soak temperature ranged between 127 to 138°F (52-59°C) in 2000 as compared to 138 to 153°F (59-67°C) in 1999.
  Occupant comfort was the direct result of total system airflow and the ability to direct the panel outlets. Reduced rear seat passengers comfort comments were greatest on systems that did not provide rear seat outlets.

  Vehicles having leather seating surfaces were rated as being uncomfortable compared to fabric seats.
  Comments on CO2 systems included compressor pumping noise and variation of the panel outlet temperature during city traffic operation.

- **Weather Conditions**
  Due to weather conditions the solar and evaporator loads were less than experienced in prior years. Chart 1 and Chart 2

  Since cloud cover conditions existed, at different times, over the three-day periods the formal ride evaluations varied widely, both for soak conditions and occupant comfort. The data presented is the average of the formal rides, with and without solar load.

PRESENTATIONS

The reports are an electronic reproduction and due to international format differences, some data conversion may not be correct.

- Torahide Takahashi, CalsonicKansei Corporation
  Development of Carbon Dioxide (CO2) Applied Refrigeration System

- Dr. Stephen O. Andersen (U.S. EPA), Ward Atkinson (SAE) and Simon Oulouhojian (MACS)
  Mobile Air Conditioning Climate Protection Partnership

- Dr. Stephen O. Andersen, U.S. EPA
  Selecting Climate-Friendly Air Conditioning Systems

- Jan Xu and Jay Amin, Climate Control Visteon Corporation
  Development of Improved R134a Refrigerant System

- Chhotu Patel and Ralph Wooten, Hutchinson
  Reducing R134a Automotive Air Conditioner Connector Leaks under Customer Usage Conditions

- Dr. Adiprasito Baroto, Volkswagen
  CO2 A/C System COP Comparison R134a versus CO2

- K. Ijima, Zexel
  A CO 2 Refrigerant System for Vehicle Air-Conditioning
  Sub-Title: Fuel Consumption of CO2 Refrigerant System

- Virender Jain, Cary Haramoto, Isaac Shilad and Josef Pfister, Parker
  Components for C02 A/C System

- Steve Sakamoto and Peter Giese, SANDEN / LuK
  Cooperation on CO2—Compressors

- M. Ben Yahia, C. Mann and P. Meurillon, Valeo Climate Control (France)
  Optimization of the CO2 A/C system: The Gas Cooler effect.

- Jörn Fröhling, Climate Control Visteon Corporation
  CO2 as Refrigerant for A/C and Heat Pump operation

- Hans Hammer, AUDI, and Juergen Wertenbach, DAIMLERCHRYSLER
  Carbon Dioxide (R 744) as supplementary heating device

- Werner Stadtmüller, MPA Stuttgart, and Roland Cäesar, DaimlerChrysler AG
  Material Related Design Criteria and Test Methods for Components Driven by R744 as Refrigerant

- Dr.-Ing. Ulrich Hussels RISA Sicherheitsanalysen GmbH (Germany)
  FMEA of CO2 Air Conditioning Systems

PRESENTATIONS—CONTINUED

- Results of the working group: M.Lorenz (Visteon), R.Knorr (BMW), H.Mittelstrass (Behr), D.Schroeder (Audi), J.Schug (Porsche) and C.Walter (Behr)
  Safety When Handling CO2-Systems

- C.W. Bullard, J.M. Yin and P.S. Hrnjak, Air Conditioning and Refrigeration Center
  Transcritical CO2 Mobile Heat Pump and Air Conditioning System Experimental and Model Results

Unfortunately, the weather conditions resulted in lower ambient temperatures and considerable cloud cover during the test periods. This resulted in vehicle breath level temperatures being lower during soak conditions and heat input during some of the road evaluations. Not all vehicles had a formal ride evaluation. In order to offset the variable weather conditions, the formal ride data has been averaged. The individual vehicle data is provided so a separate comparison can be made under similar weather conditions.

