



SAE Alternate Refrigerant Cooperative Research Project

November 2002

Project Objective

Provide a directly comparative engineering evaluation of the existing HFC-134a systems and other refrigerant technologies.

Organization

Three core groups interfaced with vehicle and A/C system manufacturers

USA Core-USA manufacturers

JAMA-Asian manufacturers

VDA-European manufacturers

Project Overview

- SAE Alternate Refrigerant Cooperative Research Program
- Independent Laboratory Evaluation of three alternatives
 - R134a Baseline System representative of that used in a current production mid-sized passenger car
 - R744 System representative of the current state of development for R744 systems in mid-2001
 - R134a Enhanced System representative of next generation R134a system components
- Test schedule developed with industry input
- Detail test administration by representatives of four of the major OEM's
 - Two from USA, two from Europe
- System configurations were also chosen by this group

Project History

Alternate Refrigerant Cooperative Research Program Partners

The partners are most major vehicle OEM's and Climate System suppliers, U.S. Army and Environmental Protection Agency, and Environment Canada

This report covers an overview of the project. Complete reports are only issued and available to the ARCRP partners.

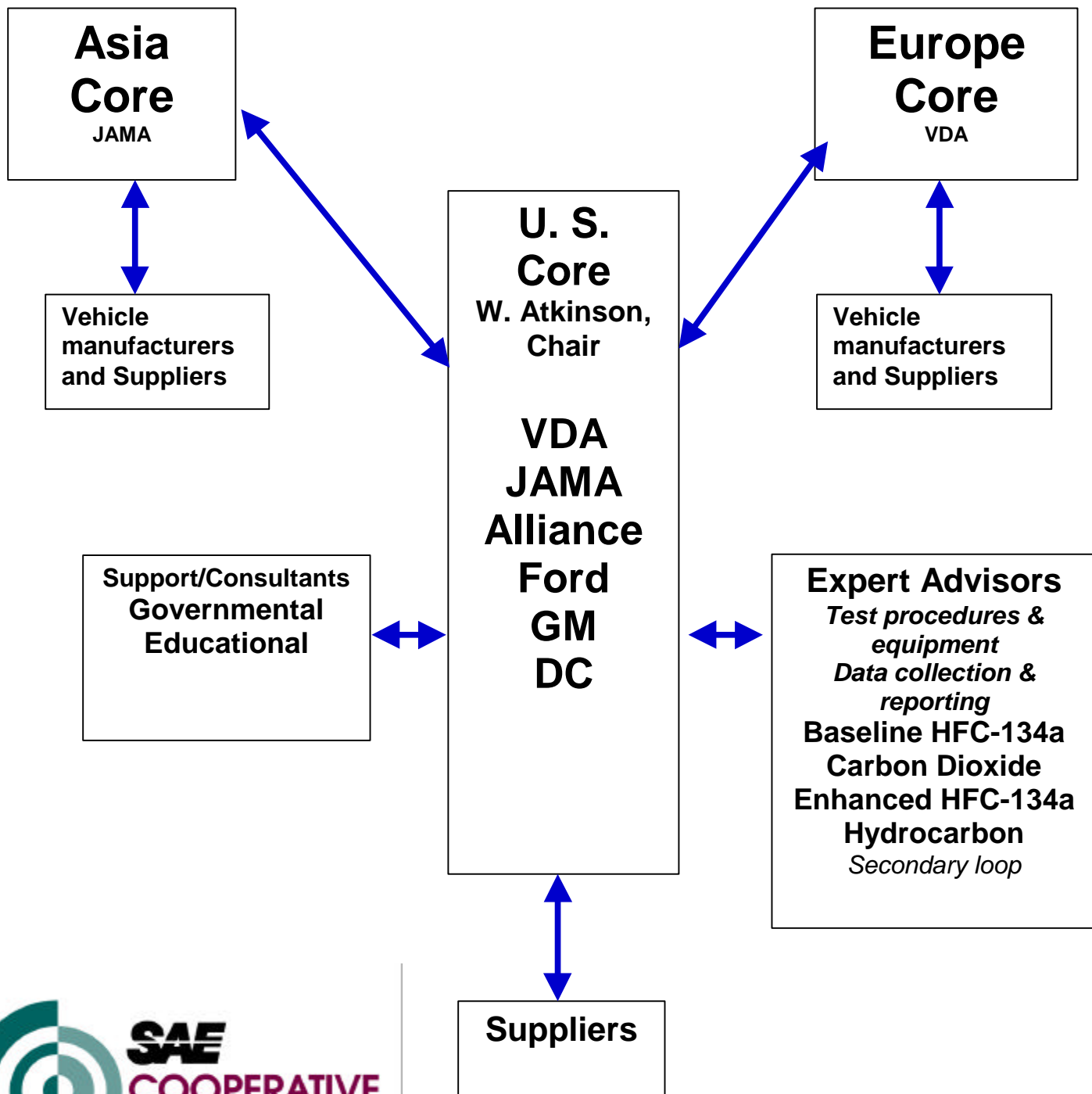
First Interim Report Distributed-Baseline R134a Nov., 2001

Second Interim Report Distributed-CO₂ May, 2002

Third Interim Report on Baseline vs CO₂ vs Improved R134a-September, 2002

Project Complete by the end of 2002

SAE Alternate Refrigerant Cooperative Research Project



System Comparison

Component	Feature	Baseline R134a	R744	Enhanced R134a
	Core Effective Face [mm]	W768xH400xD20	W689xH464xD16	W679xH465xD16
	Face area [mm ²]	307,200	319,696	315,735
Condenser	Core volume [mm ³]	6,144,000	5,115,136	5,051,760
	Aspect Ratio	0.52	0.67	0.68
	Mass [kg]	2.8	2.4	2.9
	Core Effective Face [mm]	W280xH216xD73	W305xH210xD58	W294xH216xD50
	Face area [mm ²]	60,480	64,050	63,504
Evaporator	Core volume [mm ³]	4,415,040	3,714,900	3,175,200
	Aspect Ratio	0.77	0.70	0.73
	Mass [kg]	2.0	2.7	1.6
	Type	Variable Swash - plate	Variable Swash - plate	Variable Swash -plate
Compressor	Displacement [cc.]	~165	~33	~165
	Mass(including pulley) [kg.]	6.4	7.0	6.4
SLHX	Length [mm.]		2100	
	Mass [kg.]	N/A	1.1	N/A
Receiver/Drier	Volume [cc.]			
	Mass [kg.]	0.4	1.4	IRD, see condenser
Oil Separator	Volume [cc.]			
	Mass [kg.]		0.2	
Total Mass	[kg]	11.6	14.8	10.9

