NISTIR 7225

A Curve-Based Mixed System Rating Method for Unitary Air Conditioners

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Nomenclature

A	EVAP-COND air-side heat transfer coefficient correction factor
A-Test	refers to ARI Standard 210/240 steady-state test conditions of 35 ºC (95 ºF) outdoor air and 16.7 ºC (80 ºF) dry-bulb/ 19.4 ºC (67 ºF) wet-bulb indoor air conditions
B-Test	refers to ARI Standard 210/240 steady-state test conditions of 27.8 ºC (82 ºF) outdoor air and 16.7 ºC (80 ºF) dry-bulb/ 19.4 ºC (67 ºF) wet-bulb indoor air conditions
C_D	cyclic degradation coefficient as defined in ARI Standard 210/240-2003
C-B Method	curve-based method as presented in this report
CD Unit	condensing unit, the outdoor section of the split air-conditioner
CLF	Cooling Load Factor as defined in ARI Standard 210/240-2003
Diff	abbreviation for difference
DOF	degrees of freedom
EVAP-COND	refers to evaporator and condenser simulation software available from NIST
EER	Energy Efficiency Ratio as calculated in ARI Standard 210/240-2003, W/W (Btu/W·h)
$\dot{m}$	mass flow rate, kg/h (lb/h)
matched	refers to a split air-conditioning system, an indoor section/condensing unit combination, which rated performance is determined by laboratory testing; also may refer to the evaporator which is used in the matched system.
mixed	refers to a split air-conditioning system, an indoor section/condensing unit combination, which rated performance is not determined by laboratory testing; also may refer to the evaporator which is used in the mixed system.
n	number of tests or number of data points
P	electrical power, W
$p(82)$	condensing unit power at B-Test condition (indoor fan power not included), W
$P(82)$	total power of air conditioner at B-Test condition (condensing unit power plus indoor fan power), W
ΔP	EVAP-COND refrigerant-side pressure drop correction factor

Q	Cooling capacity, W (Btu/h)
$q(82)$	cooling capacity at B-Test condition without accounting for indoor fan heat input, W (Btu/h)
$Q(82)$	cooling capacity at B-Test conditions with the indoor fan heat input accounted for , W (Btu/h)
$q(95)$	cooling capacity at A-Test conditions without accounting for indoor fan heat input, W (Btu/h)
$Q(95)$	cooling capacity at A-Test conditions with the indoor fan heat input accounted for, W (Btu/h)
ρ	correlation coefficient
R	EVAP-COND refrigerant-side heat transfer coefficient correction factor
scfm	standard cubic feet per minute, which is equal to the equivalent volumetric flowrate of air with a density of 0.075 $\mathrm{lbm/ft^3}$
SEER	Seasonal Energy Efficiency Ratio as defined in ARI Standard 210/240-2003, Btu/(W·h)
SHR	sensible heat ratio; the ratio of sensible capacity to total capacity
$\hat{\sigma}$	data standard deviation or fit standard error
SSE	sum of squares of the error
t or t-value	percentage points of the t-distribution (Ott 1984)
ton	cooling or heating capacity equal to 12 000 Btu/h or 3.517 kW
U	absolute value of a quantity's uncertainty

Subscripts

CD	condensing unit of the split system air conditioner
cyc	cyclic testing
diff	difference
dry	dry-coil testing
evap	refers to the indoor coil or evaporator at saturated refrigerant conditions
fan	refers to the indoor coil fan
mixed	refers to the evaporator coil alone with respect to a system
ref	refrigerant
ss	steady-state

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Abstract

The curve-based method was evaluated based on performance predictions and independent laboratory testing for nine mixed systems. Capacity predictions were within ±5 % of the tested values for six of the mixed systems, and four of the SEER predictions were within ±5 % of the tested SEERs. Predictions for SEER showed an under prediction bias due to the wide variation of possible values for the cyclic degradation coefficient (C_D) and the necessity of assuming a conservative value of C_D in mixed system rating calculations. This report includes detailed measurement data for the tested evaporators and an uncertainty analysis of the rating methodology.

Keywords: air conditioner, cooling capacity, cyclic degradation coefficient, mixed system, rating procedure, SEER

ACKNOWLEDGEMENT[*]

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[*] *Use of Non-SI Units in a NIST Publication:* The policy of the National Institute of Standards and Technology is to use the International System of Units (metric units) in all of its publications. However, in North America in the heating, ventilation and air-conditioning industry, certain non-SI units are so widely used instead of SI units that it is more practical and less confusing to include some measurement values in customary units only.

1: INTRODUCTION

A given condensing unit (outdoor section consisting of a condenser, compressor, and associated tubing) is typically offered on the market in several air-conditioner models, which differ by the indoor sections they employ. For all models, the manufacturers must provide performance information, which consists of the Seasonal Energy Efficiency Ratio (SEER) and capacity at the 35 °C (95 °F) rating point, *Q*(95). Federal regulations require that only the highest sales volume indoor-section/outdoor-section combination, referred to as the matched system, be tested in a laboratory to obtain the ratings (CFR 2004a). For other combinations of indoor and outdoor sections, so called mixed systems, the federal regulations allow the use of simplified analytical methodologies upon approval by the U.S. Department of Energy (CFR 2004b).

The most commonly used simplified methodologies for rating mixed systems are those based upon publicly available *Q*(95) and SEER of the matched systems (e.g., Domanski 1989). The application of these methods requires the rater to predict the capacity of the matched evaporator, which is a major shortcoming because the rater is not often familiar with the matched system product line. Since an inaccurate prediction of the matched evaporator leads directly to inaccurate mixed system ratings, a different rating method that would not include this step, e.g. the performance curve-based method (C-B Method), has the inherent potential to be a better rating approach than the one currently used. Recently, both coil and condensing unit manufacturers expressed interest in using the C-B Method to predict mixed system performance.

Figure 1.1 shows the application of the C-B Method in a graphical form. This method uses linear fits to the cooling capacity for the mixed coil, and cooling capacities, *q*(82) and *q*(95), and power, *p*(82), for the condensing unit (CD Unit). The lines are presented as a function of the compressor suction saturation temperature. Overlapping of the evaporator and CD Unit capacities provides mixed system capacities at 27.8 °C (82 °F) and 35.0 °C (95 °F) ambient temperatures. Projecting the saturation temperature corresponding with operation at the 27.8 °C (82 °F) ambient temperature on the CD Unit power chart provides the power requirement for the CD Unit at the 27.8 °C (82 °F) rating point. Figure 1.1 is convenient for explaining the C-B method. In real applications, this method is best implemented numerically using a computer.

It should be noted that the rating process explained above is exclusive of the indoor fan power. Before the rating of the mixed system is finalized, the indoor fan power must be added to the CD Unit power to produce the power for the system at the 27.8 °C (82 °F) rating point *P*(82) The indoor fan heat must also be included as heat reducing the cooling capacities *q*(95) and *q*(82) obtained from overlapping the capacity lines of the CD Unit and mixed evaporator to produce actual mixed system capacities, *Q*(82) and *Q*(95). The energy efficiency ratio at the 27.8 °C (82 °F) rating point (EER(82)) can then be calculated using the corrected values of capacity, *Q*(82), and power, *P*(82).

$$\mathrm{EER}(82) = \frac{Q(82)}{P(82)} \qquad 1.1$$

To conclude with the SEER calculation, the value of the cyclic degradation coefficient, C_D, is required.

$$\mathrm{SEER} = (1 - 0.5 \cdot C_D)\mathrm{EER}(82) \qquad 1.2$$

The cyclic degradation coefficient, C_D, has to be obtained from a separate analysis or the default value of 0.25 may be assumed.