- **CHART 1–WEATHER COMPARISON**

Location	Date	Ambient °F	Ambient °C	Wet Bulb °F	% R.H.	Grains Moisture lb. Dry Air	Enthalpy B.T.U./lb
2000							
Phoenix	7-11-00	106	41.1	70	20	60	34.1
Phoenix	7-12-00	109	42.7	68	19	50	31.7
Phoenix	7-13-00	102	38.8	69	25	64	33.2
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

CHART 2–DAILY WEATHER

12:45 PM	Tuesday	Wednesday	Thursday
Ambient °F	**100**	**104**	**97**
Solar/BTU	***134**	***83/270**	***53**
Solar Langleys	***29**	***28/70**	***12**
R. Humidity %	**24**	**21**	**22**
2:45 PM			
Ambient °F	**106**	**109**	**102**
Solar/BTU	**220**	**222**	***133**
Solar Langleys	**57**	**57**	***33**
R. Humidity %	**20**	**19**	**25**
***Clouds**			

RIDE RESULTS

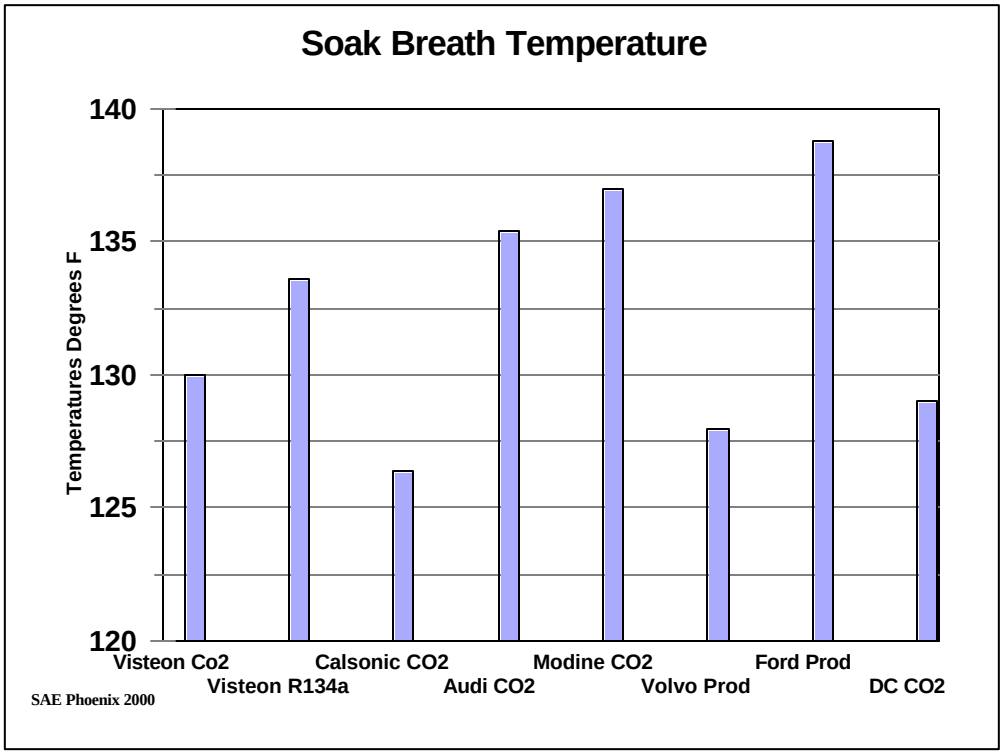
The series of nine graphs provide a summary of the formal rides and extended idle tests.

