

2008 SAE Phoenix Alternate Refrigerant System Symposium Summary

June 10-12, 2008

Ward Atkinson

The 9th SAE Alternate Refrigerant Systems Symposium held June 10-12, 2008 in Scottsdale Arizona hosted 243 world industry representatives. The attendees came from, 113 companies, 8 universities and representatives from seven governmental agencies. Included were representatives from 21-passenger car, truck and off road vehicle manufactures, 18 air-conditioning system manufacturers. In addition 11 chemical companies, 63 industry suppliers, associations and testing and engineering companies were in attendance.

This overview covers vehicle comfort evaluations and listing of technical activities that occurred during the symposium.

Weather Conditions

The weather conditions resulted in generally clear sky and humidity of 12 to 18 percent during the ride periods. Ambient temperatures ranged between 96 -103°F (36-40°C) during the 3-day evaluation period. [Tables 1 and 2]

Weather Data: Test Site Daily Average

Table 1

Day	Ambient °F	Ambient °C	W.B °F	% Humidity	Enthalpy Btu/lb	Enthalpy J/kg	Langley	Buth/ft-sq.
Tue. 6-10-08	103.8	40.3	66.8	12.4	32.2	54.7	39.2	150.4
Wed. 6-11-08	96.6	36.1	65.6	18.2	30.5	52.9	53.4	208.6
Thur. 6-12-08	98	36.9	65.4	15.2	30.2	51.6	48.6	193.2

Ride Data Reference

- Comfort ratings for each vehicle
- Temperature readings for each vehicle
- Summary graphs

The vehicle and team ride schedule and vehicle specifications are found on tables 3 and 4.

Systems Evaluated

There were 6 demonstration vehicles, provided by General Motors and Hyundai-Kia evaluated during the symposium. The vehicles included production HFC-134a, Hybrid and belt driven systems and HFO1234yf and R744 direct expansion refrigerant systems.

The three 2008 Hyundai/Kia vehicles were Sportage SUV's having R134a, R744 and HFO1234yf refrigerant systems. The Sportage R744 and HFO1234yf systems had reduced performance at extended idle conditions. Figures [21 – 24] Comparison of the Sportage systems and the R134a Impala are found in Fig. 1 & 2

The Cadillac SUV results are found in Fig 3 & 4.

The breath level and panel outlet temperatures are found in Figure 8.

The summary of the ride results is found in Figures 1 through 19. Idle test results are found in Figures 21 through 24.