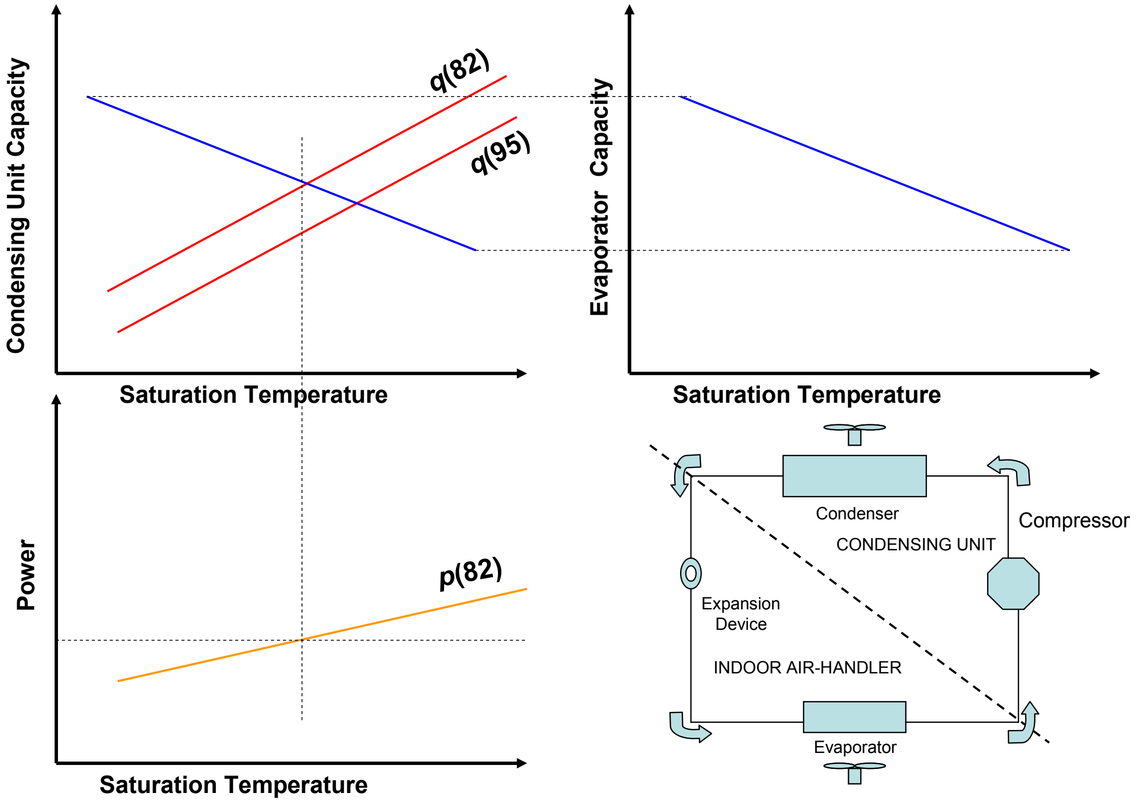

Figure 1.1: Graphical illustration of the curve-based rating procedure

The goal of this study was to evaluate the practicality and accuracy of the curve-based method through its application to nine mixed systems. In this effort, NIST assumed the role of an evaporator manufacturer and developed cooling capacity lines for nine mixed evaporator coils. After obtaining the needed condensing unit performance curves from the Air-Conditioning and Refrigeration Institute (ARI) database, NIST developed mixed system ratings, and then compared them to laboratory derived ratings obtained at an independent testing laboratory for the ARI Unitary Equipment Certification Program.

2: TESTED MIXED EVAPORATORS

Table 2.1 shows basic information on the tested mixed evaporators. They were manufactured by several different companies and had different capacities. All evaporators were of the finned-tube design. Three evaporators were inclined slabs, four coils were constructed in an A-shape configuration, and one in a semi-A-shape configuration. Three of the coils tested were equipped with a fan and required indoor fan power measurement. The remaining six coils were intended to have field-installed fans. Appendix A presents detailed design data, circuitry configuration, and pictures of the coils.

Table 2.1: Tested mixed evaporators

Coil Number	Coil Designation	Coil Configuration	Airflow Direction	Tube Outside Diameter	Expansion Device	Refrigerant
1	A01102	A	Horizontal	9.5 mm (0.375 in)	TXV	R22
2	A01070	Semi A	Horizontal	9.5 mm (0.375 in)	Piston	R22
3	A01148	A	Upflow	9.5 mm (0.375 in)	TXV	R22
4	A01138	A	Upflow	9.5 mm (0.375 in)	Piston	R22
5	A01060*	Inclined Slab	Upflow/ Horizontal	9.5 mm (0.375 in)	Piston	R22
6	A01125*	Inclined Slab	Horizontal	9.5 mm (0.375 in)	TXV	R22
7	H5326	A	Horizontal	9.5 mm (0.375 in)	Piston	R22
8	H5321	A	Upflow	9.5 mm (0.375 in)	Piston	R22
9	A01154*	Inclined Slab	Horizontal	9.5 mm (0.375 in)	TXV	R410A

*indoor fan included

3: MIXED EVAPORATOR CAPACITY DETERMINATION

3.1: Experimental setup

Figure 3.1.1 shows the experimental setup. The evaporator was installed in the indoor environmental chamber, where air conditions were controlled by a chiller/air handler system. Air was pulled through the evaporator by a centrifugal fan located at the outlet of the nozzle chamber ductwork. The adjacent outdoor chamber housed the water-cooled condensing unit and the laboratory water-chiller. Two different condensing units were used for R22 and R410A evaporators due to lubricant-related considerations. Each condensing unit was equipped with a variable-speed compressor, condenser, and subcooler. The water chiller control system manipulated the temperature and mass flow rate of the water delivered to the condensing unit. The chiller rejected heat to the in-house chilled water loop. Heat rejection was to water and did not require maintaining the outdoor chamber conditions.

The installation of the evaporator and test instrumentation conformed to ASHRAE Standard 37-1989. We used the air enthalpy method for the primary measurement of the evaporator capacity with the refrigerant enthalpy method providing the secondary measurement. Air dew-point temperature was measured at the inlet of the evaporator ductwork and in the ductwork after the evaporator and several mixers. Twenty-five node thermocouple grids, located on each side of the evaporator, were used to verify that the air was well mixed at each point. A 25-junction thermopile measured the air temperature change across the evaporator. Barometric pressure, evaporator air pressure drop, air temperature and pressure drop in the nozzle, and nozzle temperature were used along with the dew-point measurements to establish the thermodynamic state of the air. The refrigerant enthalpy method required measurement of the evaporator inlet and exit refrigerant temperatures and pressures in addition to mass flowrate. The agreement between the air-side and refrigerant-side methods was always within 4 %.

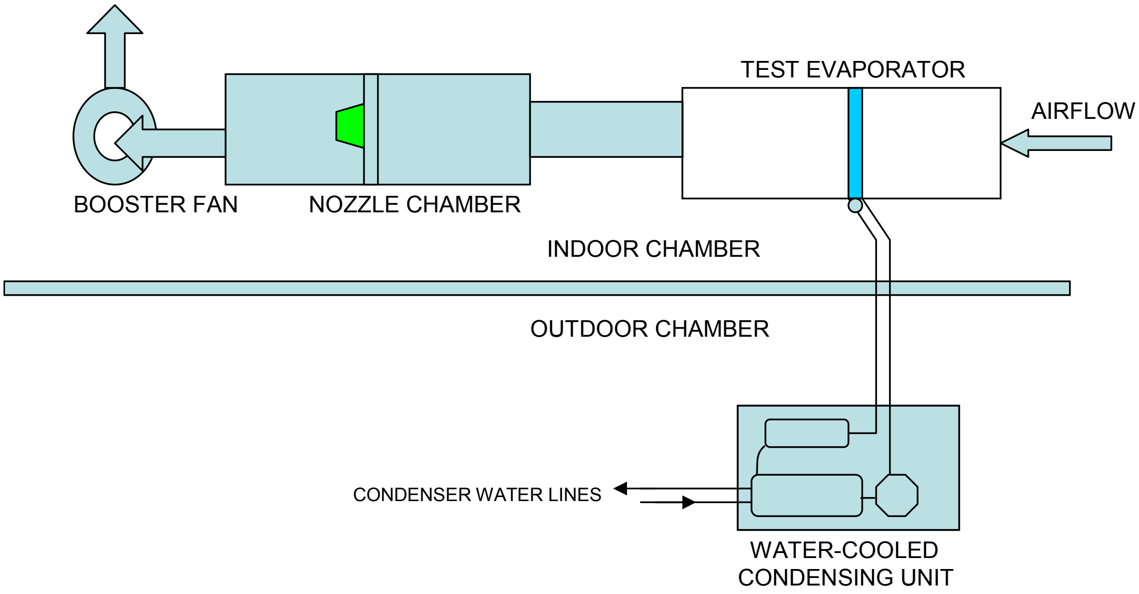

Figure 3.1.1: Evaporator test arrangement

3.2: Data acquisition and measurement uncertainty

The measurement points consisted of temperature, pressure, pressure difference, temperature difference, dew-point temperature, fan amps, fan volts, and fan power. Table 3.2.1 lists the measured quantities and their uncertainties for a 95 % confidence limit (two sigma on the mean value) (Taylor and Kuyatt 1994). The uncertainty for the evaporator capacity was calculated using a propagation of uncertainty technique, considering the uncertainty in each of the parameters associated with the capacity measurement. Appendix B explains the application of this technique in more detail.

Table 3.2.1: Measurement uncertainty

Quantity	Range	Uncertainty
Pressure	0 kPa to 3447 kPa (0 psia to 500 psia)	±3.4 kPa (±0.5 psi)
Temperature	-26.1 °C to 93.3 °C (-15 °F to 200 °F)	±0.3 °C (±0.5 °F)
Temperature Difference	0 °C to 27.8 °C (0 °F to 50 °F)	±0.3 °C (±0.5 °F)
Barometric Pressure	0 mm Hg to 1270 mm Hg (0 in Hg to 50 in Hg)	±0.34 mm Hg (±0.0135 in Hg)
Dew-point Temperature	0 °C to 50 °C (32 °F to 122 °F)	±0.2 °C (±0.4 °F)
Pressure Difference	0 Pa to 1244 Pa (0 in H_2O to 5 in H_2O)	±24.4 Pa (±0.098 in H_2O)
Mass Flow	0 kg/h to 544.3 kg/h (0 lb/h to 1200.0 lb/h)	±1 %
Evaporator Capacity	5.56 kW to 14.4 kW (19 kBtu/h to 49 kBtu/h)	±3 % to ±7 %

3.3: Tests conditions and procedure

Each evaporator coil was tested at the air volumetric flow rate that was used during mixed system tests carried out at an independent testing laboratory for the ARI certification program. For all tests, constant indoor conditions of 16.7 °C (80.0 °F) dry-bulb and 15.8 °C (60.4 °F) dew-point temperatures were applied according to ARI Standard 210/240 (2003).

On the refrigerant side, the tests were constrained by the refrigerant inlet condition, defined by the liquid line temperature and subcooling, and the outlet condition, defined by the vapor line saturation temperature and superheat. The tests of each evaporator involved three vapor suction line saturation temperatures. The evaporator capacity line was generated as a function of the evaporator exit saturation temperature from these points. Table 3.3.1 lists the refrigerant conditions imposed during the evaporator tests for all coils.