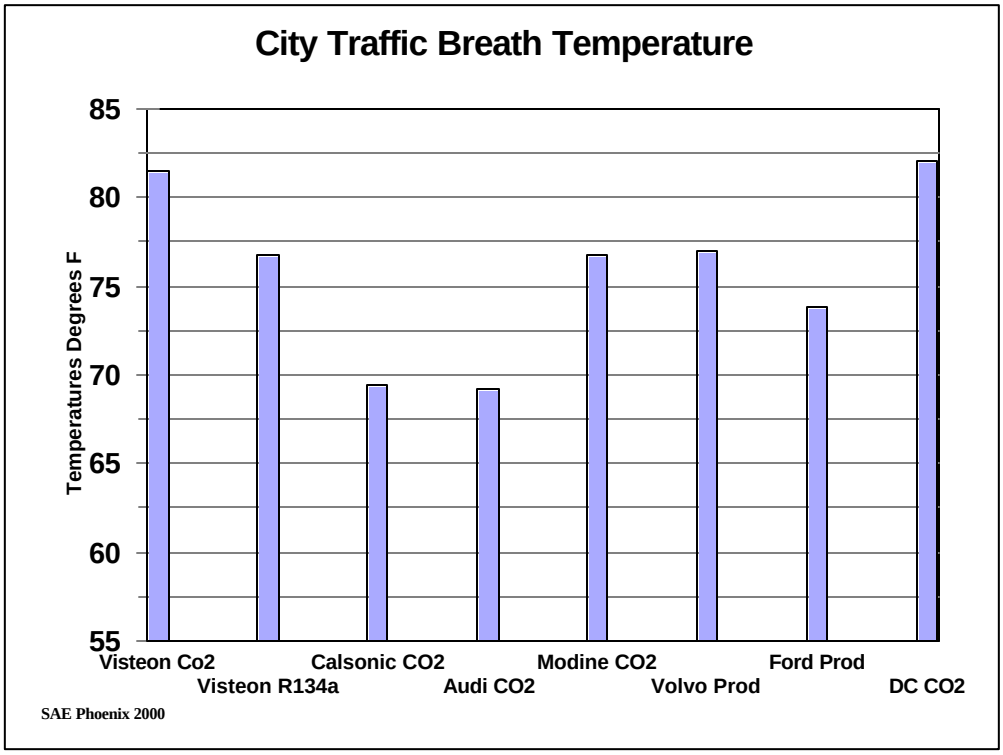
GRAPHS

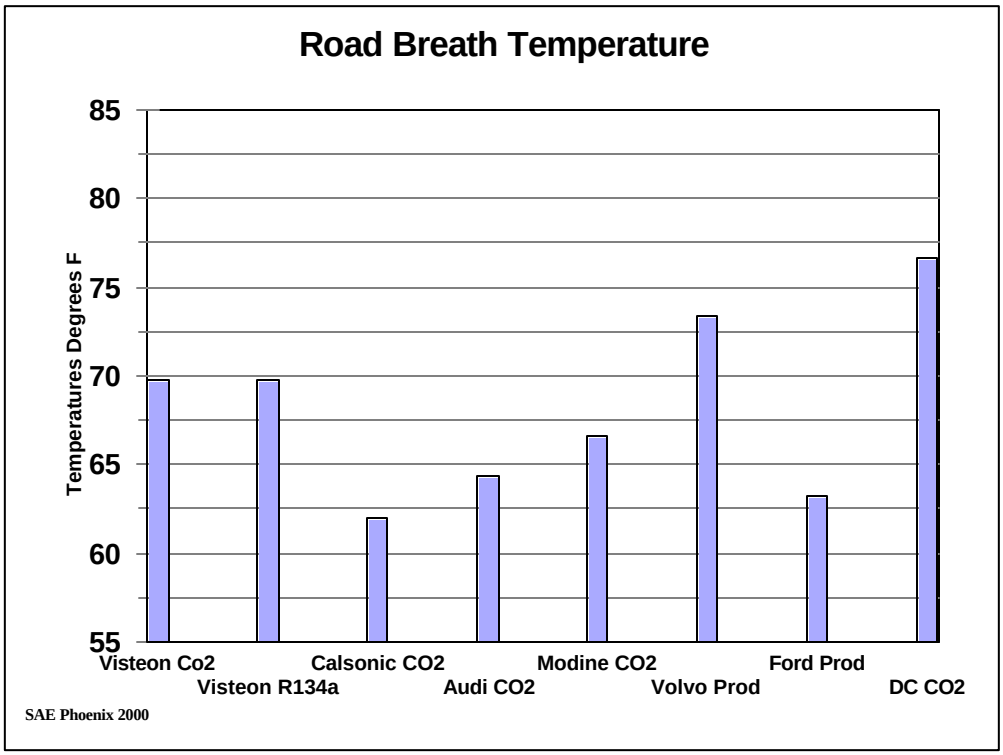
- Breath level temperatures
  - Soak
  - City traffic
  - Road
- Average (4 seat) occupant comfort
  - City traffic
  - Road
- Panel outlet air temperature
  - City traffic
  - Road
- Panel outlet air temperature at idle (no solar load)
  - Recirculated air
  - Outside air