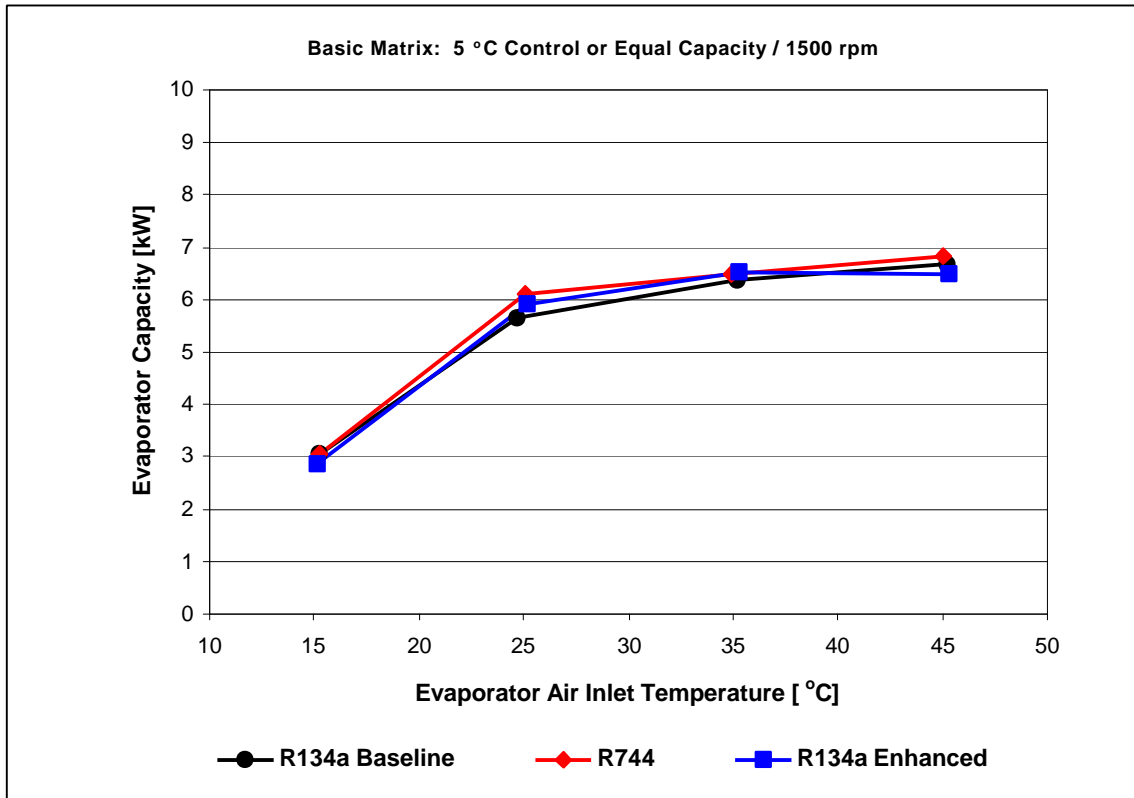
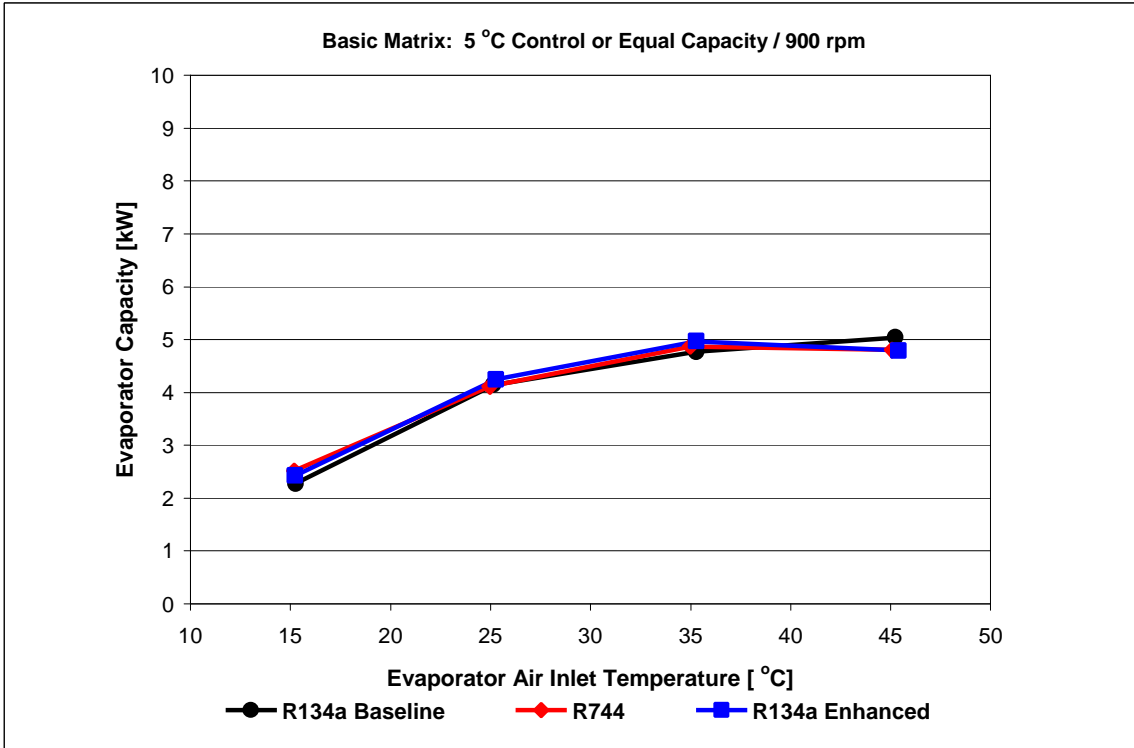
Mass includes heat exchangers, compressor and fluid storage. Does not include refrigerant lines, fittings or valves, or system controls.