Table 3.3.1: Refrigerant conditions during evaporator tests

Liquid line		Vapor line	
Temperature °C (°F)	Subcooling °C (°F)	Sat. temperature* °C (°F)	Superheat °C (°F)
40.6 ± 0.8 (105.0 ± 1.5)	5.6 to 8.3 (10.0 to 15.0)	4.4, 7.2, 10.0 (40.0, 45.0, 50.0)	5.6 to 8.3 (10.0 to 15.0)

*Three nominal conditions

The expansion devices supplied with the various evaporators were removed and replaced by precision needle valves. The liquid line temperature and subcooling, and evaporator superheat were controlled by adjusting the refrigerant charge and by changing the needle valve settings to produce the required superheat at the exit of the evaporator. In addition to compressor speed control, an evaporator pressure regulating valve was used to produce the desired exit pressure. Liquid line temperature at the inlet to the expansion valves was also controlled by varying the water flow rates through the liquid cooled subcooler and condensing unit heat exchangers. At least five tests were performed for each evaporator. If the evaporator was equipped with a fan, its power was also measured and recorded for each test.

3.4: Evaporator capacity curve fits and characterization

Figures 3.4.1 through 3.4.9 present measured coil capacities, excluding fan heat when a fan was used, as a function of the coil outlet saturation temperature. The figures also include a linear fit to capacity data obtained for each evaporator and the fit coefficients. Examination of the figures indicates that a linear capacity fit is an adequate representation of the measured data. Table 3.4.1 summarizes the cooling capacity linear slopes and intercepts. Appendix C gives detailed data summaries of the tests performed for each coil.

We may note that the presented evaporator test data – including the performance lines – refers to the evaporator exit saturation temperature. The CD Unit curves also use the evaporator exit saturation temperature to calculate cooling capacity; i.e., they include the effect of refrigerant pressure drop and heat transfer in the suction line.

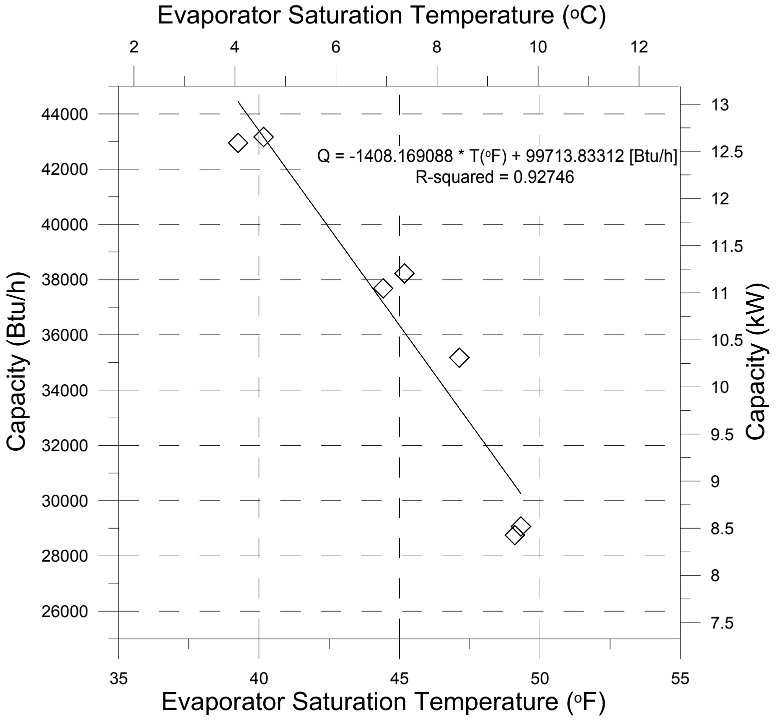

Figure 3.4.1: Coil 1 cooling capacity as a function of outlet saturation temperature

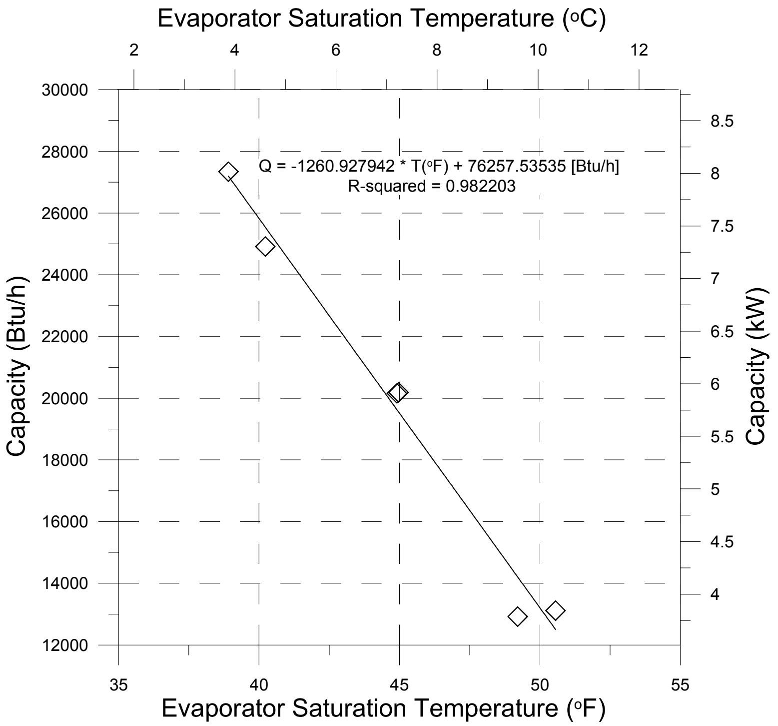

Figure 3.4.2: Coil 2 cooling capacity as a function of outlet saturation temperature

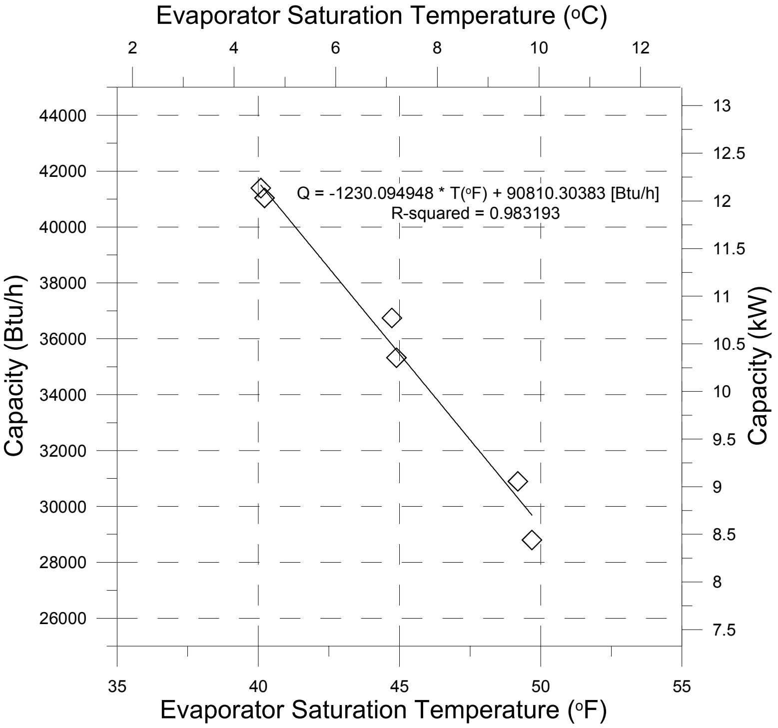

Figure 3.4.3: Coil 3 cooling capacity as a function of outlet saturation temperature

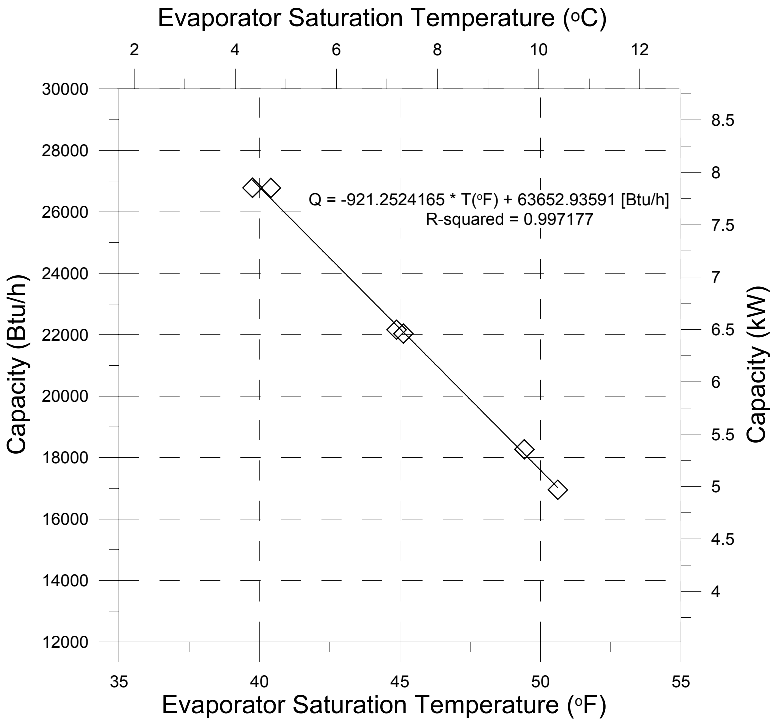

Figure 3.4.4: Coil 4 cooling capacity as a function of outlet saturation temperature