Ride Results

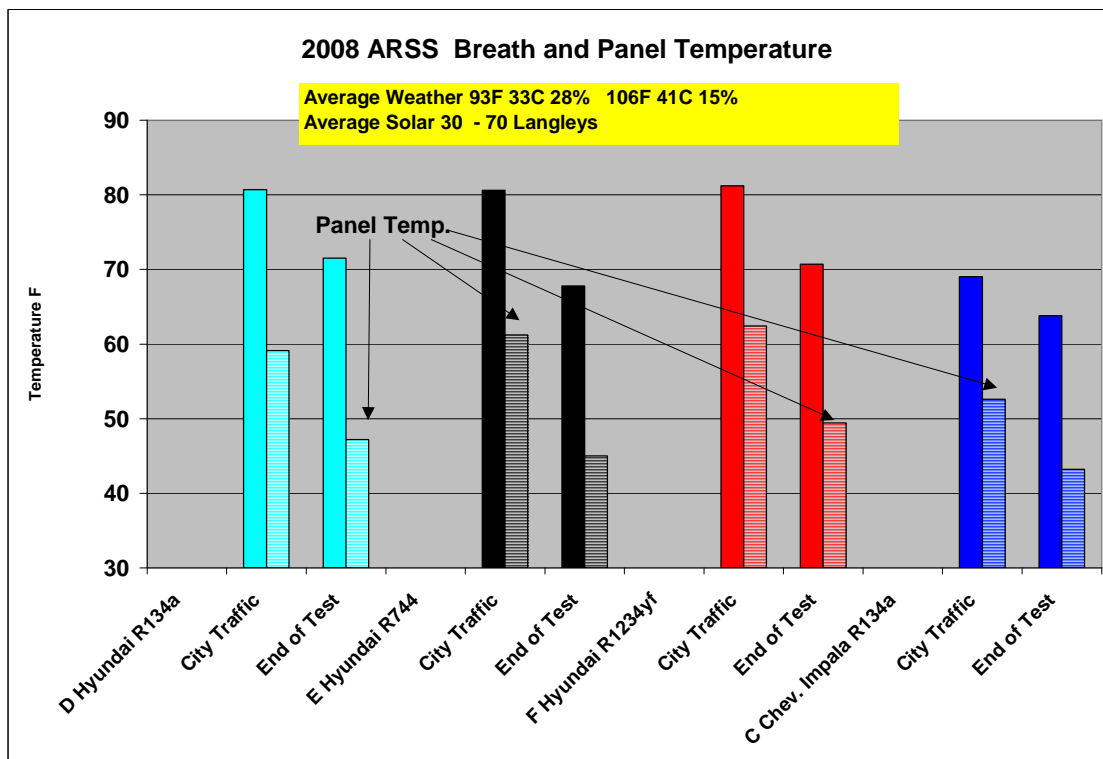


Figure 1

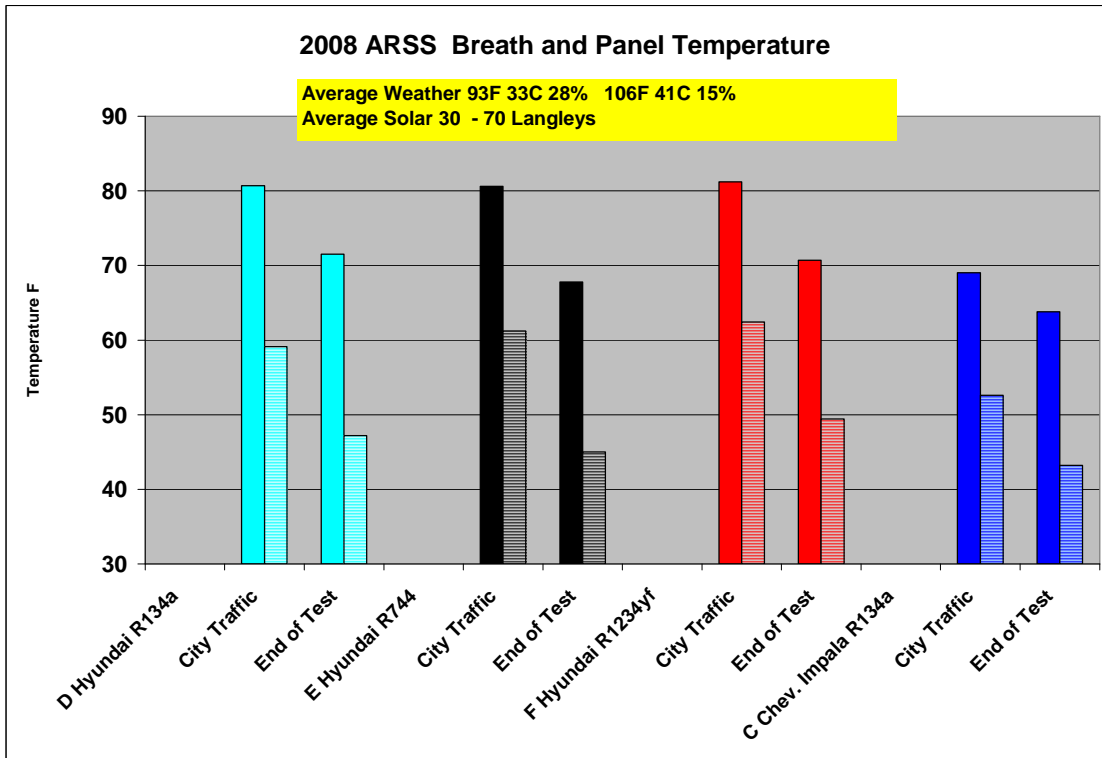


Figure 2

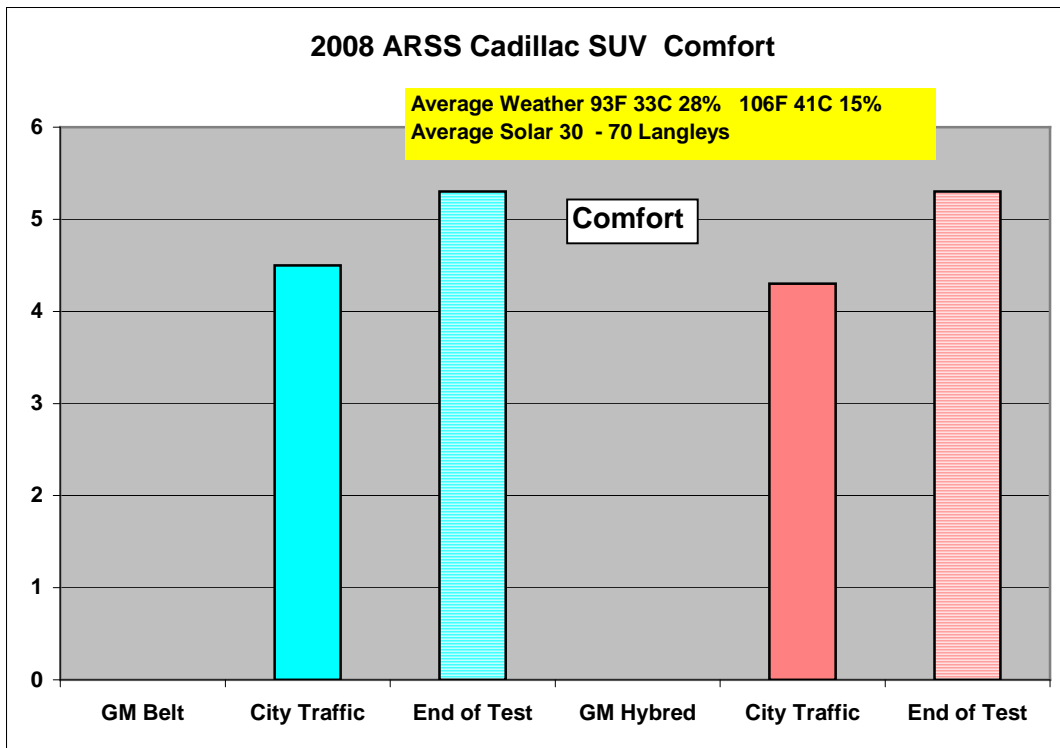


Figure 3

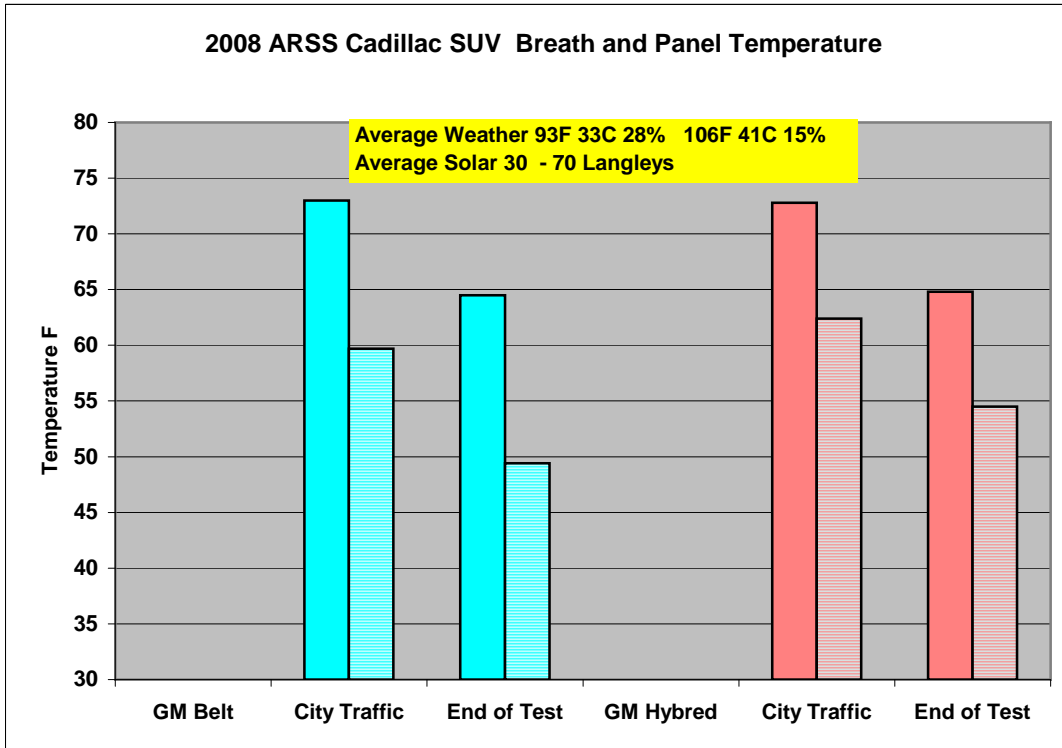


Figure 4

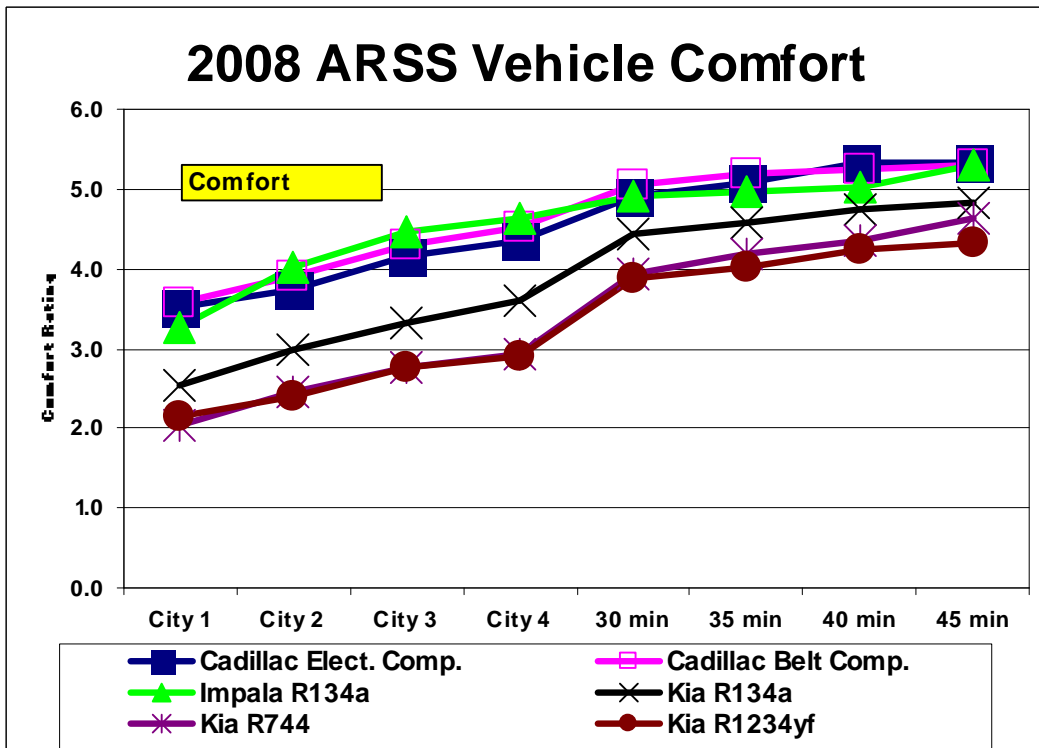


Figure 5

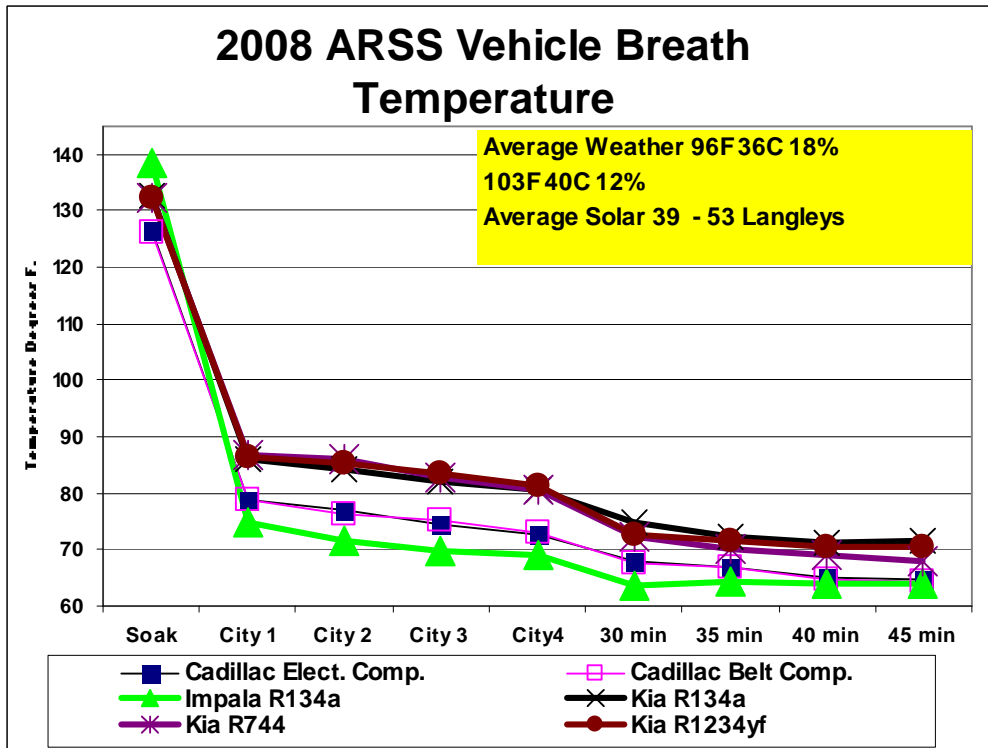


Figure 6

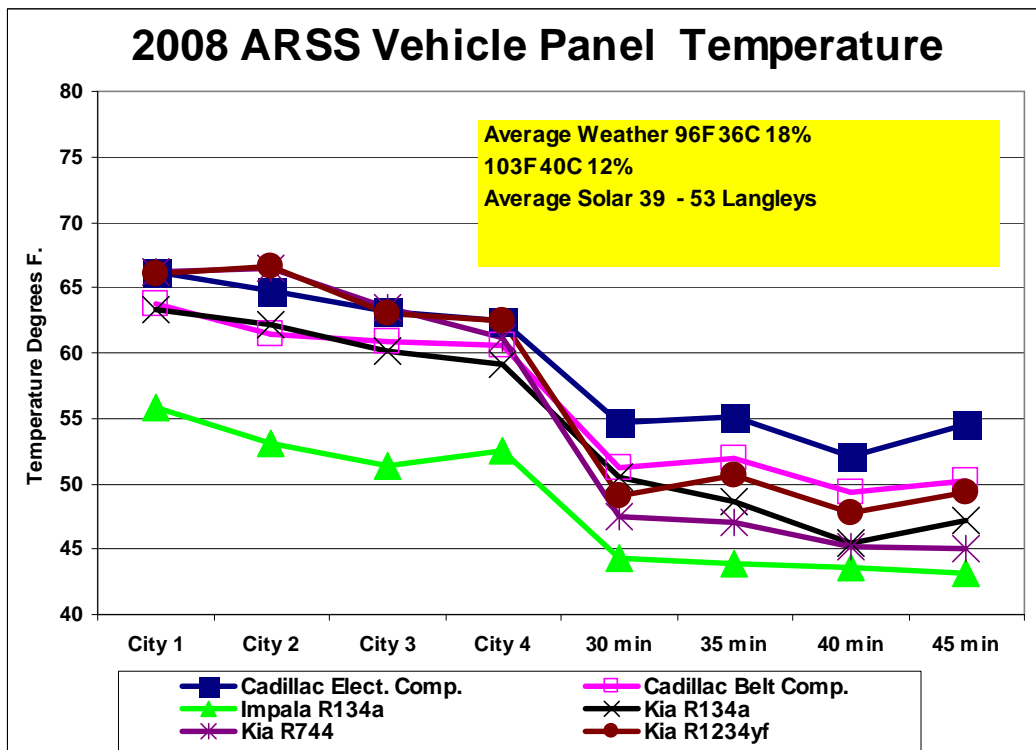


Figure 7

2008 Phoenix ARSS				Vehicle Summary		2009 Cadillac R134a		2008 Impala R134a		2008 Kia R134a		2008 Kia R744		2008 Kia R1234yf	
Vehicle A	Cadillac	Vehicle B	Cadillac	Vehicle C	Impala	Vehicle D	Kia	Vehicle E	Kia	Vehicle F	Kia	Vehicle G	Kia	Vehicle H	Kia
2009	Elect. Comp.	2008	Belt	2008	R134a	2008	R134a	2008	R744	2008	R1234yf	2008	R1234yf	2008	R1234yf
Comfort	Average	Comfort	Average	Comfort	Average	Comfort	Average	Comfort	Average	Comfort	Average	Comfort	Average	Comfort	Average
City 1	3.5	City 1	3.6	City 1	3.3	City 1	2.5	City 1	2.0	City 1	2.1	City 1	2.1	City 1	2.1
City 2	3.7	City 2	3.9	City 2	4.0	City 2	3.0	City 2	2.5	City 2	2.4	City 2	2.4	City 2	2.4
City 3	4.2	City 3	4.3	City 3	4.5	City 3	3.3	City 3	2.8	City 3	2.8	City 3	2.8	City 3	2.8
City 4	4.3	City 4	4.5	City 4	4.6	City 4	3.6	City 4	2.9	City 4	2.9	City 4	2.9	City 4	2.9
30 min	4.9	30 min	5.1	30 min	4.9	30 min	4.4	30 min	3.9	30 min	3.9	30 min	3.9	30 min	3.9
35 min	5.1	35 min	5.2	35 min	5.0	35 min	4.6	35 min	4.2	35 min	4.0	35 min	4.0	35 min	4.0
40 min	5.3	40 min	5.3	40 min	5.0	40 min	4.7	40 min	4.4	40 min	4.2	40 min	4.2	40 min	4.2
45 min	5.3	45 min	5.3	45 min	5.3	45 min	4.8	45 min	4.6	45 min	4.3	45 min	4.3	45 min	4.3
Temperature Degrees F.															
Avg. Breath															