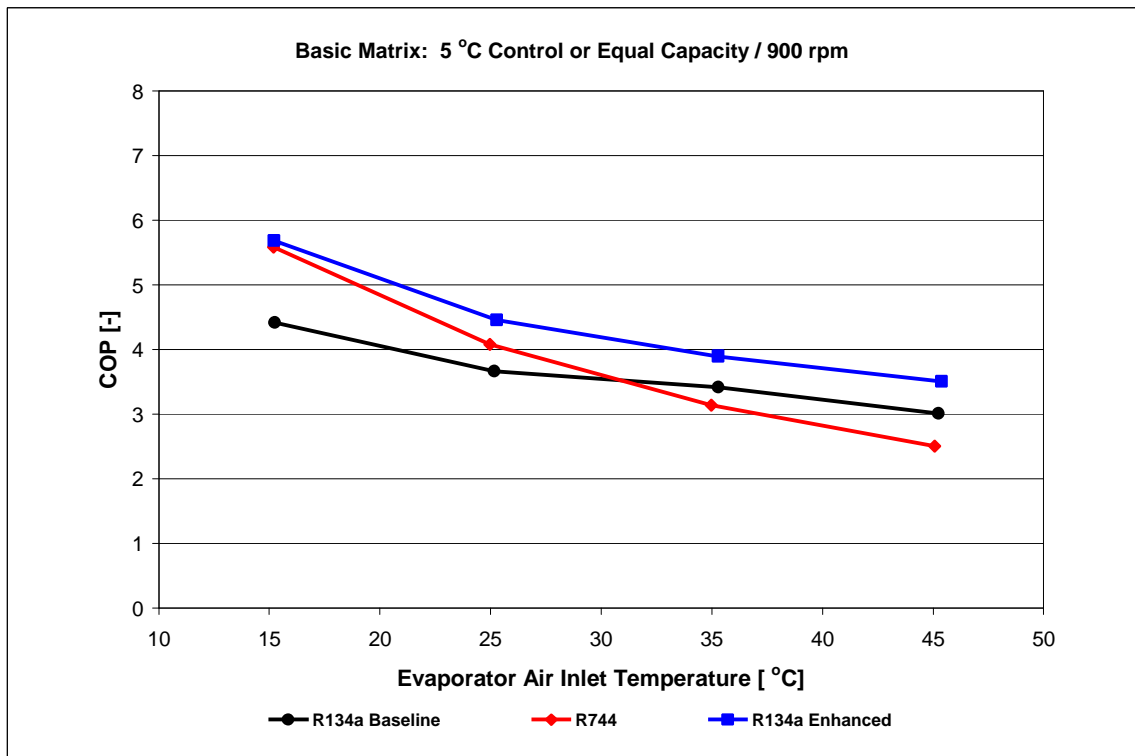
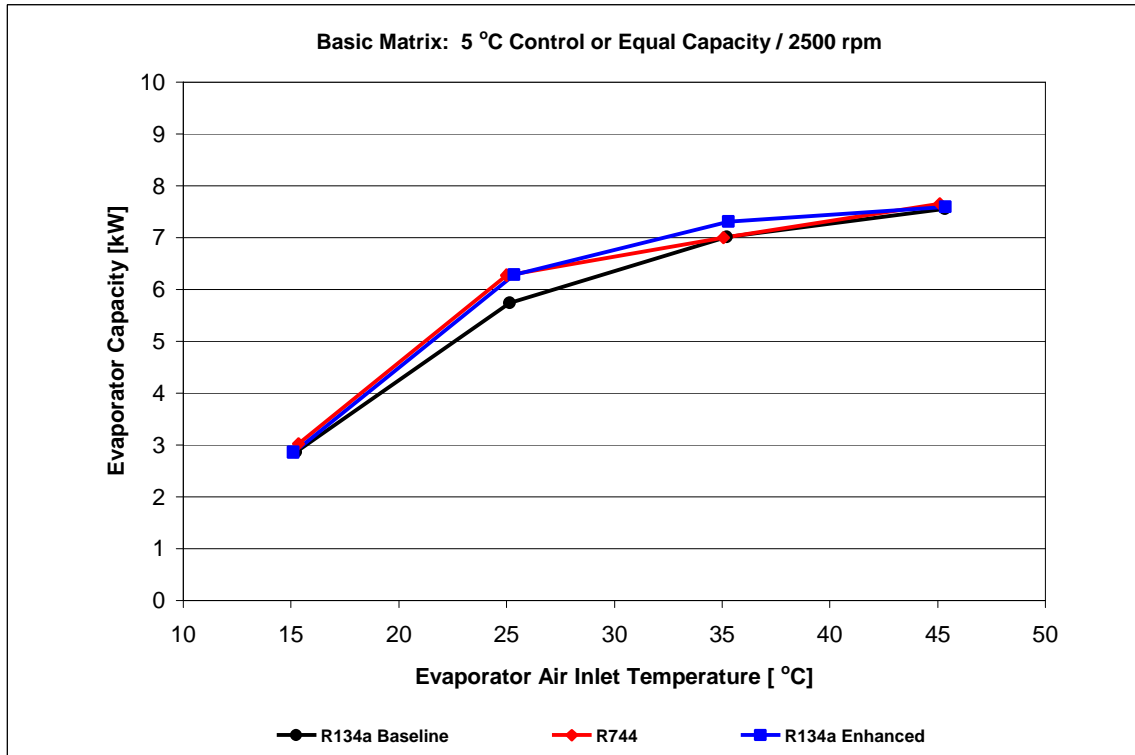
Steady State Test