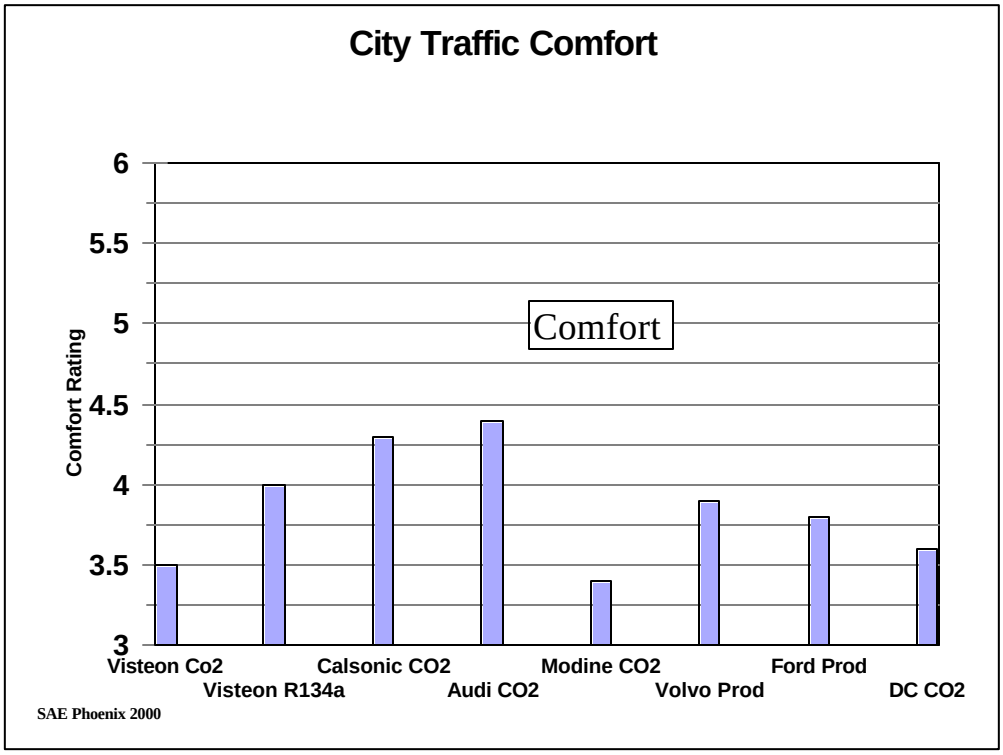
TABLES

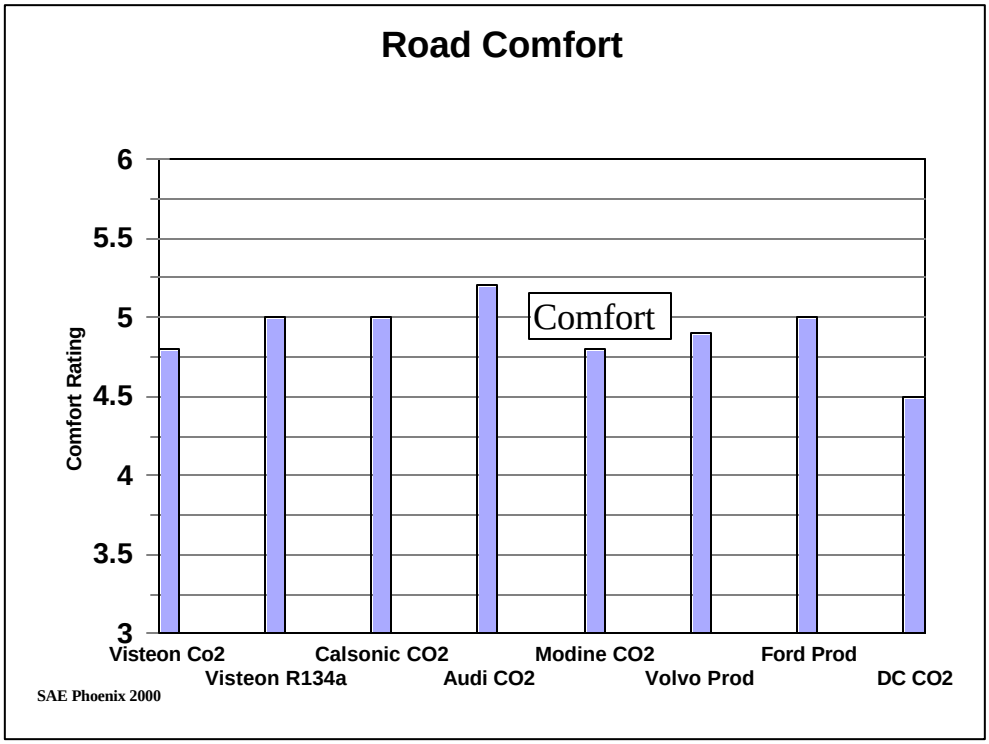
- Table 1—identifies the vehicle soak, ride times and ride teams.
- Table 2—provides vehicle specifications.