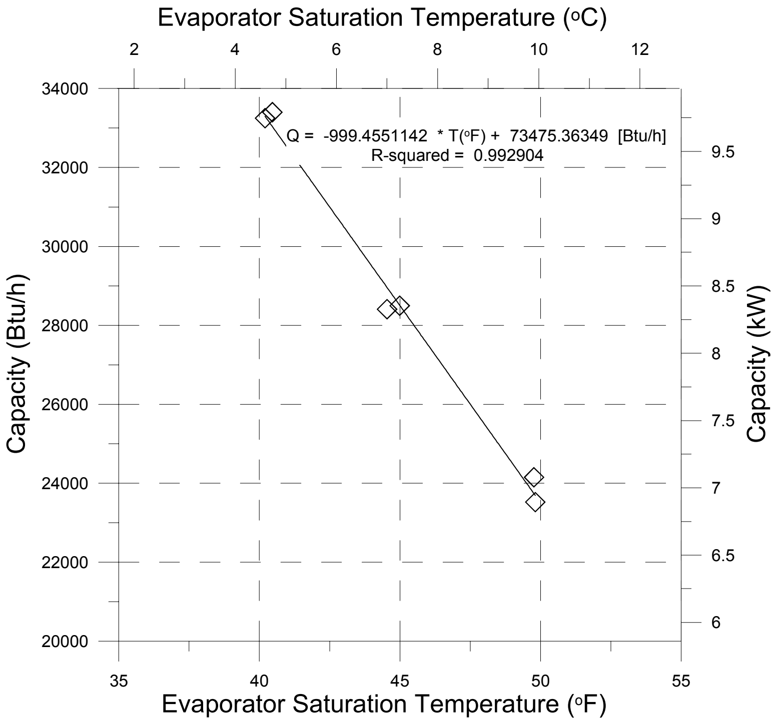

Figure 3.4.5: Coil 5 cooling capacity as a function of outlet saturation temperature

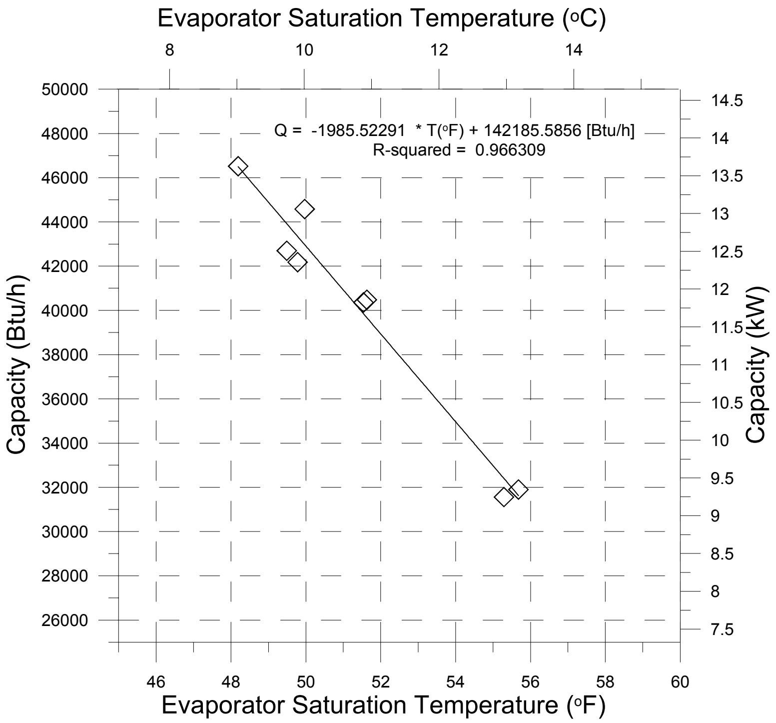

Figure 3.4.6: Coil 6 cooling capacity as a function of outlet saturation temperature

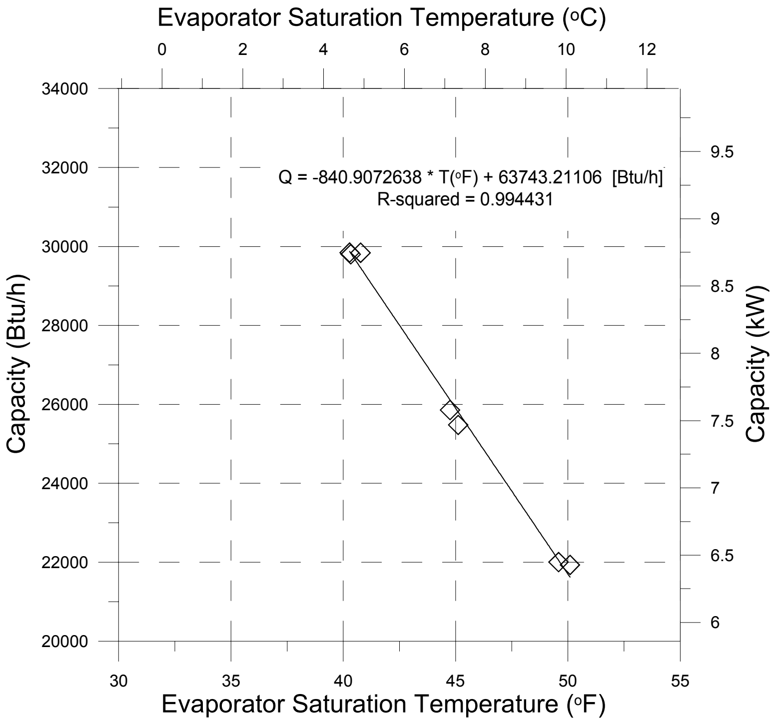

Figure 3.4.7: Coil 7 cooling capacity as a function of outlet saturation temperature

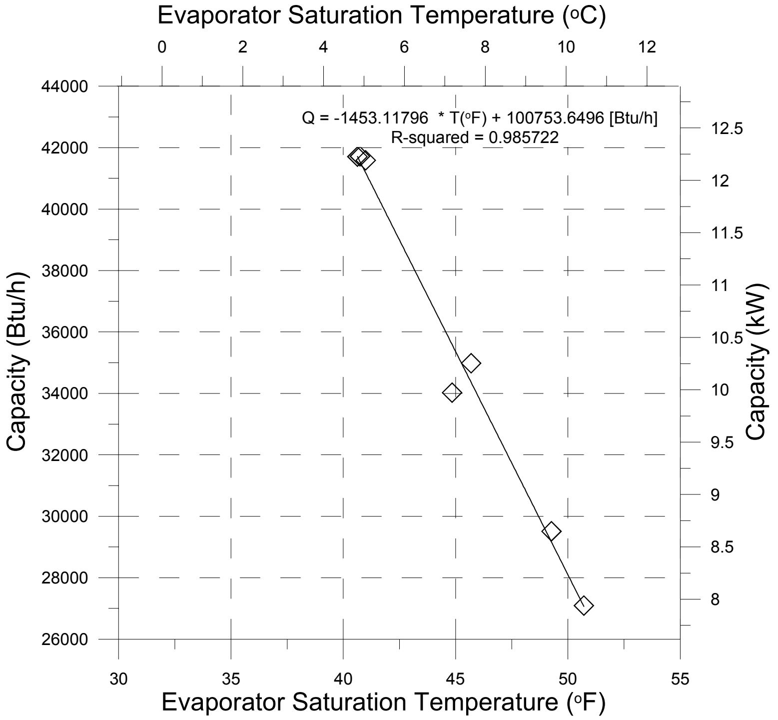

Figure 3.4.8: Coil 8 cooling capacity as a function of outlet saturation temperature

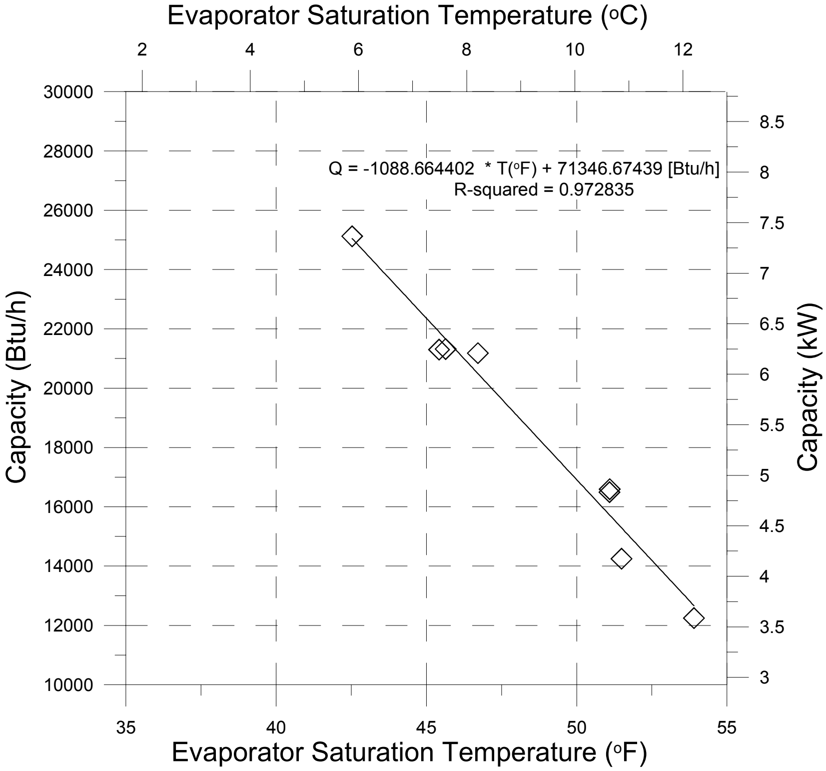

Figure 3.4.9: Coil 9 cooling capacity as a function of outlet saturation temperature