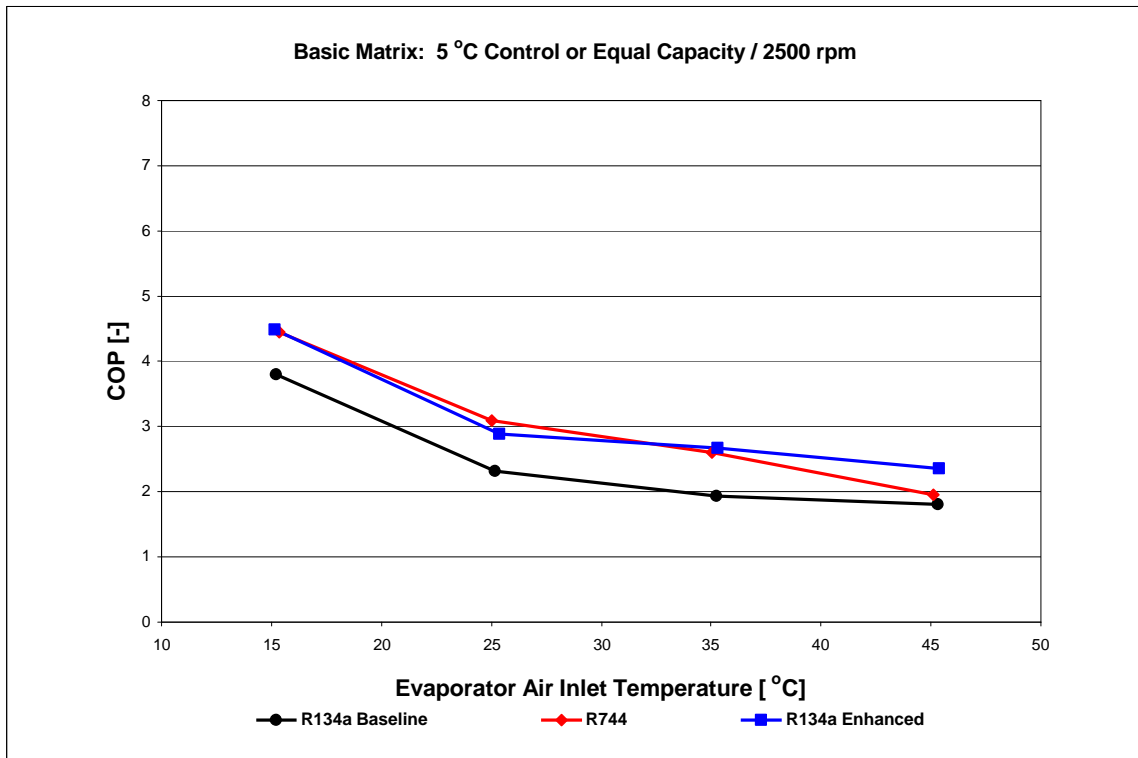
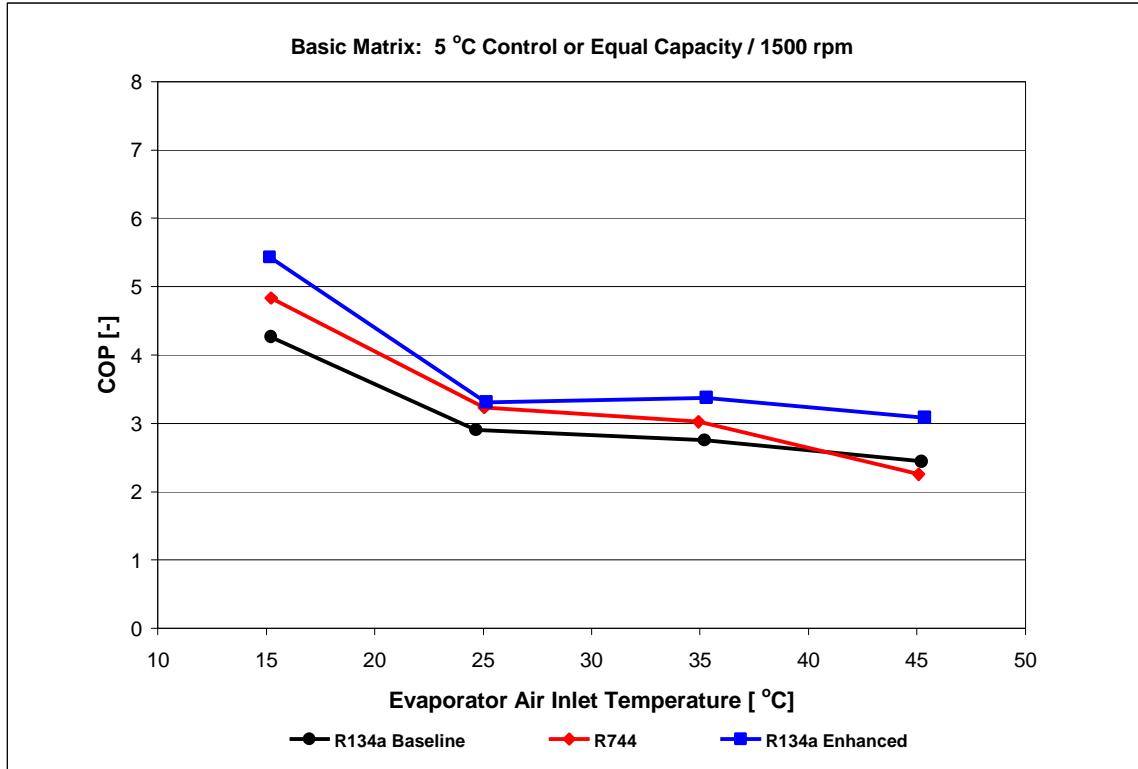
- The Steady State Test Basic Matrix maps Capacity and Coefficient of Performance over ambient and speed operating conditions encountered in mobile air conditioning applications.
- Test control permutations are:
 - Air temperature downstream of the evaporator, 5 °C.
 - OR; if the control temperature cannot be reached, systems are run at Equal Capacity.
- Additional parameters studied are:
 - Elevated air temperature into the condenser
 - Low airflow through the evaporator.
- Tests were also run at 10°C evaporator out air temperature and the results were similar but are not presented here [This simulates systems that are capable of reducing compressor energy consumption by limiting the amount of cool-down and re-heat by changing the compressor control set point.]

Basic Matrix – 5 °C Control or Equal Capacity

Basic Test Point Matrix					
Evaporator Air			Cond/Gas Cooler Air		Comp rpm
T (°C)	RH (%)	Flow (l/s)	T (°C)	Flow (l/s)	
45	27	109	45	425	900
		130		850	1500
				1320	2500
35	45	109	35	425	900
		130		850	1500
				1320	2500
25	65	109	25	425	900
		130		850	1500
				1320	2500
15	80	109	15	425	900
		130		850	1500
				1320	2500