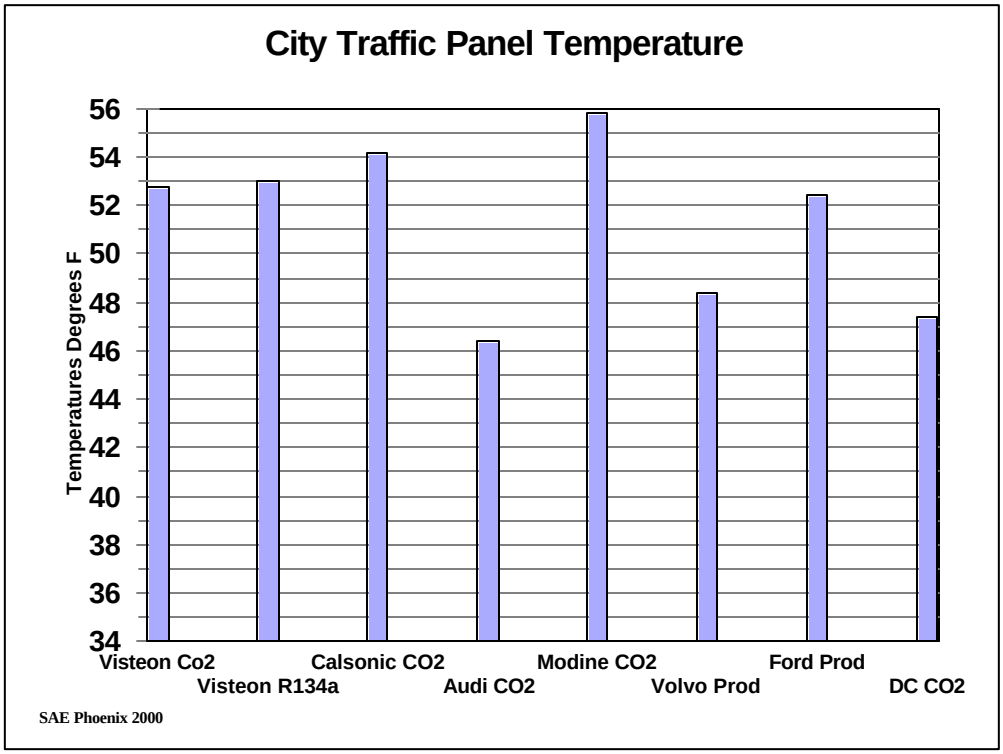

Soak Breath Temperature
140
135
130
125
120
Temperatures Degrees F
Visteon Co2
Visteon R134a
Calsonic CO2
Audi CO2
Modine CO2
Volvo Prod
Ford Prod
DC CO2
SAE Phoenix 2000