Table 3.4.1: Mixed evaporator capacity linear fit coefficients and fan powers from NIST coil tests

Coil Number	Evaporator Airflow m^3/h (scfm)	Fan Power W	Cooling Capacity Linear Coefficients	
			Slope W/ºC (Btu/h·°F)	Intercept W (Btu/h)
1	1699 (1000)	0	-742.8 (-1408.17)	29223.85 (99713.83)
2	1368 (805)	0	-665.1(-1260.93)	22348.89 (76257.54)
3	1621 (954)	0	-648.9 (-1230.09)	26613.89 (90810.3)
4*	1342 (790)	0	-486.0 (-921.25)	18654.84 (63652.94)
5	1279 (753)	271	-527.2 (-999.46)	21533.51 (73475.36)
6	1954 (1150)	784	-1047.4 (-1985.52)	41670.51 (142185.6)
7	2047 (1205)	0	-443.6 (-840.91)	18681.3 (63743.21)
8	2360 (1389)	0	-766.6 (-1453.12)	29527.99 (100753.65)
9	849 (500)	364	-574.3 (-1088.66)	20909.65 (71346.67)

* Coil 4 airflow was too high and results cannot be compared directly to ARI tests

Figures 3.4.10 thru 3.4.12 help to characterize and contrast the performance of the nine evaporators with respect to one another. Figure 3.4.10 shows the cooling capacity of each coil as a function of the evaporator saturation temperature generated from the capacity linear fits at an evaporator temperature of 7.2 ºC (45 ºF). The plot indicates the relative values of a change in capacity with respect to a change in evaporation temperature (slope) for each coil.

Figure 3.4.11 presents the airflow rate per unit of capacity for all coils, which is an indication of air temperature change across the coil. These values are from NIST tests at an evaporator saturation temperature of 10 ºC (50 ºF). All NIST tests were intended to be performed at the ARI Test airflow rates. Inadvertently, Coil 4 airflow was 262 m^3/h (154 scfm) higher than the ARI Tests. Consequently, NIST capacity measurements and predictions for Coil 4 were significantly higher (approximately 24 %) than would have been the case with correct lower airflow rate. The results for Coil 4 have been included in this report, but they cannot be directly compared with the ARI Tests. The airflow rates at the other tests differed from the ARI Test values on average by 0.14 % with a standard deviation of 1.8 %. The average airflow rate per unit cooling capacity was 0.1852 m^3/W h (383.5 scfm/ton) with a standard deviation of 0.0518 m^3/W h (107.1 scfm/ton). Coil 6 had the smallest airflow rate per unit capacity [0.1261 m^3/W h (262 scfm/ton)] as well as the largest change in cooling capacity with respect to a change in evaporator saturation temperature (see Figure 3.4.10). Coil 6 also had the lowest sensible heat ratio (SHR) of 0.710 (Fig. 3.4.12). Fig. 3.4.12 shows a linear trend of SHR with respect to airflow rate per unit capacity, which is consistent with general experience. The high sensible heat ratios were due to the high evaporating temperature of 10 ºC (50 ºF). At the lowest evaporating temperatures tested at NIST, the highest SHR's occurred for Coils 2, 7, and 8 with values of 0.77, 0.81, and 0.78, respectively. All other coils had SHR's less than 75 % at the lowest tested evaporating temperature.

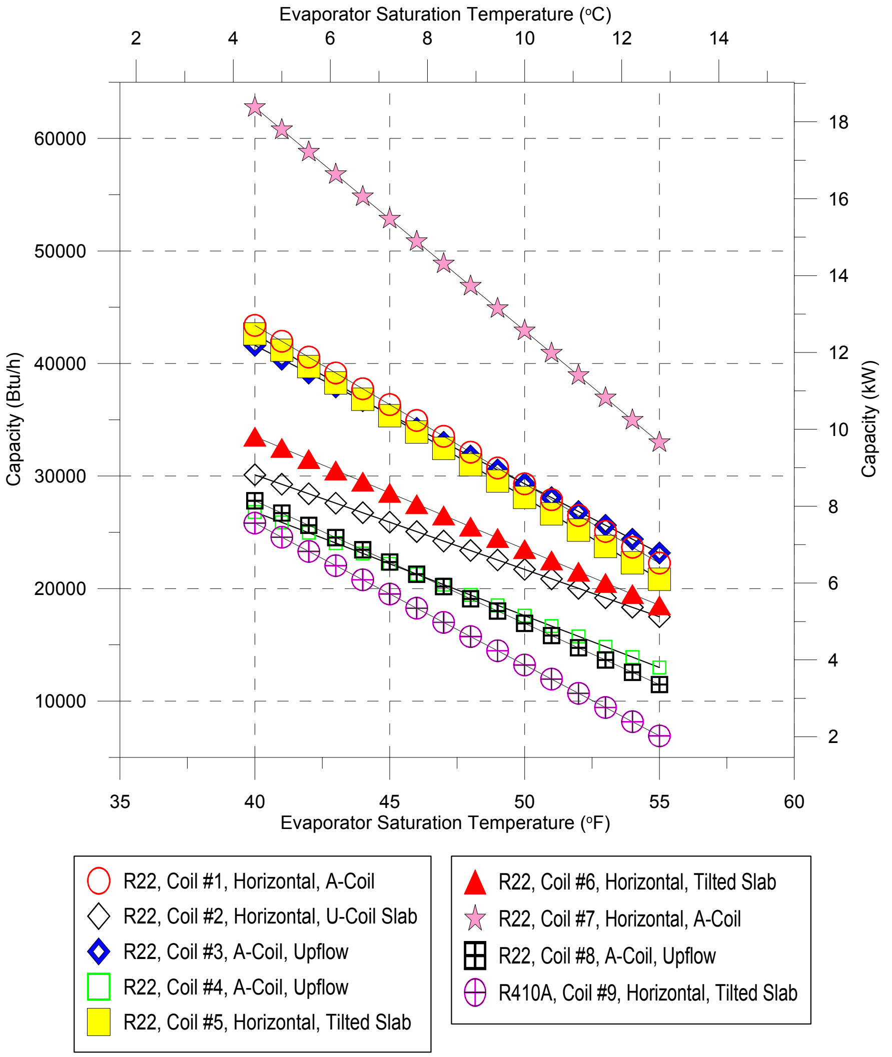

Figure 3.4.10: Cooling capacity, *q*(95), for all evaporators based on the NIST linear fit

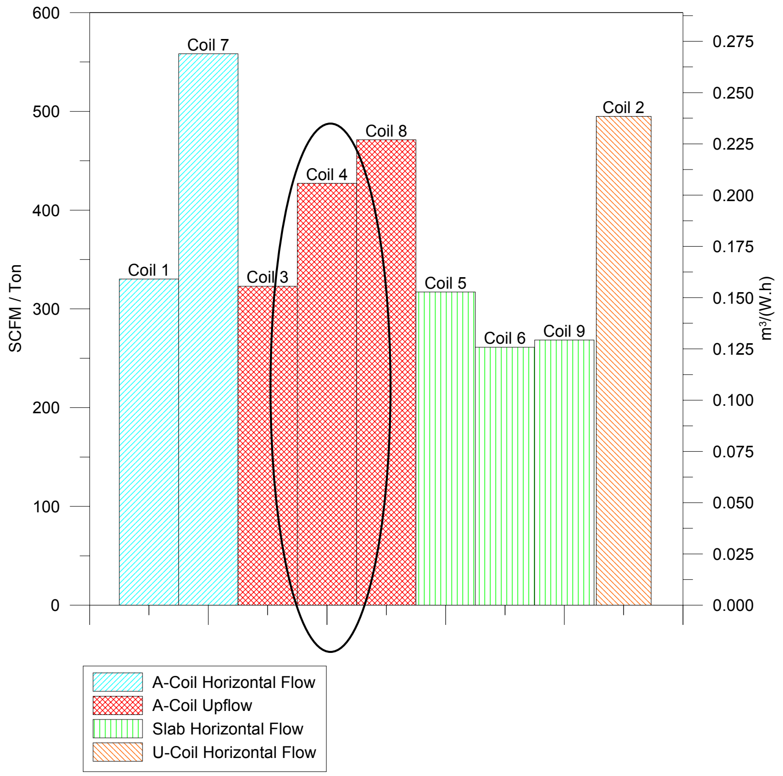

Figure 3.4.11: Airflow rate relative to cooling capacity from the NIST linear fit for all coils at an evaporation temperature of 7.2 ºC (45 ºF)

(Note: Coil 4 airflow was too high and results cannot be compared directly to ARI tests)