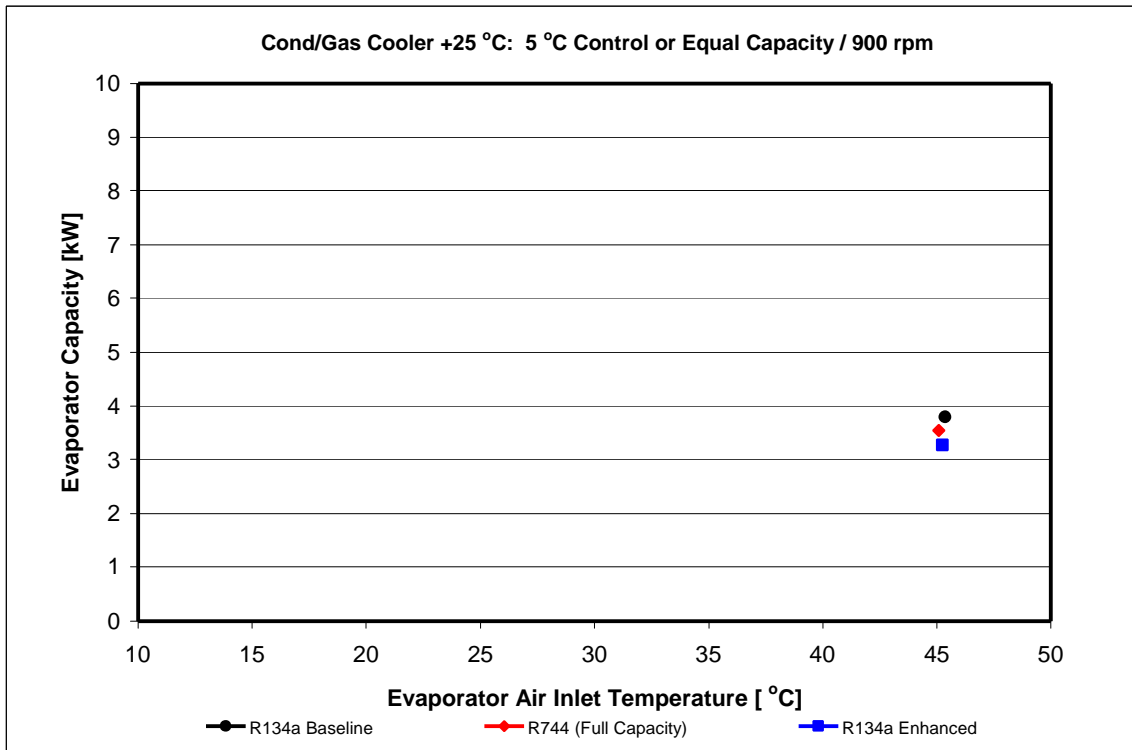
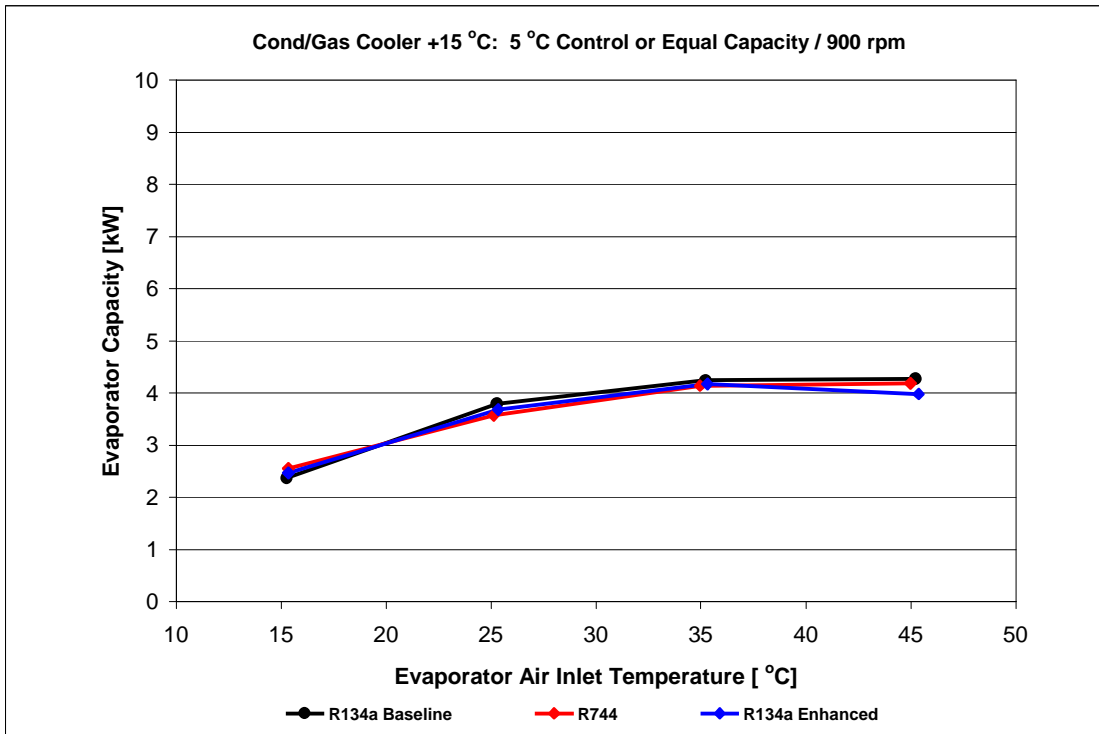


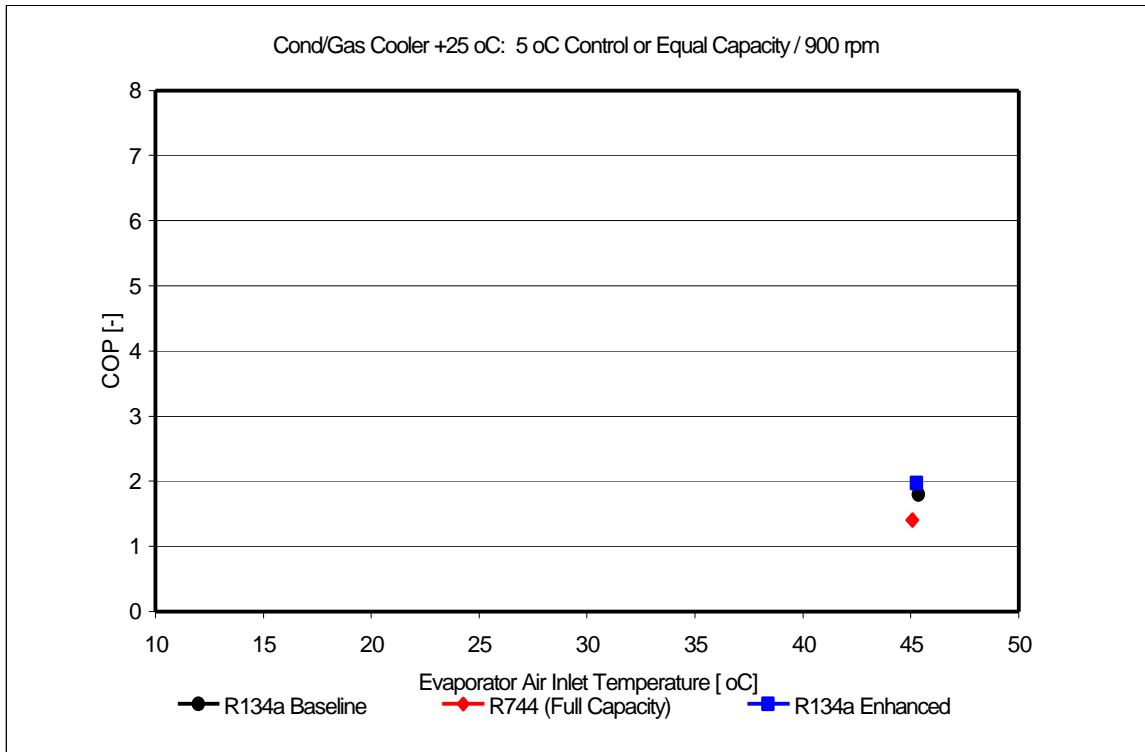
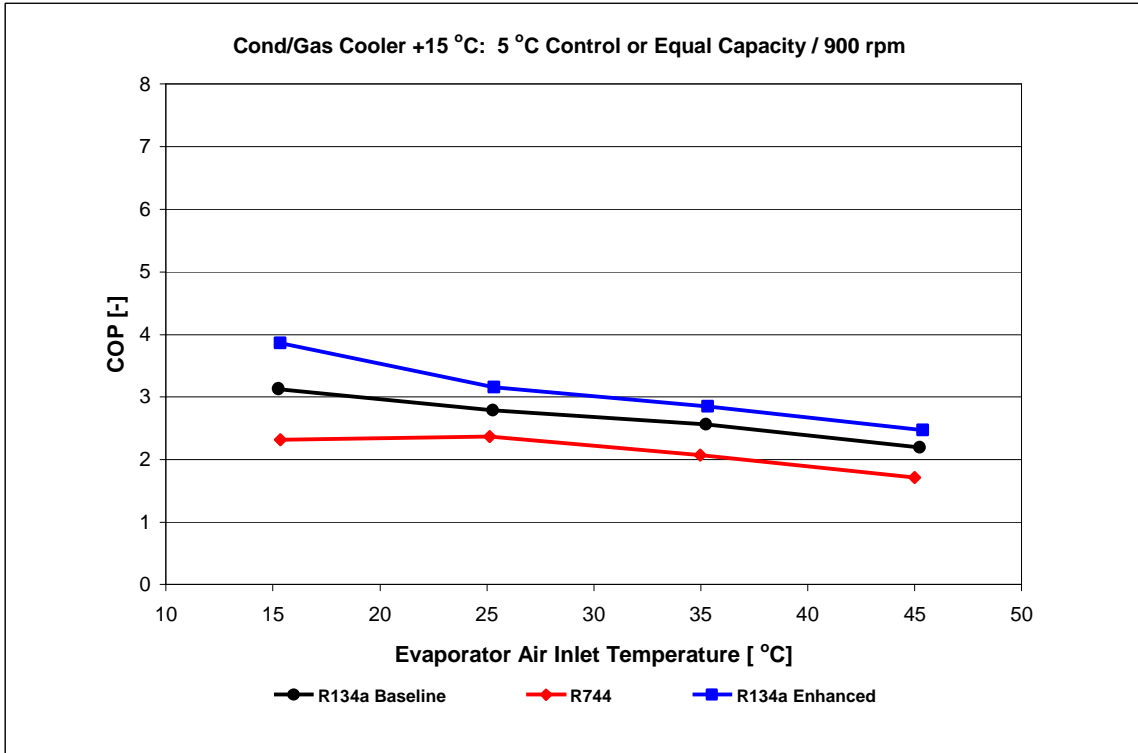
Condenser/Gas Cooler Air Temperature