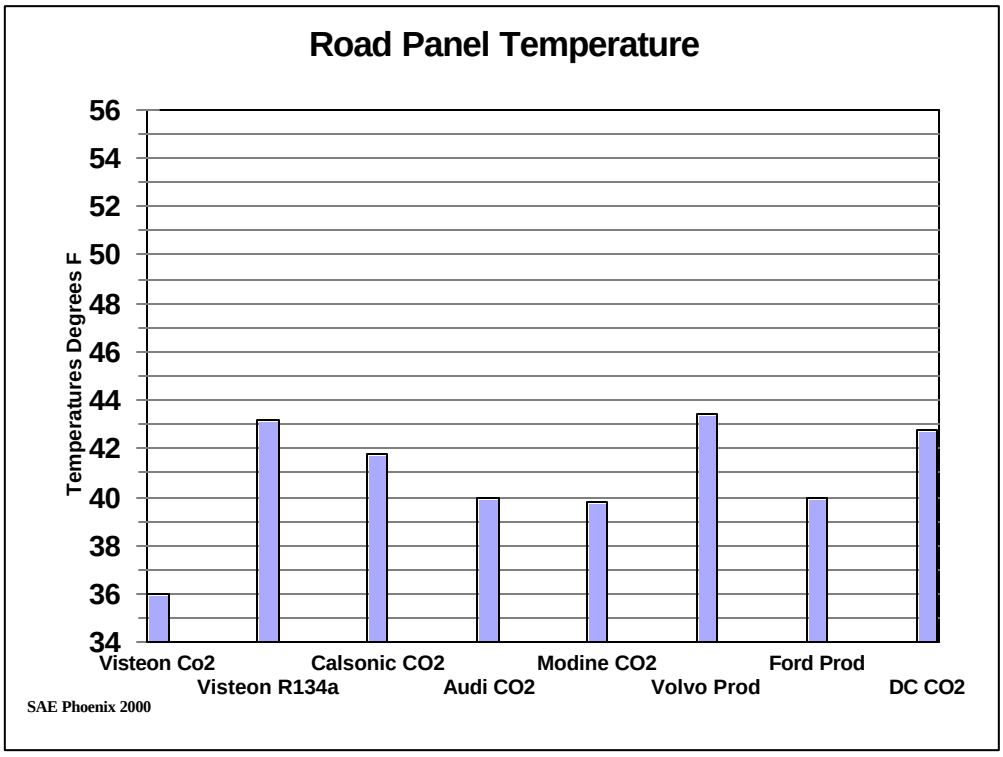

City Traffic Breath Temperature
85
80
75
70
65
60
55
Temperatures Degrees F
Visteon Co2
Visteon R134a
Calsonic CO2
Audi CO2
Modine CO2
Volvo Prod
Ford Prod
DC CO2
SAE Phoenix 2000

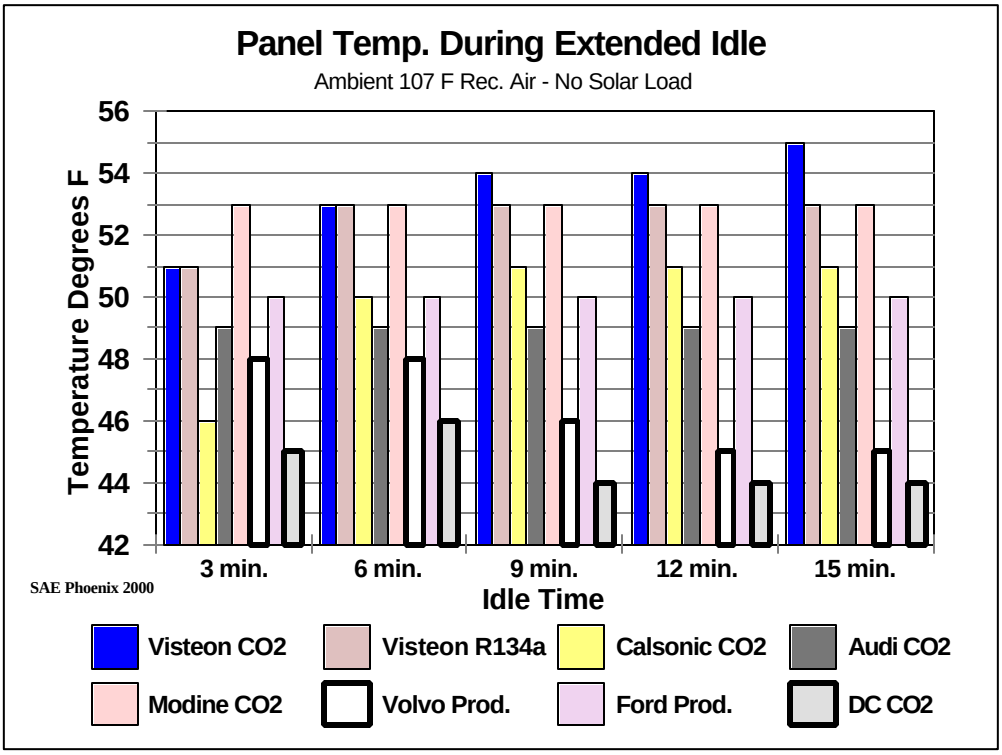

Road Breath Temperature
Temperatures Degrees F
85
80
75
70
65
60
55
Visteon Co2
Visteon R134a
Calsonic CO2
Audi CO2
Modine CO2
Volvo Prod
Ford Prod
DC CO2
SAE Phoenix 2000