Soak	126.7	Soak	126.2	Soak	138.3	Soak	132.8	Soak	132.2	Soak	132.5	Soak	132.5	Soak	132.5
City 1	78.7	City 1	78.8	City 1	74.7	City 1	86.2	City 1	86.6	City 1	86.3	City 1	86.3	City 1	86.3
City 2	77.2	City 2	76.2	City 2	71.5	City 2	84.3	City 2	86.0	City 2	85.3	City 2	85.3	City 2	85.3
City 3	74.5	City 3	75.2	City 3	69.8	City 3	82.0	City 3	82.8	City 3	83.7	City 3	83.7	City 3	83.7
City 4	72.8	City 4	73.0	City 4	69.0	City 4	80.7	City 4	80.6	City 4	81.2	City 4	81.2	City 4	81.2
30 min	68.0	30 min	67.5	30 min	63.5	30 min	74.7	30 min	72.4	30 min	72.5	30 min	72.5	30 min	72.5
35 min	66.8	35 min	66.8	35 min	64.2	35 min	72.3	35 min	70.2	35 min	71.7	35 min	71.7	35 min	71.7
40 min	65.2	40 min	64.8	40 min	63.8	40 min	71.3	40 min	69.2	40 min	70.5	40 min	70.5	40 min	70.5
45 min	64.8	45 min	64.5	45 min	63.8	45 min	71.5	45 min	67.8	45 min	70.7	45 min	70.7	45 min	70.7
Temperature Degrees F.															
Avg. Panel															
City 1	66.2	City 1	63.7	City 1	55.8	City 1	63.3	City 1	66.2	City 1	66.1	City 1	66.1	City 1	66.1
City 2	64.8	City 2	61.4	City 2	53.0	City 2	62.2	City 2	66.4	City 2	66.6	City 2	66.6	City 2	66.6
City 3	63.2	City 3	60.9	City 3	51.4	City 3	60.2	City 3	63.5	City 3	63.1	City 3	63.1	City 3	63.1
City 4	62.4	City 4	60.6	City 4	52.6	City 4	59.1	City 4	61.2	City 4	62.4	City 4	62.4	City 4	62.4
30 min	54.7	30 min	51.3	30 min	44.3	30 min	50.6	30 min	47.5	30 min	49.1	30 min	49.1	30 min	49.1
35 min	55.2	35 min	51.9	35 min	43.9	35 min	48.6	35 min	47.1	35 min	50.7	35 min	50.7	35 min	50.7
40 min	52.2	40 min	49.3	40 min	43.7	40 min	45.5	40 min	45.2	40 min	47.7	40 min	47.7	40 min	47.7
45 min	54.5	45 min	50.2	45 min	43.2	45 min	47.2	45 min	45.0	45 min	49.4	45 min	49.4	45 min	49.4