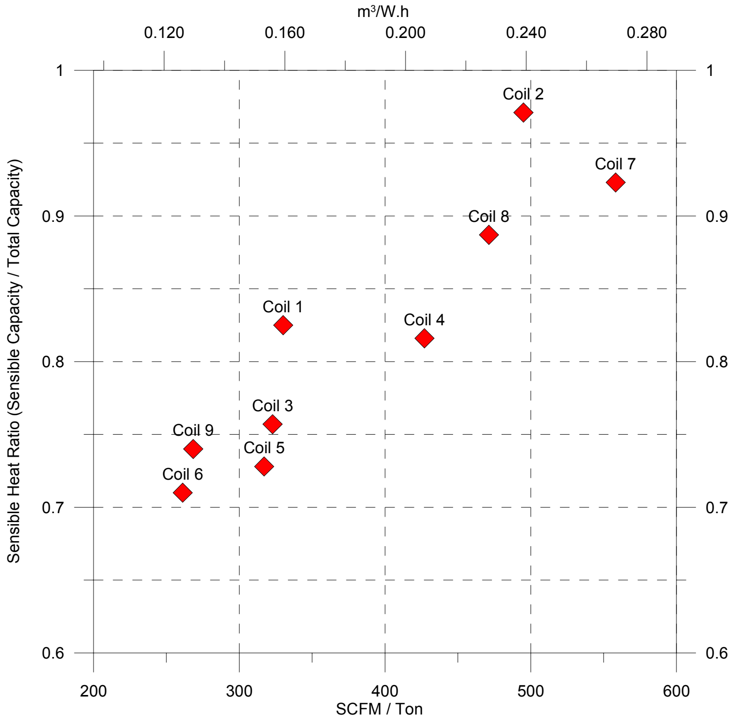

Figure 3.4.12: NIST measured SHR as a function of airflow rate per unit of cooling capacity at an evaporator exit saturation temperature of 16.2 °C (50.0 °F)

4: MIXED SYSTEM PERFORMANCE PREDICTION

4.1: Calculation of *Q*(95), *Q*(82) and EER(82)

With the coil capacity coefficients from Table 3.4.1 and CD Unit capacity coefficients from Table 4.1.1, the C-B Method was used to calculate cooling capacity and EER at 27.8 °C (82.0 °F), and cooling capacity at 35.0 °C (95.0 °F) for all coils.

Table 4.1.1: CD Unit linear coefficients for power and capacity at A-Test and B-Test conditions from ARI

Coil	*q*(82)		*p*(82)		*q*(95)		*p*(95)	
	Slope W/ºC (Btu/h ºF)	Intercept W (Btu/h)	Slope W/ºC (W/ºF)	Intercept W	Slope W/ºC (Btu/h ºF)	Intercept W (Btu/h)	Slope W/ºC (W/ºF)	Intercept W
1	312.7 (592.7)	2092.9 (7141.5)	7.38 (4.1)	2340.0	300.2 (569.1)	2217.7 (7567.0)	5.76 (3.2)	2717.1
2	184.7 (350.2)	2979.2 (10165.6)	31.14 (17.3)	1242.9	163.2 (309.3)	2785.3 (9503.9)	35.64 (19.8)	1289.6
3	312.7 (592.7)	2092.9 (7141.5)	7.38 (4.1)	2340.0	300.2 (569.1)	2217.7 (7567.0)	5.76 (3.2)	2717.1
4*	237.1 (449.5)	-622.6 (-2124.6)	22.14 (12.3)	880.9	232.2 (440.2)	-1253.0 (-4275.5)	26.1 (14.5)	877.7
5	266.2 (504.7)	674.2 (2300.5)	32.22 (17.9)	1177.1	263.3 (499.2)	22.7 (77.3)	38.7 (21.5)	1069.6
6	581.6 (1102.5)	3886.6 (13261.7)	28.98 (16.1)	3584.9	564.6 (1070.2)	2995.4 (10220.7)	32.94 (18.3)	4123.4
7	484.1 (917.6)	-148.4 (-506.2)	31.68 (17.6)	2253.8	508.6 (964.1)	-2569.6 (-8767.8)	38.34 (21.3)	2278.8
8	96.8 (735.5)	3140.6 (10716.2)	138.24 (76.8)	36.4	336.6 (638)	3420.9 (11672.7)	172.8 (96)	-697.3
9	286.6 (543.2)	984.7 (3359.9)	10.8 (6.0)	1692.8	278.5 (528.0)	423.0 (1443.2)	11.52 (6.4)	1990.9

*Coil 4 airflow was too high and results cannot be compared directly to ARI tests

The calculation procedure, which we illustrated graphically in Figure 1.1, was implemented computationally by solving the set of two linear equations for the evaporation temperature at which the cooling capacity of the mixed coil equals the cooling capacity of the CD Unit:

$$q_{\mathrm{CD}} = \mathrm{B}_{\mathrm{CD}} + \mathrm{A}_{\mathrm{CD}} T_{\mathrm{evap}} = q_{\mathrm{mixed}} = \mathrm{B}_{\mathrm{mixed}} + T_{\mathrm{evap}} \mathrm{A}_{\mathrm{mixed}} \qquad 4.1.1$$

$$T_{\mathrm{evap}} = \frac{\left(\mathrm{B}_{\mathrm{mixed}} - \mathrm{B}_{\mathrm{CD}}\right)}{\left(\mathrm{A}_{\mathrm{CD}} - \mathrm{A}_{\mathrm{mixed}}\right)} \qquad 4.1.2$$

In the equations above, B represents the intercept and A represents the slope for the CD Unit (CD subscript) and mixed evaporator (mixed subscript), respectively. Applying the obtained value of the saturation temperature into either capacity equation yields the capacity of the evaporator of the mixed system. The rated cooling capacity of the mixed system was obtained by reducing the evaporator capacity by the fan heat. For coils equipped with a fan, the fan heat was measured; for other coils it was calculated according to ARI Standard 210/240 (ARI 2003).

$$Q = q + Q_{fan} \qquad 4.1.3$$

Similarly, the power of the mixed system was obtained by applying the value of the evaporator saturation temperature from equation 4.1.2 into the condensing unit power equation 4.1.4 and making adjustment for the indoor fan power as shown in equation 4.1.5.

$$p_{\mathrm{CD}} = b_{CD} + a_{CD} T_{evap} \tag{4.1.4}$$

$$P_{CD} = p_{CD} + P_{fan} \tag{4.1.5}$$

Table 4.1.2 shows the results for A-Test mixed system capacities. Table 4.1.3 presents the results for B-Test capacity, power, and EER.

Table 4.1.2: Mixed system A-Test capacity from the C-B Method

Coil	T_{evap} °C (°F)	$q(95)$ W (Btu/h)	Indoor Airflow m^3/h (scfm)	Q_{fan} (1) W (Btu/h)	$Q(95)$ W (Btu/h)
1	8.1 (46.6)	9990 (34089)	1699 (1000)	366.3 (1250.0)	9624 (32839)
2	5.8 (42.5)	6639 (22653)	1368 (805)	294.9 (1006.3)	6344 (21647)
3	7.9 (46.3)	9935 (33898)	1621 (954)	349.5 (1192.5)	9585 (32705)
4*	9.9 (49.9)	5184 (17688)	1342 (790)	289.4 (987.5)	4894 (16700)
5	9.4 (49.0)	7188 (24526)	1279 (753)	271.0 (925.5)	6917 (23601)
6	6.2 (43.2)	16541 (56439)	1954 (1150)	784.0 (2677.5)	15756 (53761)
7	4.5 (40.2)	8781 (29962)	2047 (1205)	441.5 (1506.3)	8340 (28456)
8	5.9 (42.6)	11386 (38851)	2360 (1389)	507.0 (1736.3)	10877 (37115)
9	6.2 (43.2)	7114 (24274)	849 (500)	364.0 (1243.1)	6749 (23030)

(1) For units with no fan Q_{fan} was calculated to be 1250 Btu/h per 1000 scfm of airflow (ARI 210/240-2003).

*Coil 4 airflow was too high and results cannot be compared directly to ARI tests

Table 4.1.3: Mixed system B-Test capacity, power, and EER from the C-B Method

Coil	T_{evap} °C (°F)	q(82) W (Btu/h)	p_{CD}(82) W	Indoor Airflow, m^3/h (scfm)	$Q_{fan}^{(1)}$ W (Btu/h)	$P_{fan}^{(2)}$ W	Q(82) W, (Btu/h)	EER(82) W/W (Btu/W h)
1	7.93 (46.3)	10192 (34563)	2530	1699 (1000)	365.0 (1250.0)	365.0	9763 (33313)	3.37 (11.51)
2	5.01 (41.0)	7190 (24532)	1953	1368 (805)	293.8 (1006.3)	293.8	6895 (23525)	3.07 (10.47)
3	7.72 (45.9)	10066 (34347)	2528	1621 (954)	348.2 (1192.5)	348.2	9717 (33155)	3.38 (11.53)
4*	8.88 (48.0)	5699 (19445)	1471	1342 (790)	288.4 (987.5)	288.4	5410 (18458)	3.07 (10.49)
5	8.51 (47.3)	7666 (26182)	2024	1279 (753)	271 (924.7)	271.0	7402 (25258)	3.27 (11.01)
6	5.42 (41.7)	17361 (59291)	4257	1954 (1150)	784 (2675.0)	784.0	16593 (56616)	3.29 (11.23)
7	2.52 (36.5)	9677 (33019)	2897	2047 (1205)	439.8 (1506.3)	439.8	9236 (31513)	2.77 (9.44)
8	5.11 (41.1)	12009 (40974)	3196	2360 (1389)	507.0 (1736.3)	507.0	11500 (39238)	3.11 (10.6)
9	5.37 (41.7)	7610 (25991)	1943	849 (500)	364 (1241.9)	364.0	7253 (24749)	3.14 (10.73)

(1) For units with no fan Q_{fan} is calculated to be 1250 Btu/h per 1000 scfm of airflow (ARI 210/240-2003).