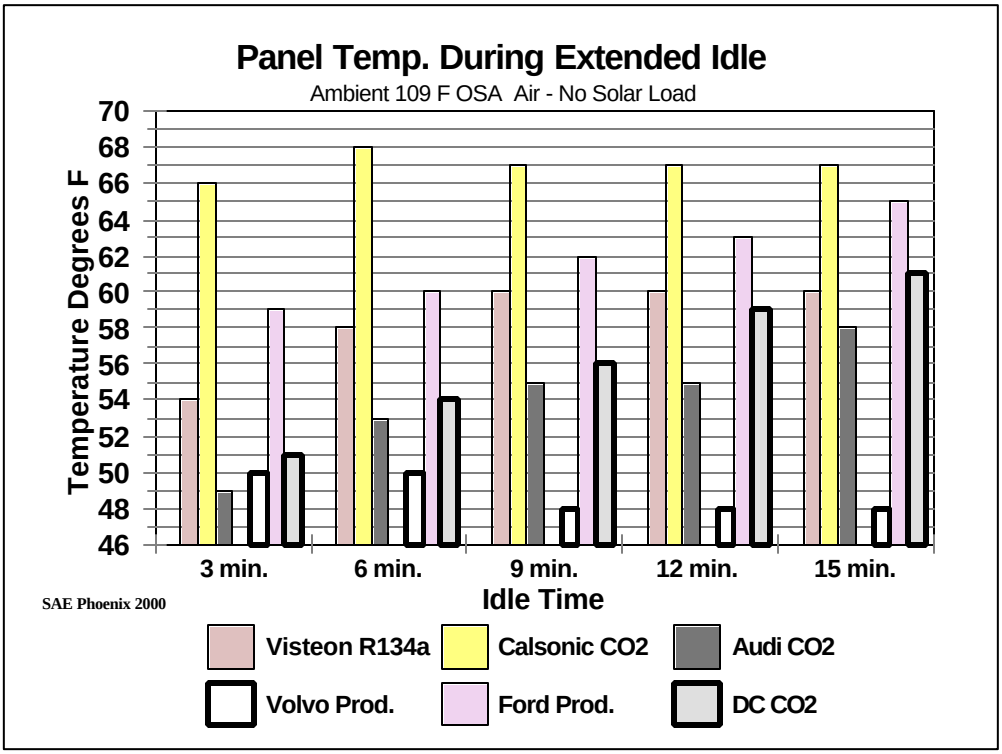

City Traffic Comfort
Comfort Rating
6
5.5
5
4.5
4
3.5
3
Comfort
Visteon Co2
Visteon R134a
Calsonic CO2
Audi CO2
Modine CO2
Volvo Prod
Ford Prod
DC CO2
SAE Phoenix 2000


Road Comfort
Comfort Rating
6
5.5
5
4.5
4
3.5
3
Comfort
Visteon Co2
Visteon R134a
Calsonic CO2
Audi CO2
Modine CO2
Volvo Prod
Ford Prod
DC CO2
SAE Phoenix 2000


City Traffic Panel Temperature
Temperatures Degrees F
56
54
52
50
48
46
44
42
40
38
36
34
Visteon Co2
Visteon R134a
Calsonic CO2
Audi CO2
Modine CO2
Volvo Prod
Ford Prod
DC CO2
SAE Phoenix 2000


Road Panel Temperature
Temperatures Degrees F
56
54
52
50
48
46
44
42
40
38
36
34
Visteon Co2
Visteon R134a
Calsonic CO2
Audi CO2
Modine CO2
Volvo Prod
Ford Prod
DC CO2
SAE Phoenix 2000


Panel Temp. During Extended Idle
Ambient 107 F Rec. Air - No Solar Load
Temperature Degrees F
56
54
52
50
48
46
44
42
3 min.
6 min.
9 min.
12 min.
15 min.
Idle Time
SAE Phoenix 2000
Visteon CO2
Visteon R134a
Calsonic CO2
Audi CO2
Modine CO2
Volvo Prod.
Ford Prod.
DC CO2


Panel Temp. During Extended Idle
Ambient 109 F OSA Air - No Solar Load
Temperature Degrees F
70
68
66
64
62
60
58
56
54
52
50
48
46
3 min.
6 min.
9 min.
12 min.
15 min.
Idle Time
SAE Phoenix 2000
Visteon R134a
Calsonic CO2
Audi CO2
Volvo Prod.
Ford Prod.
DC CO2

RIDE TEAM SCHEDULES

TABLE 1

Formal

		Tuesday July 11, 2000				Wednesday July 12, 2000				Thursday, July 13, 2000			
Group 1	**Vehicle Letter**	**11:45**	**12:45**	**1:45**	**2:45**	**11:45**	**12:45**	**1:45**	**2:45**	**11:45**	**12:45**	**1:45**	**2:45**
Visteon 1 CO_2	**A**	**s**	**1**	**s**	**2**	**s**	**3**	**s**	**5**	**s**	**4**	**s**	**6**
Visteon 2 R134a	**B**	**s**	**2**	**s**	**1**	**s**	**4**	**s**	**6**	**s**	**3**	**s**	**5**
Calsonic CO_2	**C**	**s**	**3**	**s**	**4**	**s**	**5**	**s**	**2**	**s**	**6**	**s**	**1**
Ford R134a	**D**	**s**	**4**	**s**	**3**	**s**	**6**	**s**	**1**	**s**	**5**	**s**	**2**
Group 2		**11:50**	**12:50**	**1:50**	**2:50**	**11:50**	**12:50**	**1:50**	**2:50**	**11:50**	**12:50**	**1:50**	**2:50**
Modine CO_2	**E**	**s**	**12**	**s**	**7**	**s**	**8**	**s**	**10**	**s**	**9**	**s**	**11**
Volvo	**F**	**s**	**7**	**s**	**12**	**s**	**9**	**s**	**11**	**s**	**8**	**s**	**10**
Visteon 3 CO_2	**G**	**s**	**8**	**s**	**9**	**s**	**10**	**s**	**7**	**s**	**11**	**s**	**12**
D C CO_2	**H**	**s**	**9**	**s**	**8**	**s**	**11**	**s**	**12**	**s**	**10**	**s**	**7**