Figure 8

Vehicle A Cadillac Hybrid R134a System

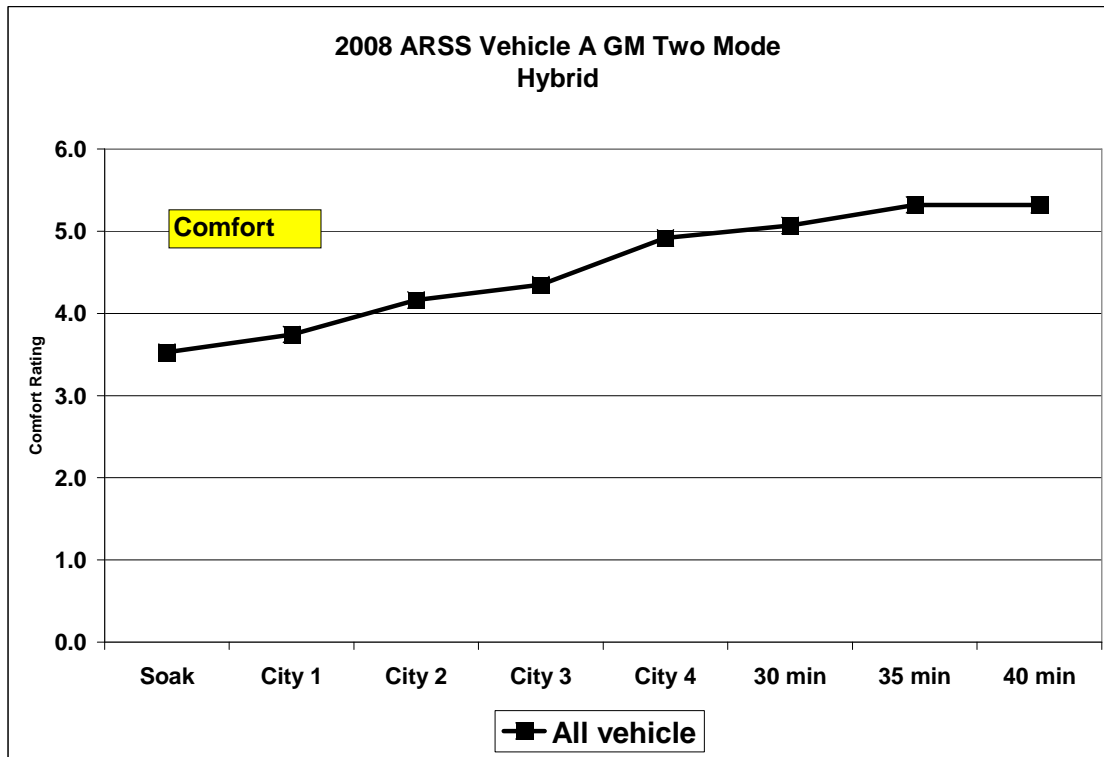


Figure 9

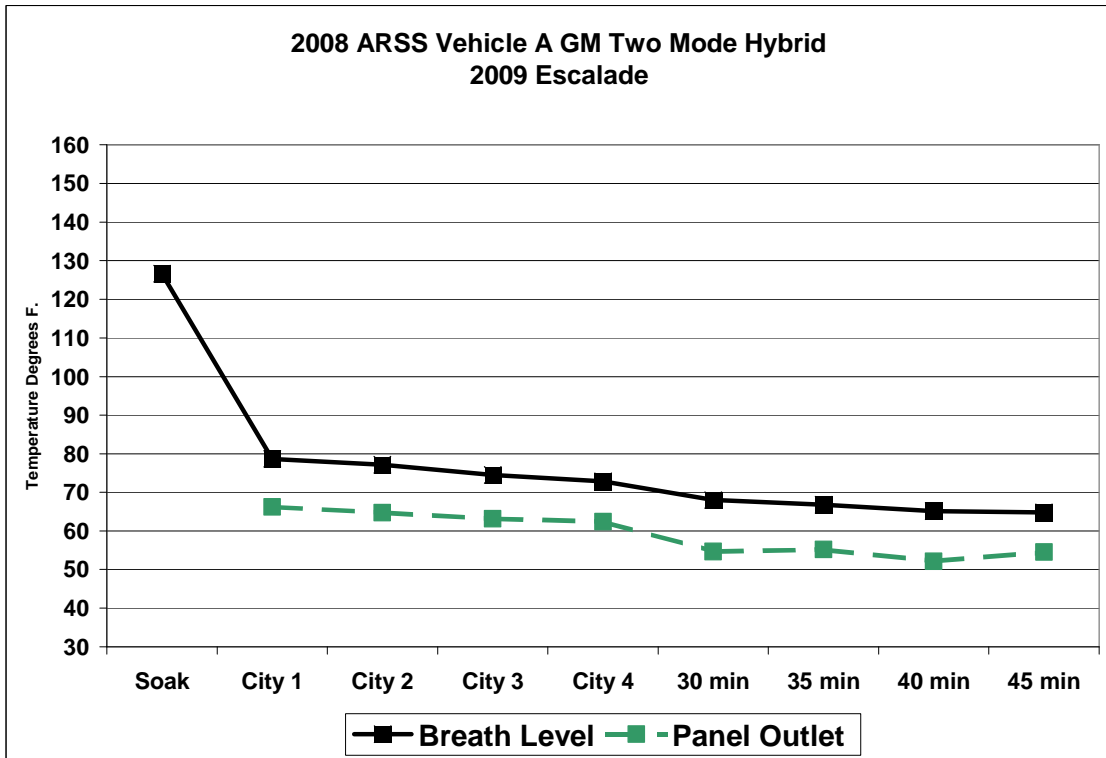


Figure 10

Vehicle A Cadillac Belt Driven R134a System

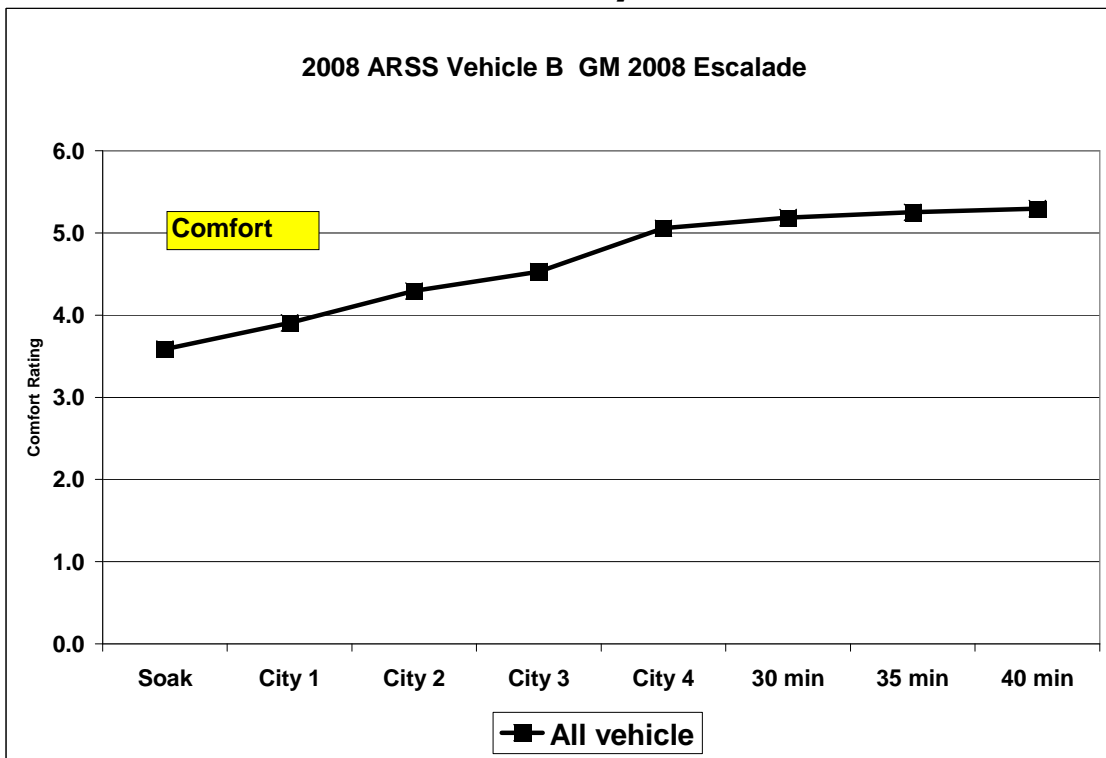


Figure 11

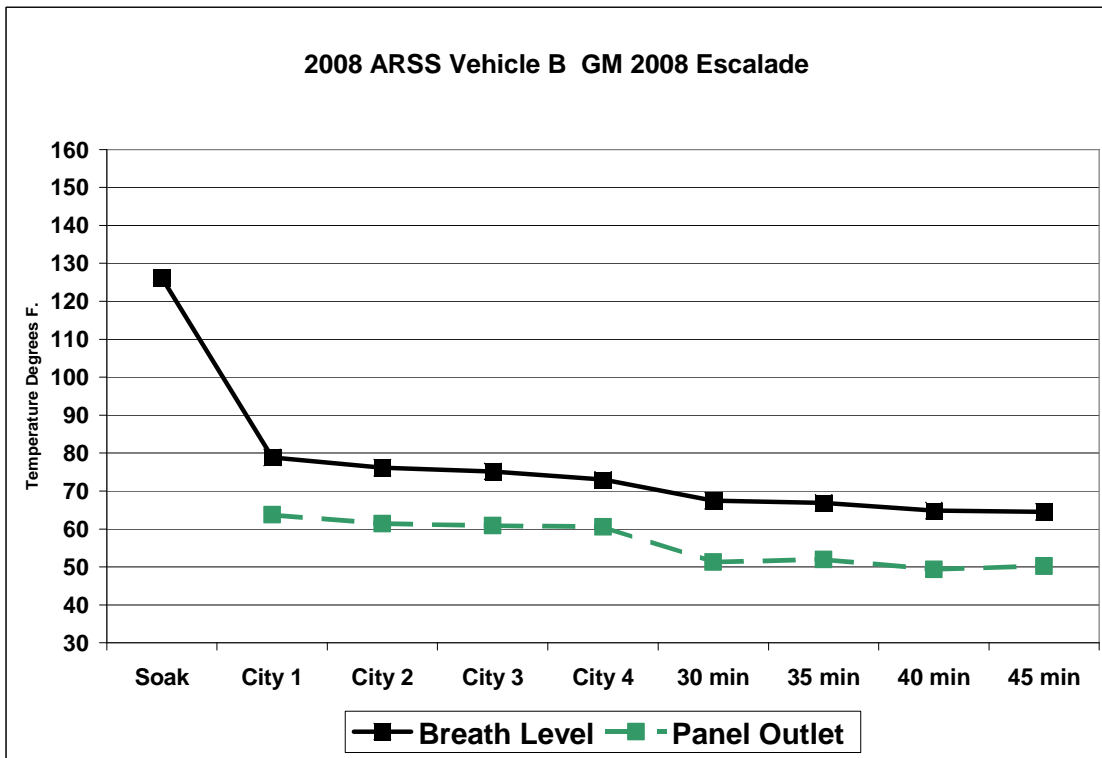


Figure 12

Vehicle C Chevrolet Impala R134a System

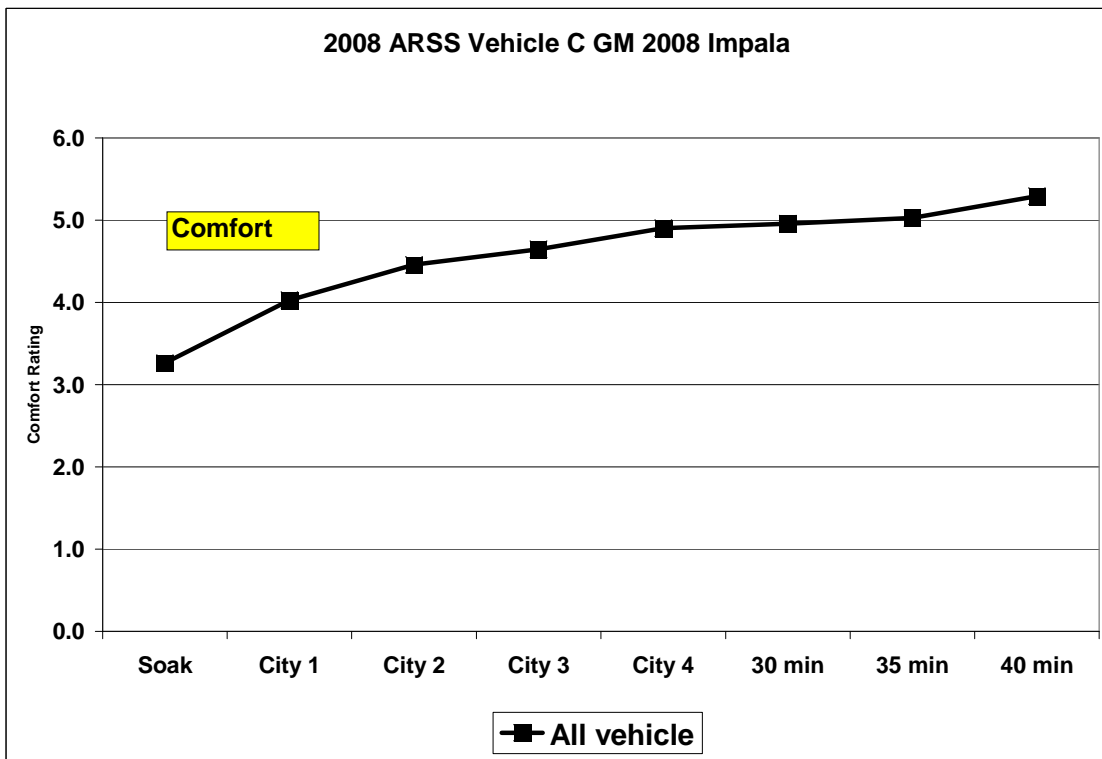


Figure 13

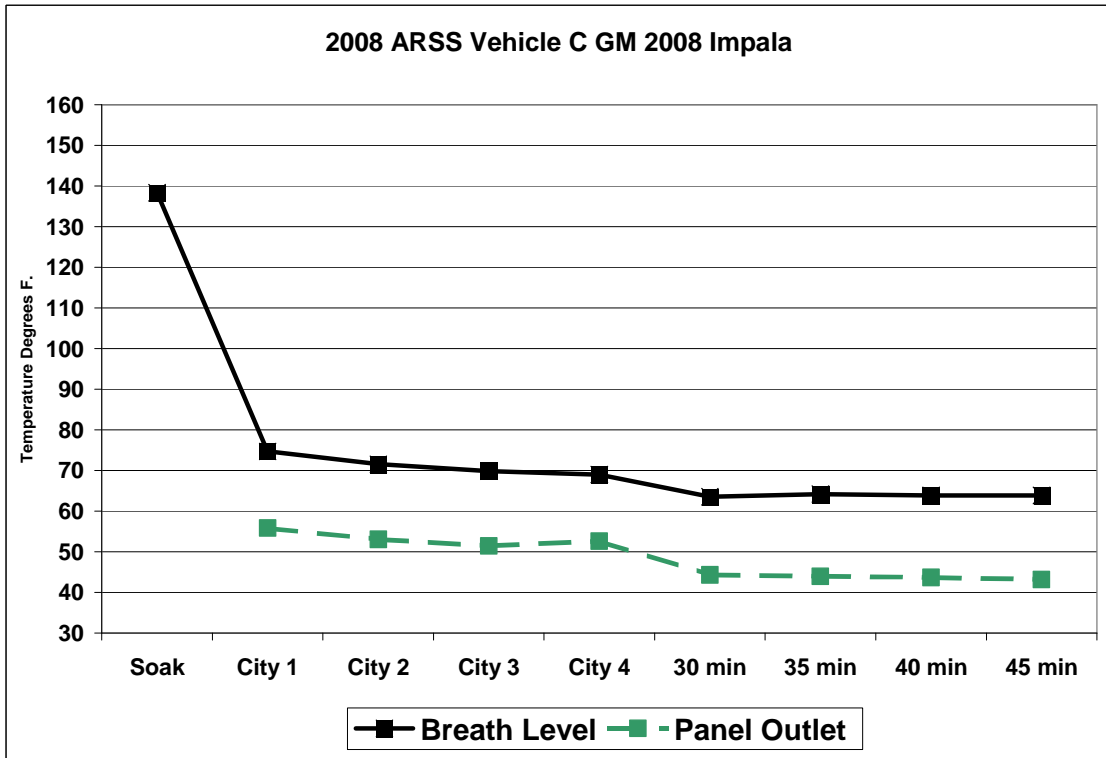


Figure 14

Vehicle D Hyundai/Kia R134a Refrigerant

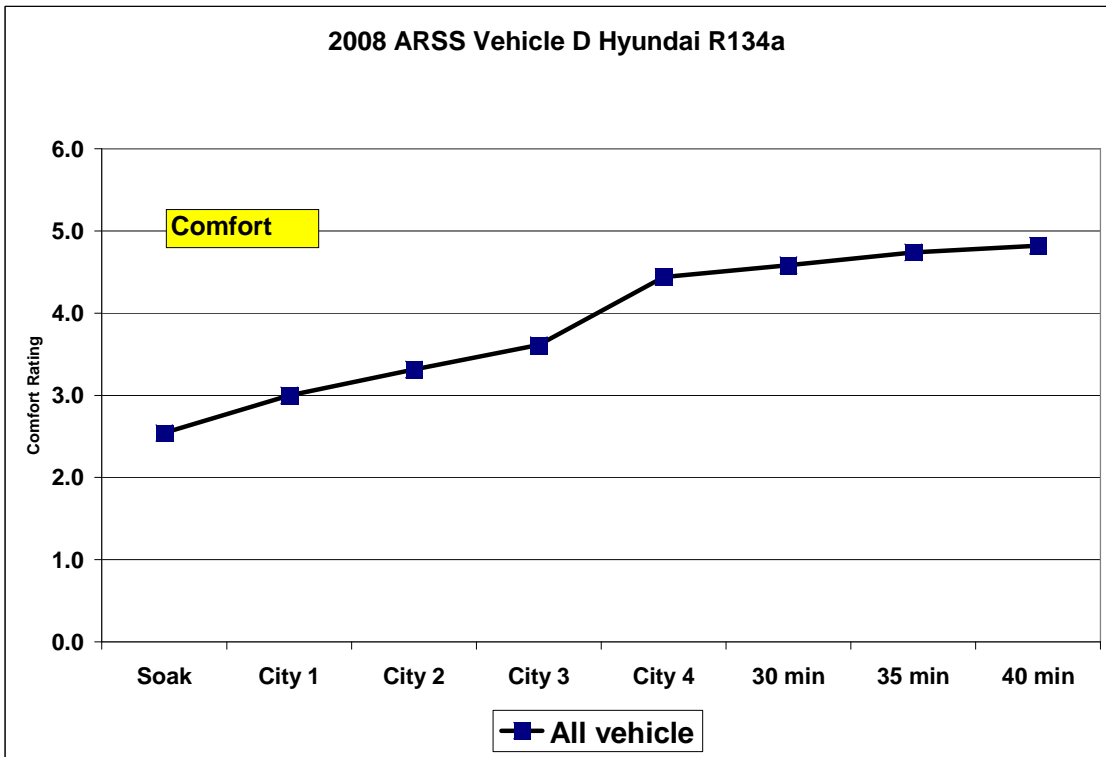


Figure 15

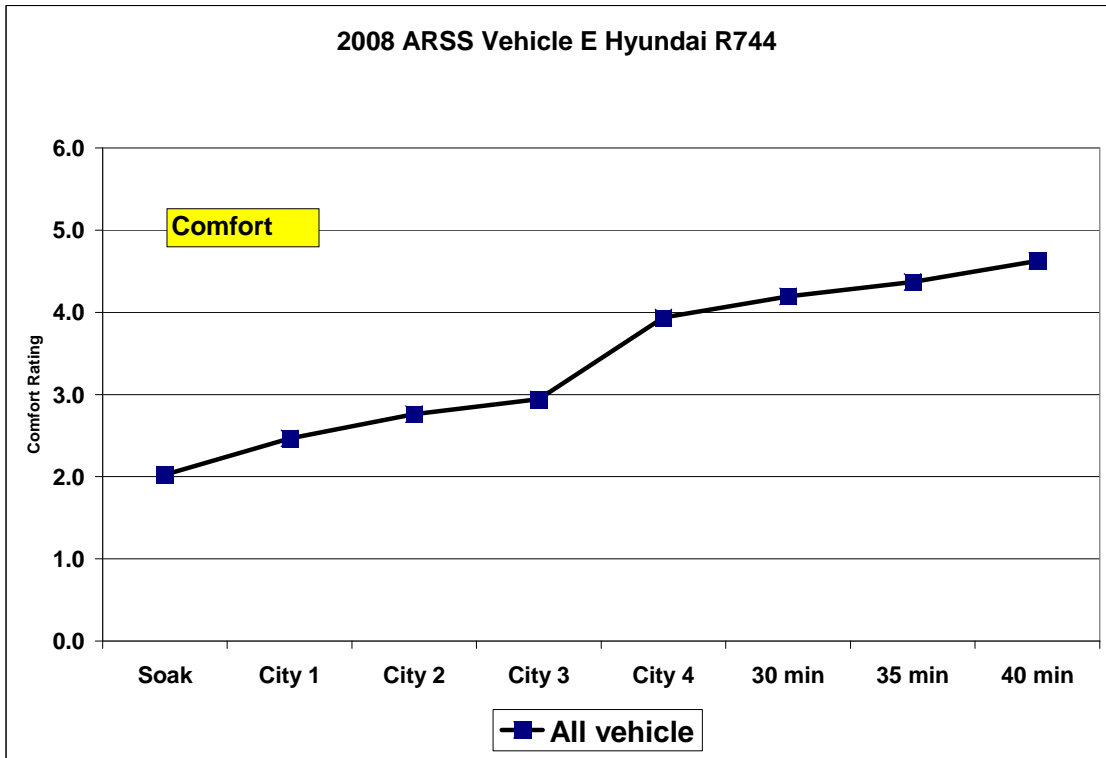


Figure 16

Vehicle E Hyundai/Kia R744 Refrigerant

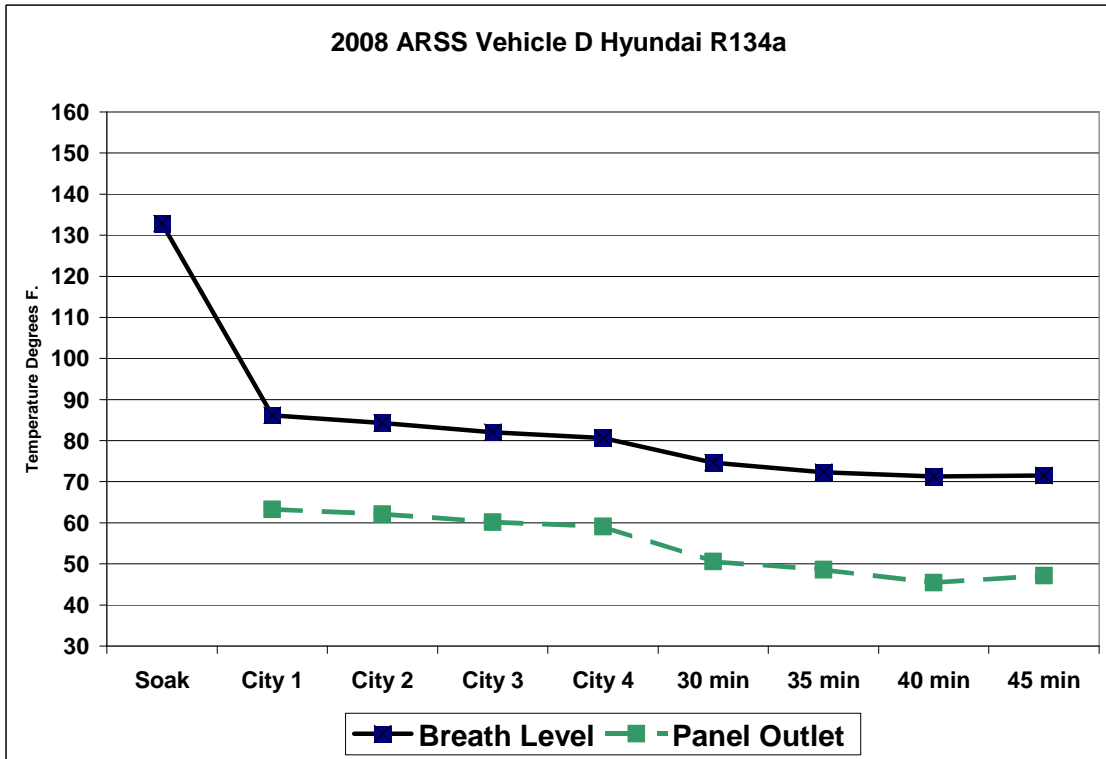


Figure 17

Vehicle E Hyundai/Kia HFO-1234yf Refrigerant