(2) For units with no fan P_{fan} is calculated to be 365 W per 1000 scfm of airflow (ARI 210/240-2003).

Coil 4 airflow was too high and results cannot be compared directly to ARI tests.

4.2: Calculation of SEER

The calculation of SEER involves the value of EER(82) and the cyclic degradation coefficient C_D.

$$\mathrm{SEER} = (1 - 0.5 \cdot C_D)\mathrm{EER}(82) \qquad 1.2$$

For the tested systems, C_D was typically obtained by conducting dry-coil steady-state and cyclic tests (C and D tests of ARI Standard 210/240, (ARI 2003)). Alternatively, the rater may use the 0.25 default value instead of performing the tests. In practice, C_D values fall between 0.0 and 0.25. Since, by definition, the mixed system is not tested, the C_D value must be obtained from some engineering analysis or the default value of 0.25 must be taken.

Dougherty (2004), working with DOE and ARI, performed a statistical analysis of experimentally determined C_D values for a large sample of systems. He grouped the studied systems into four basic categories shown in Table 4.2.1. The analysis of C_D values for these four system categories produced the C_D percentiles shown in Table 4.2.2.

Table 4.2.1: System classifications for cyclic degradation coefficient analysis

System Category	Equalize During Off Cycle	Indoor Fan Off Delay	System Components
A	Yes	No	Cap Tube Orifice Bleed TXV
B1	No	No	Non-Bleed TXV Electronic Expansion Device Liquid Line Solenoid
B2	Yes	Yes	Cap Tube Orifice Bleed TXV
C	No	Yes	Non-Bleed TXV Electronic Expansion Device Liquid Line Solenoid

The range of C_D values is rather significant in each equipment category. In category A, for example, the classification for all nine mixed systems tested for this project, the difference between the 50th and 99th percentiles is 0.24-0.09=0.15. This means that assuming the 50th percentile value for the mixed system with an actual C_D of 0.24 will result in a SEER prediction error of 7.5 %. For illustration in Table 4.2.3, we generated two SEER numbers for mixed systems using C_D values of 0.22 and 0.24, which correspond to the 95th and 99th percentiles, respectively. While both choices are conservative statistically, they still represent a risk of SEER overprediction by 1.5 % and 0.5 %, respectively, should the actual C_D value be the maximum of 0.25. We believe that the most accurate assignment of C_D for the mixed system would be that of the matched system if the changes implemented in the mixed system do not move it to a different equipment category, as defined in Table 4.2.1.

Table 4.2.2: Cyclic degradation coefficient values for different system categories

Percentile	A	B1	B2	C
99th	0.24	0.16	0.22	0.15
95th	0.22	0.14	0.14	0.12
90th	0.16	0.14	0.12	0.10
85th	0.14	0.12	0.11	0.09
80th	0.12	0.12	0.10	0.08
75th	0.12	0.11	0.10	0.07
70th	0.11	0.11	0.09	0.06
60th	0.10	0.9	0.08	0.05
50th	0.09	0.07	0.07	0.04
Sample Size	77	58	109	78

Table 4.2.3: Mixed system SEERs calculated using statistically determined C_D for 95th and 99th percentiles

Coil	Cyclic Degradation Coefficient, C_d		SEER (Btu/W·h)	
	95th	99th	95th	99th
1	0.22	0.24	10.24	10.13
2	0.22	0.24	9.32	9.22
3	0.22	0.24	10.26	10.14
4*	0.22	0.24	9.34	9.23
5	0.22	0.24	10.08	9.97
6	0.22	0.24	10.33	10.21
7	0.22	0.24	8.41	8.31
8	0.22	0.24	9.43	9.32
9	0.22	0.24	9.89	9.78

Coil 4 airflow was too high and results cannot be compared directly to ARI tests.

5: NIST PREDICTIONS AND ARI DATABASE COMPARISON

5.1: A-Test capacity comparison

Table 5.1.1 and Figure 5.1.1 present mixed system capacities, $Q(95)$, from the C-B Method and the ARI database for the A-Test conditions. Capacity predictions from the C-B Method were within ±5 % of the ARI tests for five of eight coils. Among the three cases with poor predictions, the disagreement was as high as 17.6 %.

Table 5.1.1: Mixed system A-Test capacities from ARI Tests and C-B Method

Coil	C-B Method T_{evap} °C (°F)	ARI Test T_{evap} °C (°F)	C-B Method $q(95)$ W (Btu/h)	Indoor Airflow m^3/h (scfm)	Q_{fan} W (Btu/h)	ARI Test $Q(95)$ W (Btu/h)	C-B Method $Q(95)$ W (Btu/h)	Q_{diff} 100%(NIST – ARI)/ARI
1	8.1 (46.6)	7.2 (45.0)	9991 (34089)	1699 (1000)	366.3(1) (1250.0)	10034 (34238)	9624 (32839)	-4.1
2	5.8 (42.5)	6.1 (43.0)	6639 (22653)	1368 (805)	294.9(1) (1006.3)	6529 (22278)	6344 (21647)	-2.8
3	7.9 (46.3)	7.6 (45.6)	9935 (33898)	1621 (954)	349.5(1) (1192.5)	9609 (32786)	9585 (32705)	-0.2
4*	9.9 (49.9)	8.4 (47.2)	5184 (17688)	1342 (790)	289.4(1) (987.5)	5073 (17311)	4894 (16700)	-3.5
5	9.4 (49.0)	10.5 (50.9)	7188 (24526)	1279 (753)	271.0(1) (925.5)	6787 (23157)	6917 (23601)	1.9
6	6.2 (43.2)	7.2 (44.9)	16541 (56439)	1954 (1150)	784.0(2) (2677.5)	14407 (49159)	15756 (53761)	9.4
7	4.5 (40.2)	6.8 (44.3)	8781 (29962)	2047 (1205)	441.5(2) (1506.3)	10122 (34537)	8340 (28456)	-17.6
8	5.9 (42.6)	5.7 (42.2)	11387 (38851)	2360 (1389)	507.0(1) (1736.3)	12591 (42963)	10878 (37115)	-13.6
9	6.2 (43.2)	4.1 (44.2)	7114 (24274)	849 (500)	364(2) (1243.1)	6480 (22112)	6749 (23030)	4.2

(1) Coil without a fan; Q_{fan} was calculated to be 1250 Btu/h per 1000 scfm of airflow (ARI 210/240-2003)

(2) Coil equipped with a fan; fan power measured by NIST

*Coil 4 airflow was too high and results cannot be compared directly to ARI tests.

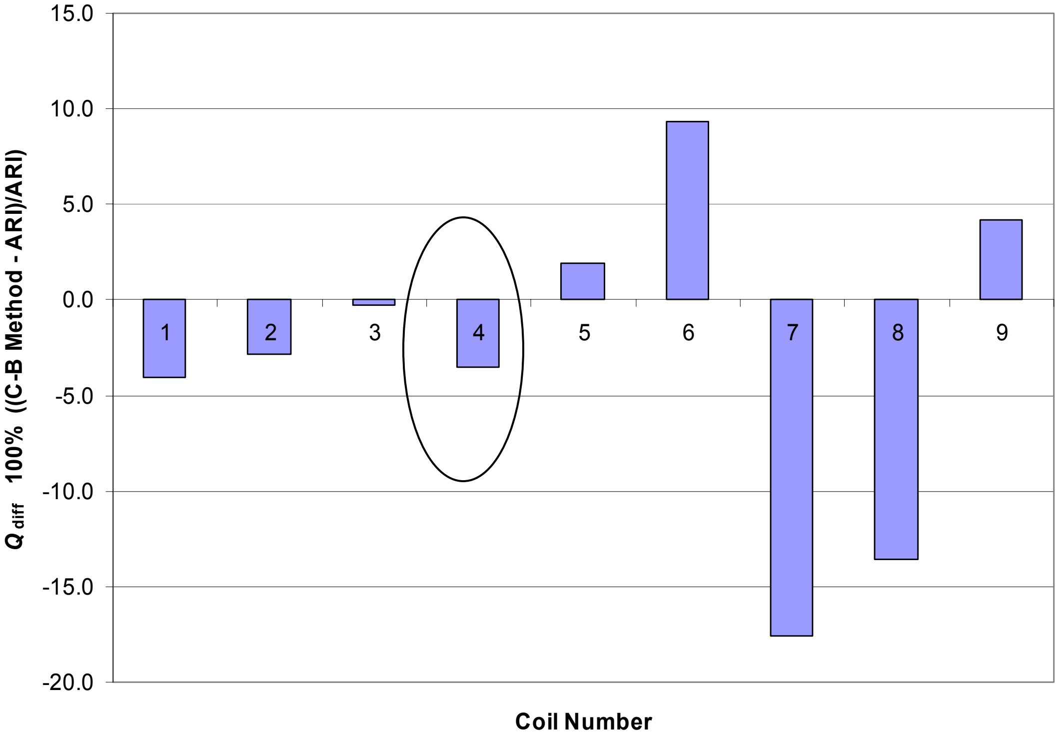

Figure 5.1.1: Comparison of mixed system A-test capacities from the ARI tests and the C-B Method
(Note: Coil 4 airflow was too high and results cannot be compared directly to ARI tests)

Table 5.1.1 also shows evaporator saturation temperatures obtained from the C-B Method and measured during mixed system certification tests. Ideally, these temperatures should be the same or very close for good capacity predictions. One can rationalize that a saturation temperature from the C-B Method that is lower than that from the certification tests should result in an overprediction of capacity while a higher C-B Method saturation temperature should drive toward the opposite effect. This physical rationale holds somewhat for Coils 1, 5, and 6, while other coils do not conform. In particular, Coil 7, associated with the largest underprediction of *Q*(95) of 17.6 % has a 4.5 °C (40.2 °F) C-B Method saturation temperature versus a 6.8 °C (44.3 °F) saturation temperature measured during certification tests.