- The purpose is to simulate re-circulation of hot engine compartment air into the condenser at idle.
- 900 rpm performance was run with elevated temperature into the condenser/gas cooler.
- Air temperature into the condenser/gas cooler was elevated +15 °C at 15, 25, 35 and 45 °C conditions and also +25 °C at 45 °C.
- Tests were run for Equal Capacity conditions.

Condenser/Gas Cooler Air Temperature

Condenser/Gas Cooler Air Temperature Matrix					
Evaporator Air			Cond/Gas Cooler Air		Comp rpm
T (°C)	RH (%)	Flow (l/s)	T (°C)	Flow (l/s)	
45	27	109	60 70	425	900
35	45	109	50	425	900
25	65	109	40	425	900
15	80	109	30	425	900

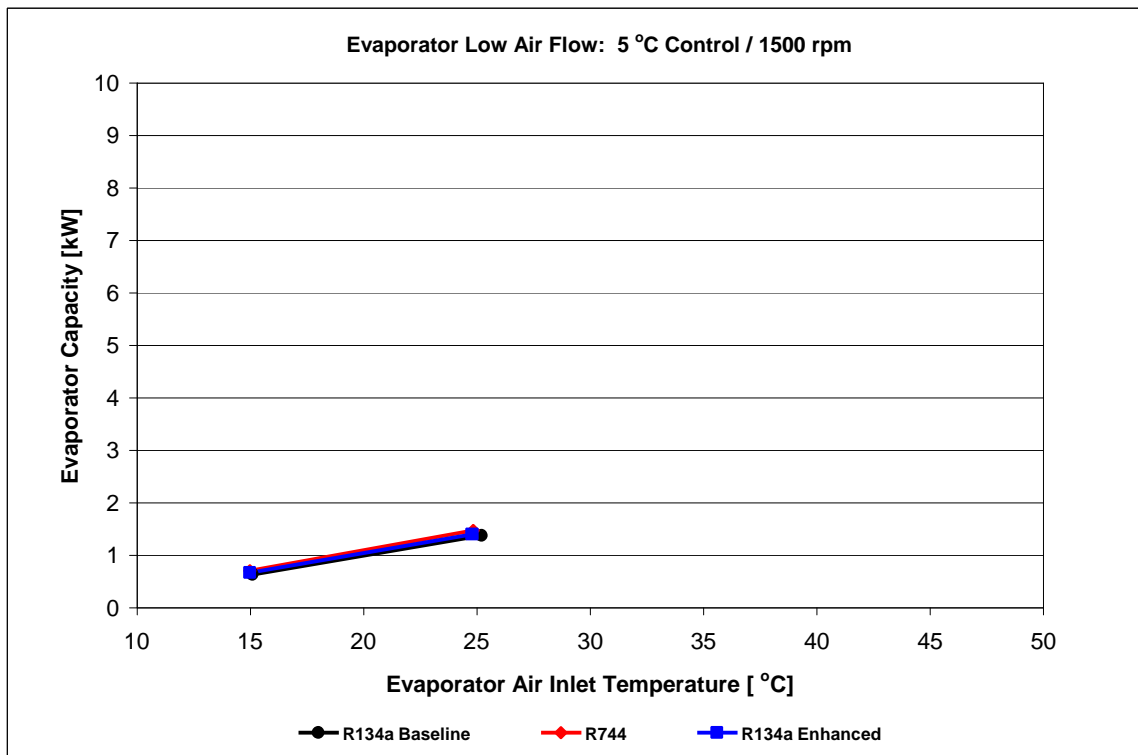
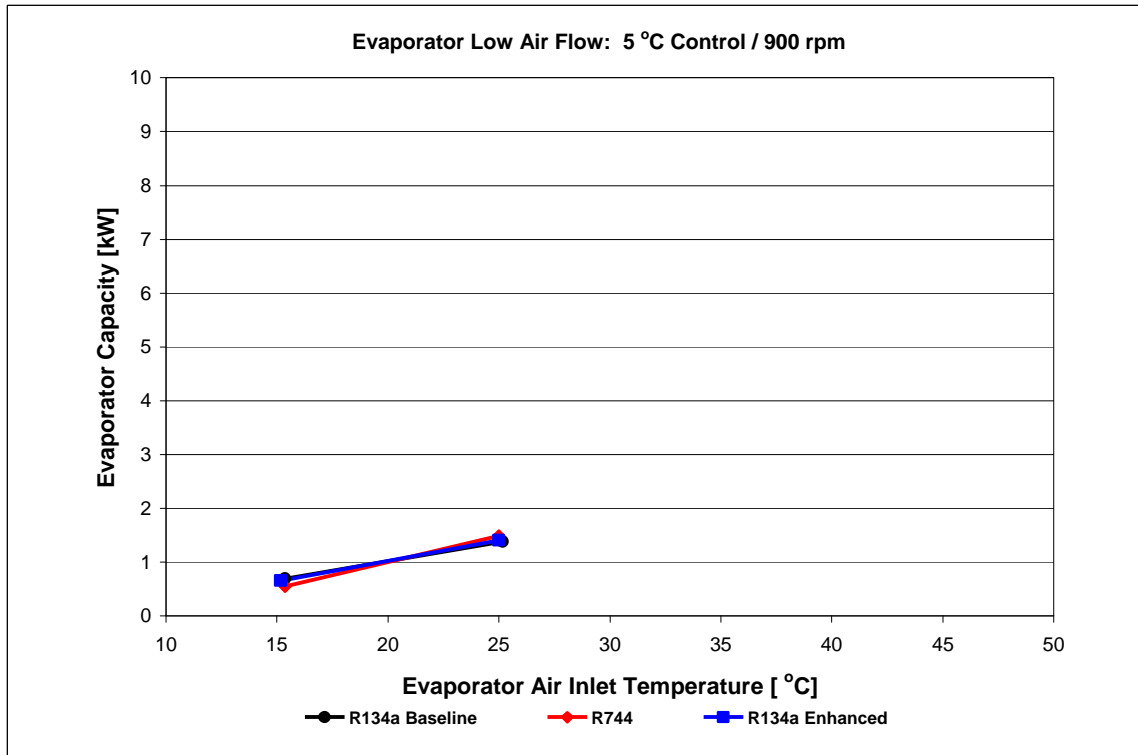