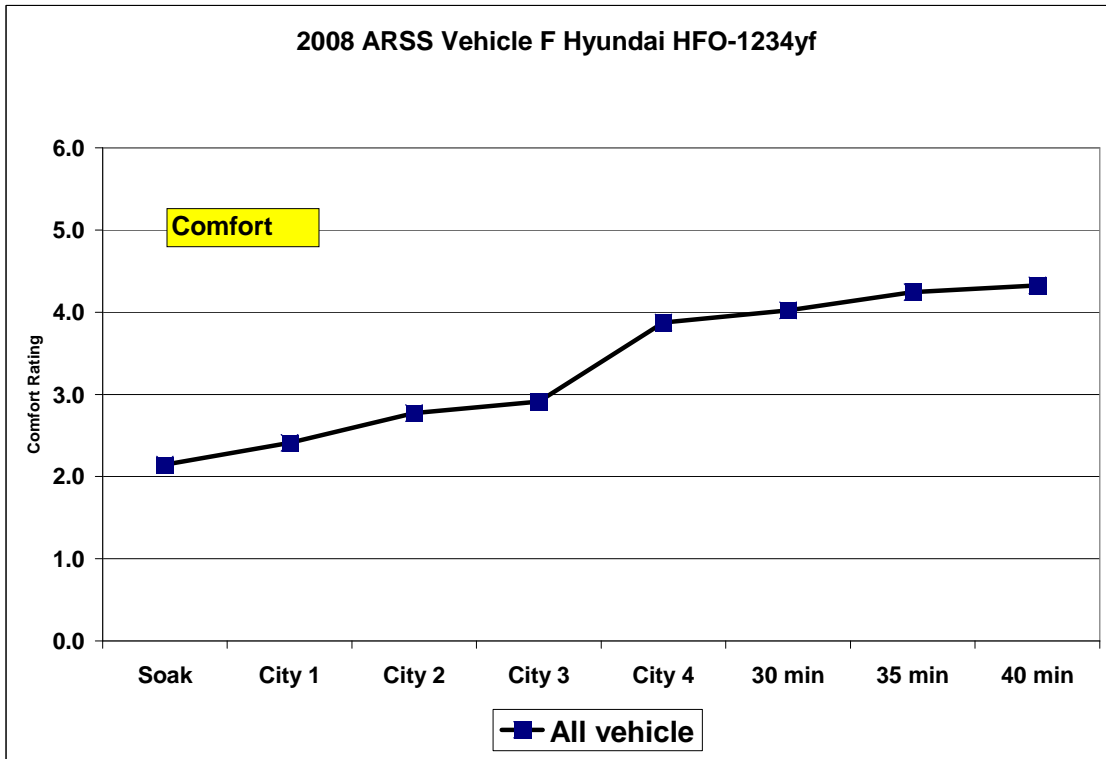


Figure 18

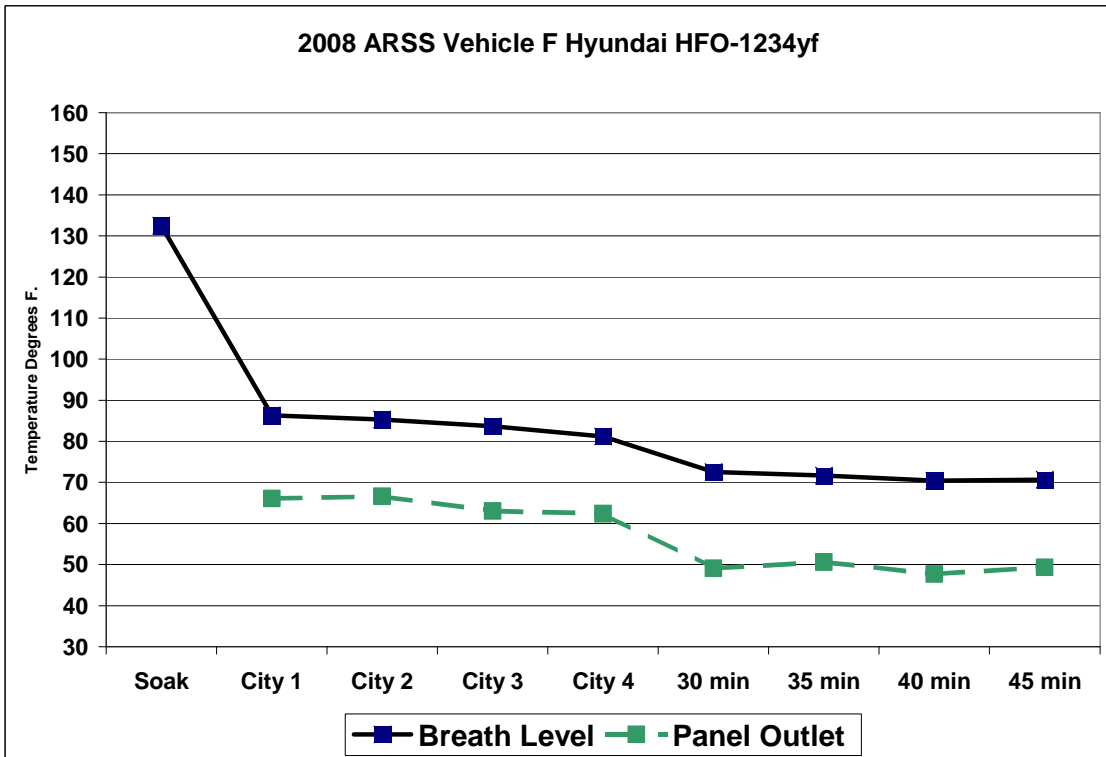


Figure 19

Hybrid System Evaluations

The ARSS programs have evaluated Hybrid and specialty mobile A/C systems during the 1998, 2004 and 2008 meetings. In prior evaluations these A/C systems provide reduced comfort levels as compared to belt driven compressor production systems.

Since hybrid and belt driven compressors systems are now available on comparable vehicle product lines it was part of the 2008 ARSS activity to have a comfort ride for cooling performance comparison of the new technology.

Invitations were sent to all vehicle manufacturers that currently produce hybrid vehicles to supply vehicles for the ride evaluation program.

