

Heat Pump Annex 54

Heat Pump Systems with Low-GWP Refrigerants

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Gathering Data from the Air-Conditioning (AC) Industry

- Interview several equipment and chemical manufactures to gather data about representative refrigerants and systems for the US market
- Refrigerants with GWP < 750 and GWP < 150 were the main target for further optimization of heat exchangers

Type of equipment	Size (tons)	Make	Configuration
Residential or light commercial AC	2	Company A	Split
	2.5	Company B	Split
	3	Company C	Split
	4	Company D	Packaged



Model Calibration Against Industry Data

- System model predictions were compared against industry data for 2 systems
- In general, agreement was within experimental uncertainty of data ($\pm 5\%$)

	Cooling Capacity	EER	Suction Pressure	Compressor Outlet Pressure	Suction Superheat	Condenser Subcooling	Power
Within Uncertainty	$\pm 3.0\%$	$\pm 3.0\%$	± 3 psi	± 5 psi	$\pm 0.5^{\circ}\text{C} / 1^{\circ}\text{F}$	$\pm 0.5^{\circ}\text{C} / 1^{\circ}\text{F}$	$\pm 1.0\%$
Acceptable	$\pm 5.0\%$	$\pm 5.0\%$	± 5 psi	± 7 psi	-	-	$\pm 2.0\%$
Unacceptable*	$> \pm 5.0\%$	$> \pm 5.0\%$	$> \pm 5$ psi	$> \pm 7$ psi	-	-	$> \pm 2.0\%$

3-ton System, Test Condition A							
	Cooling Capacity	EER	Suction Pressure	Compressor Outlet Pressure	Suction Superheat	Condenser Subcooling	System Power
	BTU/hr	(BTU/hr)/W	psi	psi	$^{\circ}\text{C}$	$^{\circ}\text{C}$	W
Test Data	35663	13.609	160.2	386.6	4.89	4.22	2621
Physics Model	35311	13.289	160.3	391.3	4.92	4.27	2657
Difference	-1.0%	-2.3%	0.1 psi	4.7 psi	0.03 $^{\circ}\text{C}$	0.05 $^{\circ}\text{C}$	1.4%

2.5-ton System, Test Condition A							
	Cooling Capacity	EER	Suction Pressure	Compressor Outlet Pressure	Suction Superheat	Condenser Subcooling	System Power
	BTU/hr	(BTU/hr)/W	psi	psi	$^{\circ}\text{F}$	$^{\circ}\text{F}$	W
Test Data	28823	12.06	160.6	381.8	13.5	9.4	2389
Physics Model	29260	12.08	156.7	380.7	13.3	10.0	2422
Difference	1.51%	0.19%	-3.86	-1.10	-0.20	0.58	1.37%

Optimization Results

- Using the calibrated model, an optimization of the system (mainly exchangers) was performed
- R-454B looks suitable for soft optimization without change of compressor or size of heat exchangers
- R-454C will require a larger compressor and a more significant redesign of heat exchangers
- Overall, results look promising; experimental validation would be the next logical step

		SC	SH	FPI _{OD}	$\dot{V}_{OD}$	FPI _{ID}	$\dot{V}_{ID}$	CDV	EER	CC
R-454B	A	1.13	-1.82	-2	4%	-2	4%	-5%	14%	-1%
	B	1.34	-2.62	-2	0%	-2	0%	-5%	10%	-2%
R-454C	A	0.73	0.08	-2	3%	-1	3%	42%	14%	1%
	B	0.94	-0.72	-2	0%	-1	0%	42%	13%	2%
	A-sm	0.73	0.08	-2	4%	-1	4%	38%	17%	1%