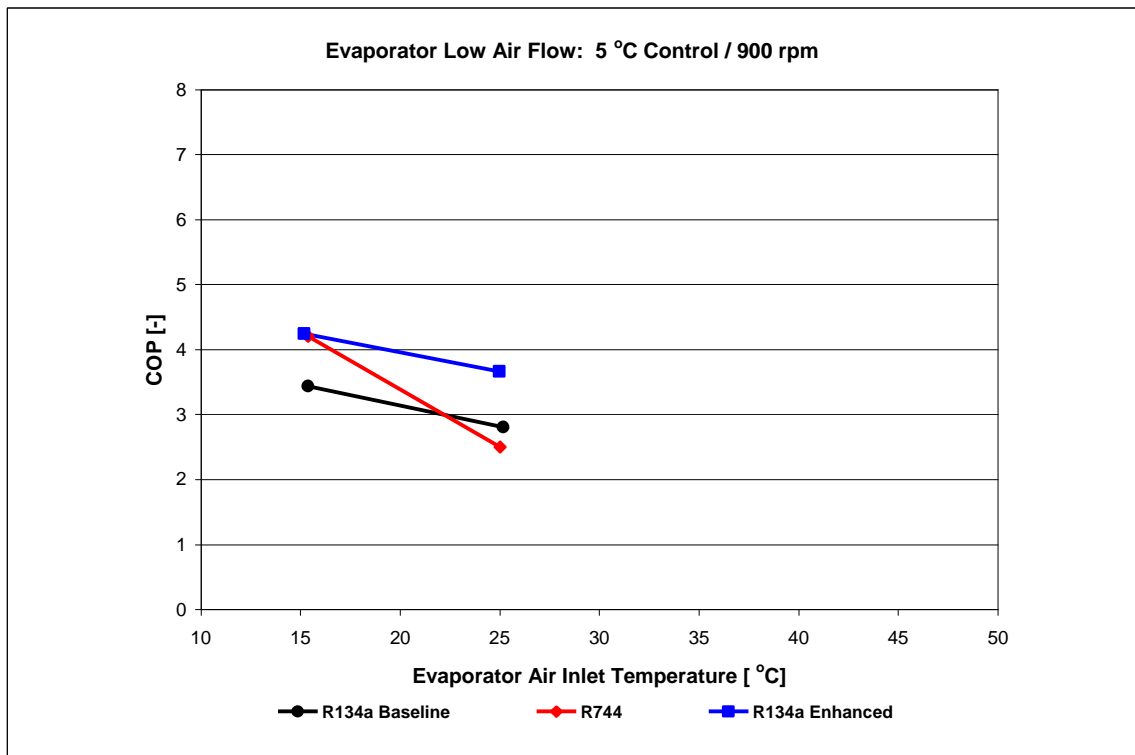
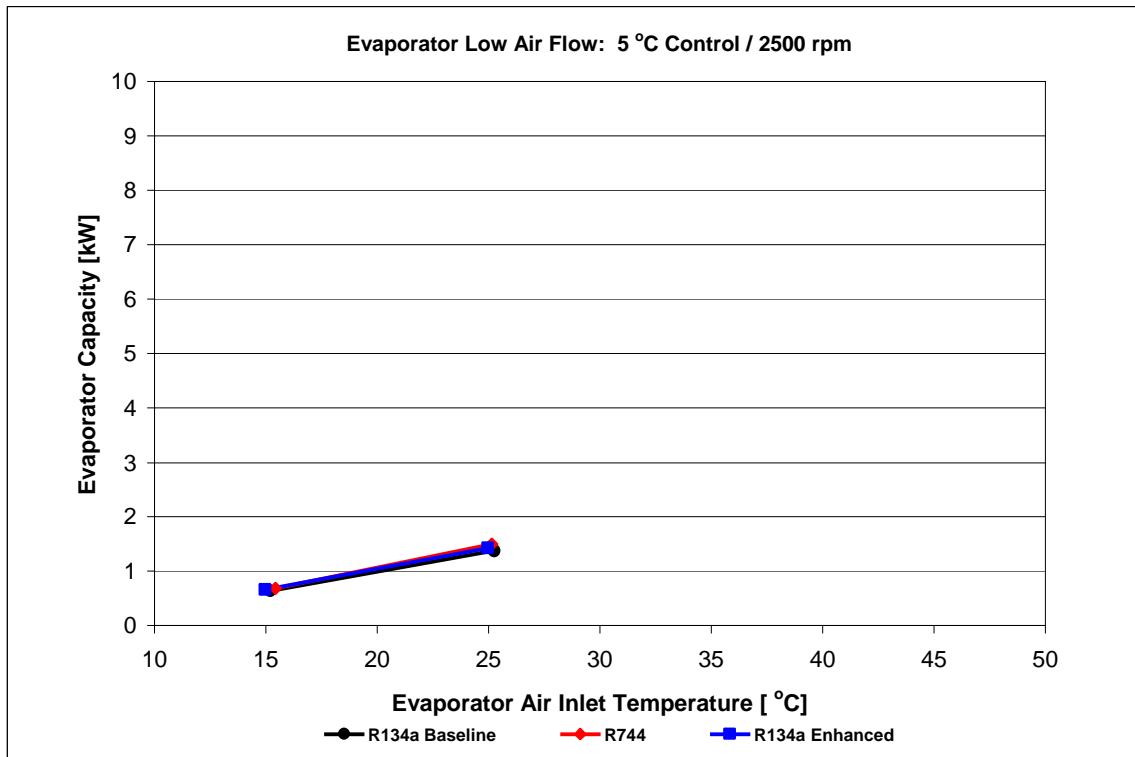