General Motors provided the only hybrid vehicle for the 2008 evaluation and based upon the results the consumer's perceived level of comfort for this SUV vehicle, will be the same for an electric or belt driven compressor A/C system. [Figures 3, 4 and 20]

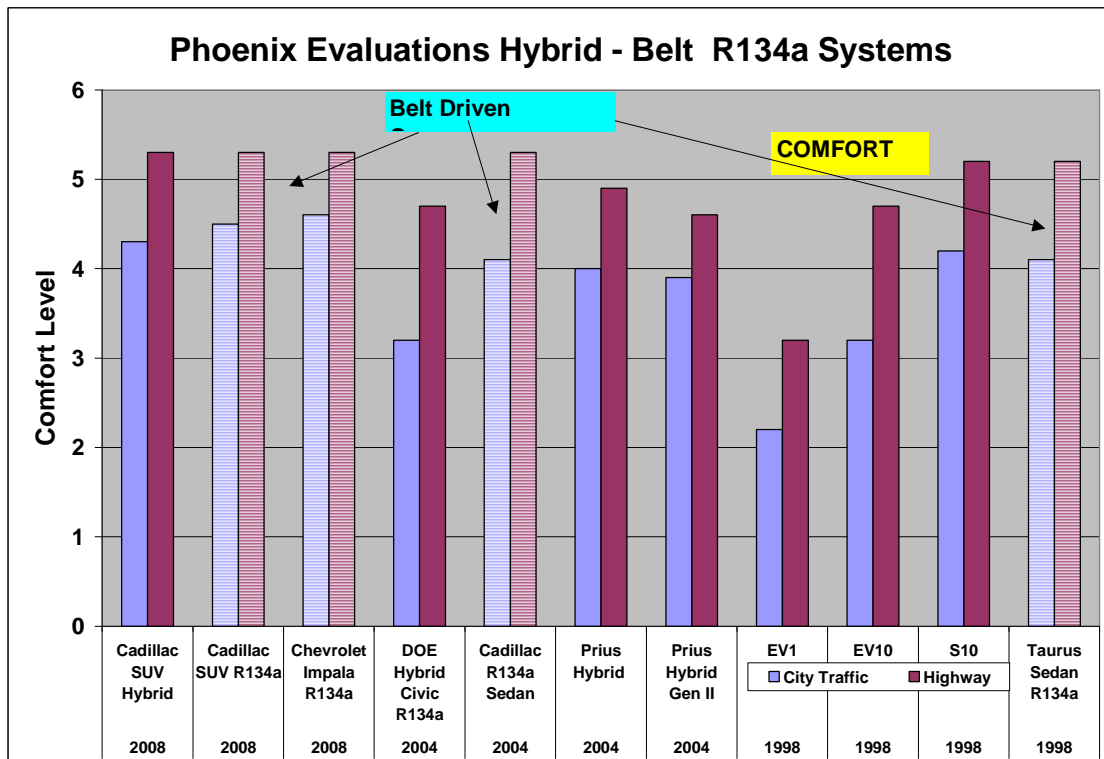


Figure 20

Extended Idle

An addition test was included after the formal ride comparing panel outlet air and breath level temperatures during an extended idle period. The vehicles were idled for 15 minutes on outside air and recirculated air. To eliminate the effect of solar load the tests were run in a covered area. The panel outlet air and breath temperatures were recorded every 3 minutes. The data can be found in Figures 21 through 24.