s = 1 hour soak

Informal

		Tuesday, July 11		Wednesday, July 12		Thursday, July 13	
Group 1	**Vehicle**	**3:50 p.m.**	**4:25 p.m.**	**3:50 p.m.**	**4:25 p.m.**	**3:50 p.m.**	**4:25 p.m.**
Visteon 1 CO_2	**A**	12	14	16	13	15	17
Visteon 2 R134a	**B**	13	12	17	16	14	15
Calsonic CO_2	**C**	15	16	12	14	17	13
Ford R134a	**D**	14	13	15	17	12	16
Group 2		**4:00 p.m.**	**4:35 p.m.**	**4:00 p.m.**	**4:35 p.m.**	**4:00 p.m.**	
Modine CO_2	**E**	19	18	21	20	22	
Volvo	**F**	18	20	19	22	21	
Visteon 3 CO_2	**G**	20	19	22	21	18	
D C CO_2	**H**	21	22	18	19	20	

7/7/00

TABLE 2– VEHICLE SPECIFICATIONS

Vehicle			Type	Model	Body Style	Engine	Trans	Axle Ratio	Color Ext.	Color Int.	Windows
Group 1											
Visteon 1 CO_2	A	1	Ford	Mondeo	5 Dr	2.01	Auto		Dark Blue	Grey	Tint
Visteon 2 R134a	B	2	Ford	Taurus	4 Dr	3	Auto	3.77	Light Blue	Grey	No Tint
Calsonic CO_2	C	3		Cefiro	4 Dr	2.5	Auto 4 speed	4.087	White	Brown	No Tint
Ford R134a	D	4	Ford	Taurus	4 dr						
Group 2											
Modine Co_2	E	5	BMW	328i	4 DR	2.8	Auto 5 sp		Gun Metal Grey	Black	Tint
Volvo	F	6	Volvo	V70	5 Dr	2.41	Auto 5sp	2.44	Ashgold Metallic	Black	No Tint
Visteon 3 CO_2	G	7	Ford	Taurus	4 dr	3	Auto	3.77	Silver	Grey	No tint
D C CO_2	H	8	Jeep			Diesel			Green	Sand	

EXTENDED IDLE STUDY

Test Condition Panel air temp

			REC Air				
Date	**Start Time**	**Ambient**	**3 min**	**6 min**	**9 min**	**12 min**	**15 min**
07/11/2000							
07/11/2000	3:35 p.m.	107	51	53	54	54	55
07/11/2000	3:35 p.m.	107	51	53	53	53	53
07/11/2000	3:35 p.m.	107	48	50	51	51	51
07/11/2000	3:35 p.m.	107	49	49	49	49	49
07/11/2000	3:37 p.m.	107	53	53	53	53	53
07/11/2000	3:37 p.m.	107	48	48	46	45	45
07/11/2000	3:37 p.m.	107	50	50	50	50	50
07/11/2000	3:37 p.m.	107	45	46	44	44	44

Date	**Start Time**	**Ambient**		**3 min**	**6 min**	**9 min**	**12 min**	**15 min**
07/12/2000								
07/12/2000								
07/12/2000	3:30 p.m.	109		54	58	60	60	60
07/12/2000	3:30 p.m.	109		66	68	67	67	67
07/12/2000	3:30 p.m.	109		49	53	55	55	58
07/12/2000	3:40 p.m.	109	**Not OSA**	**57**	**57**	**55**	**55**	**55**
07/12/2000	3:40 p.m.	109		50	50	48	48	49
07/12/2000	3:40 p.m.	109		59	60	62	63	65
07/12/2000	3:30 p.m.	109		51	54	56	59	61