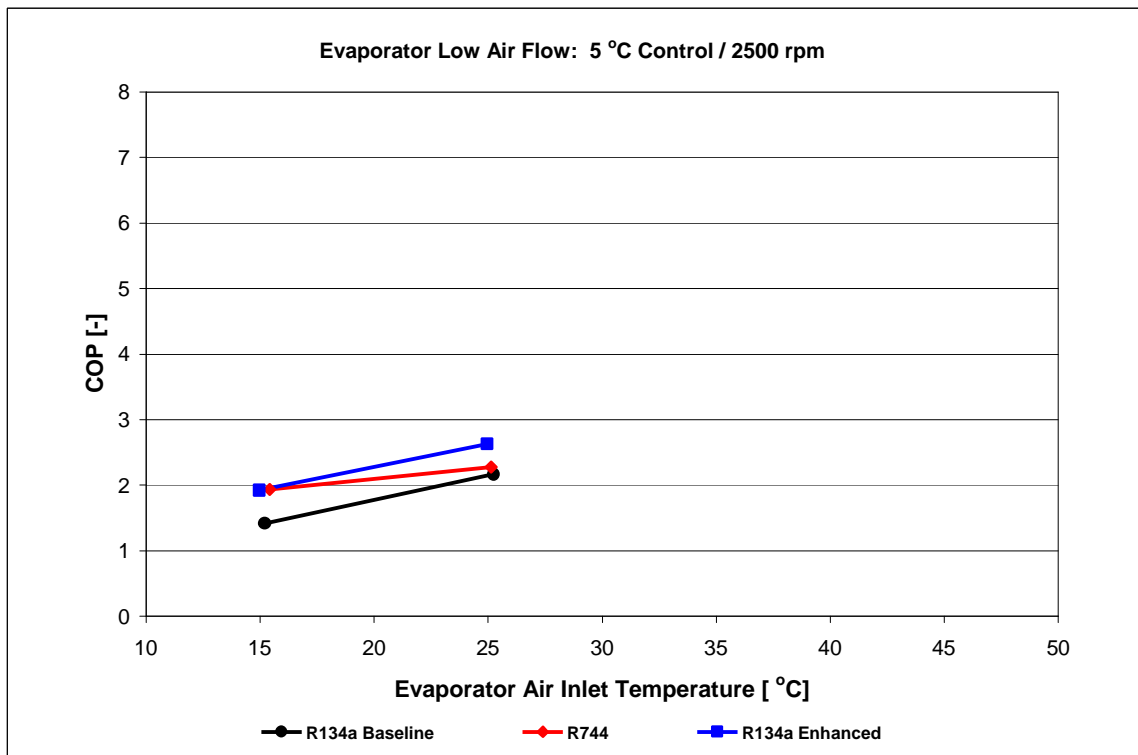
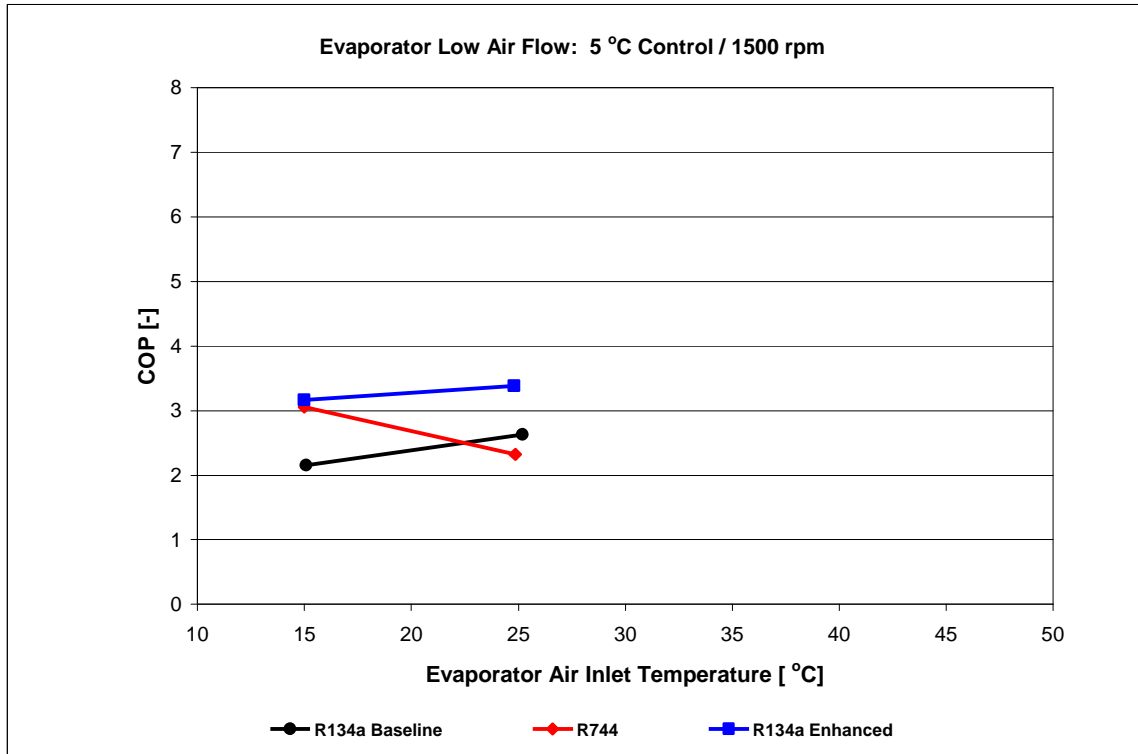
Evaporator Low Air Flow (5 °C Control)

- The purpose is to simulate low blower operation in moderate ambient temperature conditions.
- Evaporator low air flow was run at the 25 °C and 15 °C conditions.

Evaporator Low Air Flow Matrix					
Evaporator Air			Cond/Gas Cooler Air		Comp rpm
T (°C)	RH (%)	Flow (l/s)	T (°C)	Flow (l/s)	
25	65	28	25	425	900
				850	1500
				1320	2500
15	80	28	15	425	900
				850	1500
				1320	2500







SAE ARCRP University of Illinois Test Facility



Compressor Chamber



Condenser Chamber



Evaporator Chamber

Typical System Schematic