Idle Tests

Recirculating Air

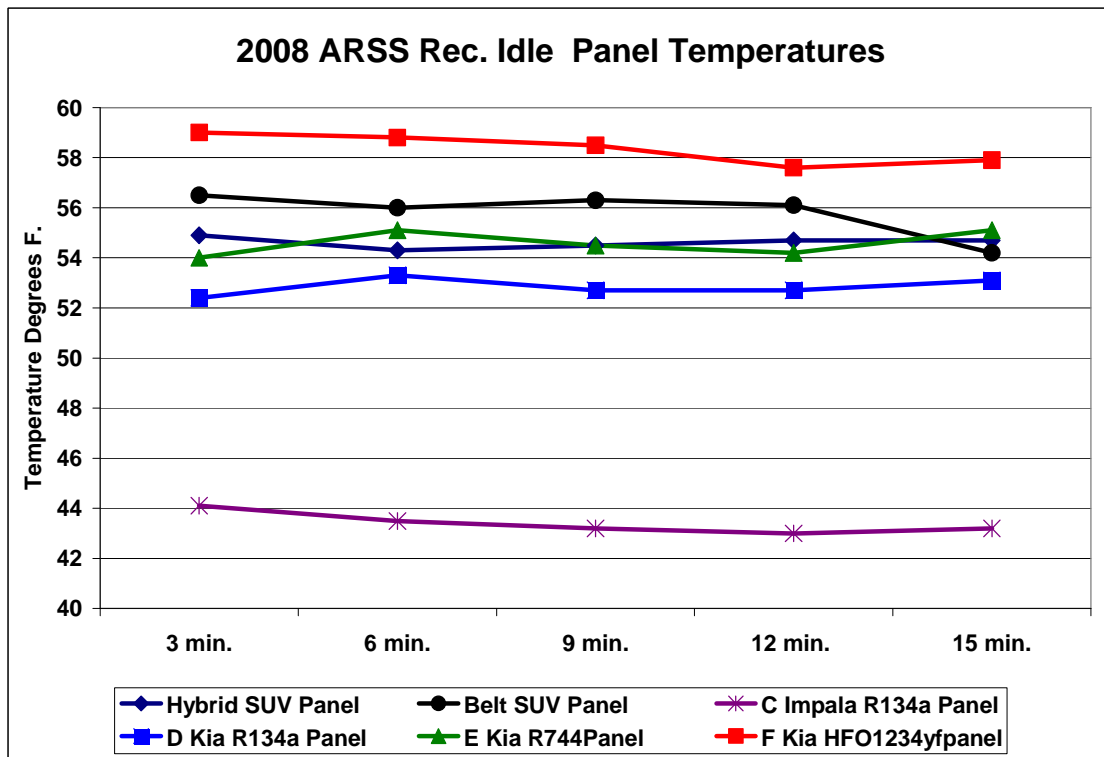


Figure 21

Outside Air

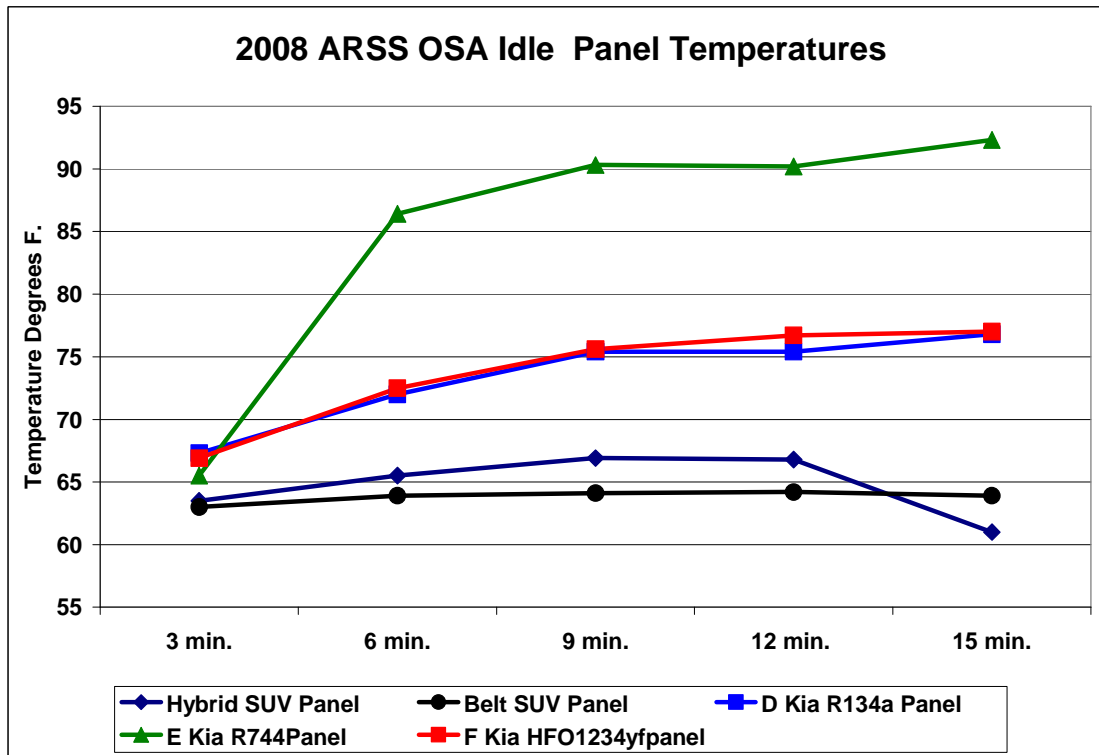


Figure 22

Idle Tests

Extended Idle Study		Rec. Air							
Test condition		REC. Air							
Vehicle		Date	Start Time	Ambient	3 min.	6 min.	9 min.	12 min.	15 min.
A	GM SUV Hybrid	6/11/2008	3:40 PM	97					
B	GM SUV Belt								
C	GM Impala R134a								
D	Hundai R134a								
E	Hundai R744								
F	Hundai R1234yf								

Figure 23

Extended Idle Study		OSA Air							
Test condition	Date	Start Time	Ambient	3 min.	6 min.	9 min.	12 min.	15 min.	
Vehicle	6/10/2008	3:55 PM	103 F						
A	GM SUV Hybrid			Panel Temp.	63.5	65.5	66.9	66.8	61
				Breath Temp.	74	75	76	76	71
B	GM SUV Belt			Panel Temp.	63	63.9	64.1	64.2	63.9
				Breath Temp.	73	74	74	73	73
C	GM Impala Compressor shut off			Panel Temp.	113	117.3	117.2	118	116.2
				Breath Temp.	100	104	105	107	108
D	Hyundai R134a			Panel Temp.	67.3	72	75.4	75.4	76.8
				Breath Temp.	78	82	84	84	84
E	Hyundai R744			Panel Temp.	65.5	86.4	90.3	90.2	92.3
				Breath Temp.	78	88	91	93	94
F	Hyundai R1234yf			Panel Temp.	66.9	72.5	75.6	76.7	77
				Breath Temp.	78	80	82	84	84

Figure 24

Ride Comments

The three 2008 Hyundai/Kia vehicles were Sportage SUV's having R134a, R744 and HFO1234yf refrigerant systems. This allowed for a closed hood ride evaluation and the evaluators did not have any information regarding what type of system or refrigerant was in each vehicle.

After completion of the evaluation ride the teams were told what system and refrigerant was in each vehicle.

Vehicle A

General Motors "R134a Electric Compressor" "Two Mode Hybrid 2009 Escalade" "Full size SUV
8-passenger

6 Rides –

Driver: Feet too warm without floor bleed

Right Front: Noisy blower rated 4 Overall NVA issue is blower noise

Right Front: Feet warm - Seat warm Comfortable with operation of seat cooler

Right Front: More vibration after 1 minute idle

Left rear: At 95F- too cool without adjusting controls (fan Temp)

Left rear: Vibration from system but acceptable

Vehicle B

General Motors "R134a Belt Driven Compressor" 2008 Escalade "Full size SUV 8-passenger"

6 Rides –

Driver: Left hand knuckle freeze

Right front: Fan airflow noise – frequency change

Right rear: When vehicle changes direction blast of cold felt on back

Vehicle C

General Motors R134a 2008 Chevrolet Impala 4 Door Sedan

6 Rides –

Right front: Water drops from extreme right vent CT 1 and CT 2

Vehicle D

Hyundai/Kia R134a Kia Sportage SUV

6 Rides –

No comments

Vehicle E

Hyundai/Kia R744 Kia Sportage SUV

6 Rides –

No comments

Vehicle F

Hyundai/Kia HFO1234yf Kia Sportage SUV

6 Rides –

Right front: Can feel temperature variation between idle and road speed.

2008 Weather Data

Recorded at test site

Weather Data					Solar	
Tue. 6-10-08	Ambient F.	Ambient C.	W.B. F.	% Humidity	Langleys	Btuh/ft-sq.
11:30 a.m.	98	37	68	20	60	240
12:00 p.m.	100	38	68	18	55	210
12:30 p.m.	100	38	67	17	50	195
1:00 p.m.	10	38.5	68	18	46	150
1:30 p.m.						
2:00 p.m.	103	40	67	13	30	140
2:30 p.m.	103	40	65	10	30	135
3:00 p.m.	103	40	66	11	40	135
3:30 p.m.	104	40.5	67	13	46	182
4:00 p.m.	106	41	69	15	50	160
Average	103.8	40.3	66.8	12.4	39.2	150.4
					Solar	
Wed. 6-11-08	Ambient F.	Ambient C.	W.B.	% Humidity	Langleys	Btuh/ft-sq.
11:30 a.m.	93	33.5	68	28	69	261
12:00 p.m.	93	34	68	28	70	270
12:30 p.m.	94	35	66	21	70	270
1:00 p.m.	94	35	66	21	70	270
1:30 p.m.	95	35	65	19	69	261
2:00 p.m.	95	35	65	19	65	250
2:30 p.m.	95	35	65	19	60	240
3:00 p.m.	96	36	65	18	52	203
3:30 p.m.	97	36.5	67	20	50	190
4:00 p.m.	100	38	66	15	40	160
Average	96.6	36.1	65.6	18.2	53.4	208.6
					Solar	
Thur. 6-12-08	Ambient F.	Ambient C.	W.B.	% Humidity	Langleys	Btuh/ft-sq.
11:30 a.m.	92	33	67	27	55	220
12:00 p.m.	93	33.5	66	23	55	219
12:30 p.m.	94	35	67	23	62	240
1:00 p.m.	95	35	65	19	54	210
1:30 p.m.	95	35	63	15	64	248
2:00 p.m.	96	36	66	19	60	240
2:30 p.m.	97	36	67	18	57	220
3:00 p.m.	98	37	64	12	52	200
3:30 p.m.	99	37.5	63	10	46	181
4:00 p.m.	100	38	67	17	28	125
Average	98	36.9	65.4	15.2	48.6	193.2

Table 2

2008 Formal Ride Schedule Table 3

Sponsor Vehicle	Type of Refrigerant System	Vehicle Model	Body Style	Engine	Trans	Axle Ratio	Color Ext.	Color Int.	Windows	Seat Surface	Comp. Ratio	
Phoenix 2008												
General Motors	A	R134a Electric Compressor	Two Mode Hybrid 2009 Escalade	Full size SUV 8-passenger	V8 Vortec 6.0	Two Mode Hybrid	3.08	Red	Black	Front: Clear 2nd & 3rd rows tinted	Leather	NA
General Motors	B	R134a Belt Driven Compressor	2008 Escalade	Full size SUV 8-passenger	V8 Vortec 6.2	6-Speed Automatic	3.42	Gold	Gold	Front: Clear 2nd & 3rd rows tinted	Leather	1.72
General Motors	C	R134a	2008 Impala	4 Door Sedan	V6 3500	4-Speed A/T		Silver	Lt. Grey	Front: Solar Side Tinted	Cloth	
Hyundai/Kia	D	R134a	Kia Sportage	SUV	2.7 V6	A/T		Blue	Gray	CLR/TINTED		
Hyundai/Kia	E	R744	Kia Sportage	SUV	2.7 V6	A/T		Blue	Gray	CLR/TINTED		
Hyundai/Kia	F	R1234yf	Kia Sportage	SUV	2.7 V6	A/T		Blue	Gray	CLR/TINTED		

2008 Vehicle Specifications Table 4

		Vehicle Soak and Ride Times											
Vehicle		Tuesday June 10, 2008				Wednesday June 11, 2008				Thursday June 12, 2008			
	Vehicle	11:45	12:45	1:45	2:45	11:45	12:45	1:45	2:45	11:45	12:45	1:45	2:45
Group 1													
GM	A	s	1	s	2	s	3	s	4	s	5	s	6
GM	B	s	2	s	3	s	4	s	5	s	6	s	1
GM	C	s	3	s	4	s	5	s	6	s	1	s	2
Hyundai	D	s	4	s	5	s	6	s	1	s	2	s	3
Hyundai	E	s	5	s	6	s	1	s	2	s	3	s	4
Hyundai	F	s	6	s	1	s	2	s	3	s	4	s	5

TECHNICAL SESSIONS

No audio or video recording of presentations is permitted, except by SAE. Please turn off cell phones and pagers before entering technical session rooms.

MONDAY, 8:00 a.m. – 12 noon
June 9, 2008 **SAE CRP1234-1** (Members only) The
McDowell Room

12 noon

Lunch (On your own)

1:30 - 4:30 p.m.

SAE CRP1234-2 (Members only) The
McDowell Room

1:00 p.m. - 5:00 p.m.

ARSS Registration [Riders of vehicles must pre-register]

TUESDAY, 7:00 a.m.
June 10, 2008 **Registration** – The Navajo Room
Breakfast - The McDowell Room

8:00 a.m.

Opening Remarks

Ward Atkinson 8:10 a.m.

R1234yf System Enhancements

John Meyer, visteon Climate Control 8:40 a.m.

SAE CRP 1234-2 Overview of HFO-1234yf Project

William Hill, GM Technical Center 9:10 a.m.

The Four Fiat Pandas Experiment - To evaluate different MAC systems

Carlo-Andrea Malvicino, CrF veicoli 9:40 a.m.

Refreshment Break

10:00 a.m.

Assessment of MACs Direct Refrigerant Emissions Depending on Driving Mileage and Ambient Conditions

Roberto Monforte, Fiat Group Automobiles S.p.A. 10:30 a.m.

GM HFO-1234yf Refrigerant Development

Kenneth Porrett and Eric Scarlett, GM

11:00 a.m.

HFO-1234yf Low GWP Refrigerant - A Global Sustainable Solution for Mobile Air Conditioning

Mark Spatz, Honeywell intl. inc.;

Barbara Haviland-Minor, DuPont Fluorproducts

11:30 a.m.–12:00 p.m.

Ride Commentary

12:00 – 1:15 p.m.

Lunch - The McDowell Room

AUTOMOTIVE

12:45 – 3:45 p.m.

Formal Vehicle Rides

Formal Vehicle rides are for members of specifically assigned ride teams. 1:30 – 2:00 p.m.

Personal Climate Controlled Seating: Combining Enhanced Comfort with Improved Fuel Economy

Edward I. Wolfe IV, Delphi Automotive Systems; Karl Kennedy, Lear Corporation *Demonstration vehicle will be on site during the Symposium for comfort rides upon request.*

3:00 - 5:00 p.m.

Committee Working Group Meetings - LCCP

6:00 – 7:00 p.m.

Welcome Reception – The Pavilion Room

7:00 a.m.

Registration – The Navajo Room **Breakfast** - The McDowell Room

8:00 a.m.

COP Determination of MAC

Harald Riegel, Behr GmbH & Co. KG 8:30 a.m.

Update on EPA SNAP Regulations

Karen Thundiyil, U.S. Environmental Protection Agency 8:45 a.m.

Flammability Assessment HFO-1234yf

Christophe Proust, iNERIS 9:00 a.m.

Comparative Life Cycle Assessment on Alternative Refrigerant Systems

Scott Bang, Jinyoung Yoo and Naksup Sung, Hyundai & Kia Corp.

WEDNESDAY,
June 11, 2008

WEDNESDAY,
June 11, 2008

TECHNICAL SESSIONS

9:30 a.m.

Greenhouse Gas Emissions and Abatement Opportunities in Do-It-Yourself Recharging of Leaky Motor Vehicle Air Conditioning Systems in California

Alberto Ayala, CARB 10:00 a.m.

Refreshment Break

10:20 a.m.

Leakage Analysis of R744 Compressor Shaft Seal

Markus Schwerdtfeger, KACO GmbH + Co KG Dich. 10:50 a.m.

“Piflex” Flexible All Aluminum Hose for R744 MAC Systems

Henry Petersen, PIFLEX P/S ; Carsten Post, Hydro Aluminium 11:20 a.m.

A/C System Control Strategies for Major Refrigerant Options

Christophe Petitjean, valeo

12:00 – 1:15 p.m.

Lunch - The McDowell Room

12:45 – 3:45 p.m.

Formal Rides

Formal Vehicle Rides are for member of specifically assigned ride teams. 3:00 – 5:00

p.m.

Committee meeting of standards working groups, including ISO document development

6:00 – 7:00 p.m.

THURSDAY,
June 12, 2008

Evening Reception – The Pavilion Room

7:00 a.m.

Registration – The Navajo Room

Breakfast - The McDowell Room

8:00 a.m.

Test Results of Refrigerant R-152a in an Automotive Air-conditioning System

Man-Hoe Kim, Korea Advanced inst. of Science & Technology 8:30 - 10:05

a.m.

Industry Updates

Results of Audi A5 Evaluation with Alternate Refrigerants

Hans Hammer, Audi AG

Results of Nissan and Toyota Investigation of Alternate Refrigerants Regulation

Kenta Aoki, Nissan; Tohru Ikegami, Toyota

Hyundai/Kia Evaluation of Alternate Refrigerants

Scott Bang, Jinyoung Yoo and Naksup Sung, Hyundai & Kia Corp.

Results of GM Evaluation of Alternate Refrigerants

Harry Eustice, GM

Current Status of Alternate Refrigerant Evaluation

Jean-Marie L'Huillier, Renault; Roberto Monforte, Fiat; Bruno Rose, PSA 10:05 am

Refreshment Break

10:20 a.m.

Mobile A/C Impact on CO2 Exhaust Emissions - Over the Road Monitoring in Real Time

Timothy Fox, California State Univ. - Northridge 10:50 a.m.

The Great Refrigerant Debate

Panel of global OEM and Tier one representatives to offer "opinions" on a range of questions related to refrigerant choices to meet the EU regulation mandated for 2011.

Kenta Aoki, Nissan

Scott Bang, Hyundai Tim Craig, Delphi

Harry Eustice, GM

Hans Hammer, Audi AG Tohru Ikegami, Toyota

Jean-Marie L'Huillier, Renault Roberto Monforte, Fiat

Christophe Petitjean, valeo Bruno Rose, PSA

SAE Disclaimer:

The purpose of this session is to provide an open exchange of ideas. Remarks made by participants or members of the audience cannot be quoted or attributed to the individual or their company unless express permission has been granted by the individual and their company. Any record of remarks, discussion, or photographs may not be used unless express permission has been granted by the individual and their company.

12:00 – 1:15 p.m.

Lunch

12:45 - 3:45 p.m.

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Committee Working Group Meetings - ICC