To further explore the reasons for inconsistent *Q*(95) predictions, we compared test-obtained mixed system *Q*(95) capacities with those calculated for mixed evaporators from NIST-developed capacity lines and those calculated for condensing units from condensing performance curves using the same evaporator saturation temperature as measured during the mixed system certification tests. Table 5.1.2 presents the data. It is desirable for these three capacities to be close, ideally equal, to each other. The table shows that NIST-calculated capacities agreed with the certification test capacities for Coils 1, 3, 6, and 9 within ± 2.5 %, which is a remarkable agreement. The capacities for coils 2 and 5 are underpredicted within 6.5 %. The largest disagreement of -27.6 % is for Coil 7. For condensing unit capacities, the agreement with mixed system data was within ± 6.5 % for six cases. In the remaining cases, the deviations from mixed system capacities were as much as -14.2 %.

Looking back at the predicted *Q*(95) presented in Table 5.1.1, we can see that we obtained good predictions of *Q*(95) in every case where the capacities from three sources shown in Table 5.1.2 are in good agreement (Coils 1, 2, 3, and 9). Also good *Q*(95) predictions are for Coil 5 in Table 5.1.1; in this case the capacity calculated from evaporator and condensing unit correlations in Table 5.1.2 underpredicted and overpredicted the mixed system capacity by a similar percentage. The result is a good prediction of *Q*(95) at a somewhat different evaporator saturation temperature than that measured during a system test.

In the cases with the largest *Q*(95) prediction errors, Coils 6, 7 and 8, no offsetting of errors took place; even for Coil 8 where the C-B Method predicted the evaporator saturation temperature within 0.2 °C (0.4 °F). Since evaporator capacity and mixed system capacity for Coil 6 in Table 5.1.2 agree within 2.5 % while the condensing unit capacity deviates by 13.1 %, a suggestion can be made that the condensing unit correlation could be faulted for the *Q*(95) underprediction. Using the same rationale, a case against the evaporator capacity correlation could be made for Coil 7. For Coil 8, the evaporator and condensing unit correlations yield similar capacities and disagree with the system test data by a similar capacity percentage, -12.2 % and -14.2 %, respectively, suggesting some testing irregularity or an error in data handling.

Table 5.1.3 allows additional analysis of capacity predictions from the NIST-developed capacity lines. The table shows the tested mixed system capacities and those calculated using capacity lines (adjusted for the indoor fan heat) as presented in Table 5.1.2, but it includes temperature and subcooling of the refrigerant entering the expansion valve and the refrigerant superheat at the evaporator exit. Since values of these parameters are different for most cases, it was of interest to assess the extent to which these differences could affect the evaporator capacity predictions. For this purpose, we used the EVAP-COND simulation package (NIST 2003) to simulate coil performance at different inlet refrigerant temperatures and outlet superheats.

For example, for Coil 7, the ARI superheat was 2.4 ºC (4.3 ºF) and the NIST superheat was 7.3 ºC (13.2 ºF); a difference of 4.9 ºC (8.9 ºF). Keeping the same evaporator saturation temperature and liquid temperature (inlet quality), and changing the superheat to the ARI value increased the predicted Coil 7 capacity by 494 W (1686 Btu/h) to 7818 W (26 675 Btu/h), thus reducing the percent difference from -27.6 % to -22.8 %. Changing the liquid temperature from 40.6 ºC (105.1 ºF) to the ARI value of 49.4 ºC (120.9 ºF) and keeping the same subcooling of 7.7 ºC (13.8 ºF), increased the capacity by an additional 222 W (758 Btu/h) to 8038 W (27 433 Btu/h), thus reducing the ARI-NIST percent difference to -20.5 %. It appears that some installation and test condition related factors are responsible for the remaining -20.5 % deviation in the Coil 7 results.

Table 5.1.2: Mixed system A-Test capacities from the ARI tests, condensing unit capacities from CD Unit curves, and evaporator capacities from NIST-developed evaporator capacity curves at the ARI-test evaporating temperature(1,2)

	Coil 1		Coil 2		Coil 3		Coil 4*		Coil 5		Coil 6		Coil 7		Coil 8		Coil 9	
	W	Btu/h	W	Btu/h	W	Btu/h	W	Btu/h	W	Btu/h	W	Btu/h	W	Btu/h	W	Btu/h	W	Btu/h
ARI Value *Q*(95)	10034	34238	6529	22278	9609	32786	5073	17311	6787	23157	14407	49159	10122	34537	12591	42963	6480	22112
NIST *Q*(95)	10282	35083	6163	21029	9829	33536	5622	19183	6353	21679	14760	50363	7324	24989	11049	37702	6443	21984
CD Unit *Q*(95)	10338	35273	6388	21796	9475	32330	4548	15518	7198	24562	16294	55598	9508	32441	10804	36866	6899	23539
NIST/ARI %	2.5		-5.6		2.3		10.8		-6.4		2.5		-27.6		-12.2		-0.6	
CD Unit/ARI %	3.0		-2.2		-1.4		-10.4		6.1		13.1		-6.1		-14.2		6.5	

(1) Mixed system evaporating temperature, T_{evap}, is listed in Tables 5.1.1.

(2) Indoor fan heat from the mixed system accounted for in all capacity calculations

(3) Q_{diff} = 100% (NIST – ARI)/ARI

(4) Q_{diff} = 100% (CD Unit – ARI)/ARI

*Coil 4 airflow was too high and results cannot be compared directly to ARI tests

Table 5.1.3: Mixed system A-test capacities from ARI values and evaporator capacities from NIST-developed evaporator capacity curves at the ARI-test evaporating temperature(1)

	Coil 1		Coil 2		Coil 3		Coil 4*		Coil 5		Coil 6		Coil 7		Coil 8		Coil 9	
	ARI	NIST	ARI	NIST	ARI	NIST	ARI	NIST	ARI	NIST	ARI	NIST	ARI	NIST	ARI	NIST	ARI	NIST
T_{liq} °C (°F)	37.2 (99.0)	40.7 (105.3)	41.1 (106.0)	40.5 (104.9)	35.2 (95.4)	40.5 (104.9)	42.2 (108.0)	40.7 (105.3)	40.3 (104.6)	40.4 (104.8)	40.3 (104.6)	40.4 (104.8)	49.4 (120.9)	40.6 (105.1)	39.1 (102.4)	40.9 (105.7)	40.8 (105.4)	40.6 (105.0)
T_{sub} °C (°F)	6.9 (12.5)	6.2 (11.1)	11.8 (21.2)	6.6 (11.9)	7.7 (13.8)	7.7 (13.9)	13.8 (24.9)	7.6 (13.6)	7.7 (13.9)	7.7 (13.9)	6.4 (11.6)	7.7 (13.9)	6.7 (12.0)	7.7 (13.8)	11.1 (19.94)	7.1 (12.8)	5.9 (10.6)	7.6 (13.6)
T_{evap} °C (°F)	7.2 (45.0)	7.2 (45.0)	6.1 (43.0)	6.1 (43.0)	7.6 (45.6)	7.6 (45.6)	8.4 (47.2)	8.4 (47.2)	10.5 (50.9)	10.5 (50.9)	7.2 (44.9)	7.2 (44.9)	6.8 (44.3)	6.8 (44.3)	5.7 (42.2)	5.7 (42.2)	6.8 (44.2)	6.8 (44.2)
T_{suph} °C (°F)	6.2 (11.2)	7.1 (12.8)	4.7 (8.5)	8.1 (14.6)	11.6 (20.9)	7.4 (13.4)	2.1 (3.8)	7.4 (13.3)	0.8 (1.5)	7.8 (14.0)	7.1 (12.7)	7.6 (13.6)	2.4 (4.3)	7.3 (13.2)	3.9 (7.1)	7.4 (13.4)	6.2 (11.2)	7.8 (14.0)
Q, W (Btu/h)	10034 (34238)	10282 (35083)	6529 (22278)	6163 (21029)	9609 (32786)	9829 (33536)	5073 (17311)	5622 (19183)	6787 (23157)	6353 (21679)	14407 (49159)	14760 (50363)	10122 (34537)	7324 (24989)	12591 (42963)	11049 (37702)	6480 (22112)	6443 (21984)
Q_{diff} (%)(2)		2.5		-5.6		2.3		10.8		-6.4		2.5		-27.6		-12.2		-0.6

(1) Indoor fan heat from the mixed system accounted for in all capacity calculations

(2) Q_{diff} = 100% (NIST – ARI)/ARI

*Coil 4 airflow was too high and results cannot be compared directly to ARI tests

5.2: B-Test EER comparison

Table 5.2.1 shows EER values from the ARI tests and the C-B Method. Coils 5 and 7 show an agreement within ±5 %. The C-B Method overpredicted the ARI values by more than 5 % in four cases. System power, fan power, *Q*(82), and EER(82) were compared in Figure 5.2.1 to illustrate the sources of disagreement between the C-B Method and the ARI tests.

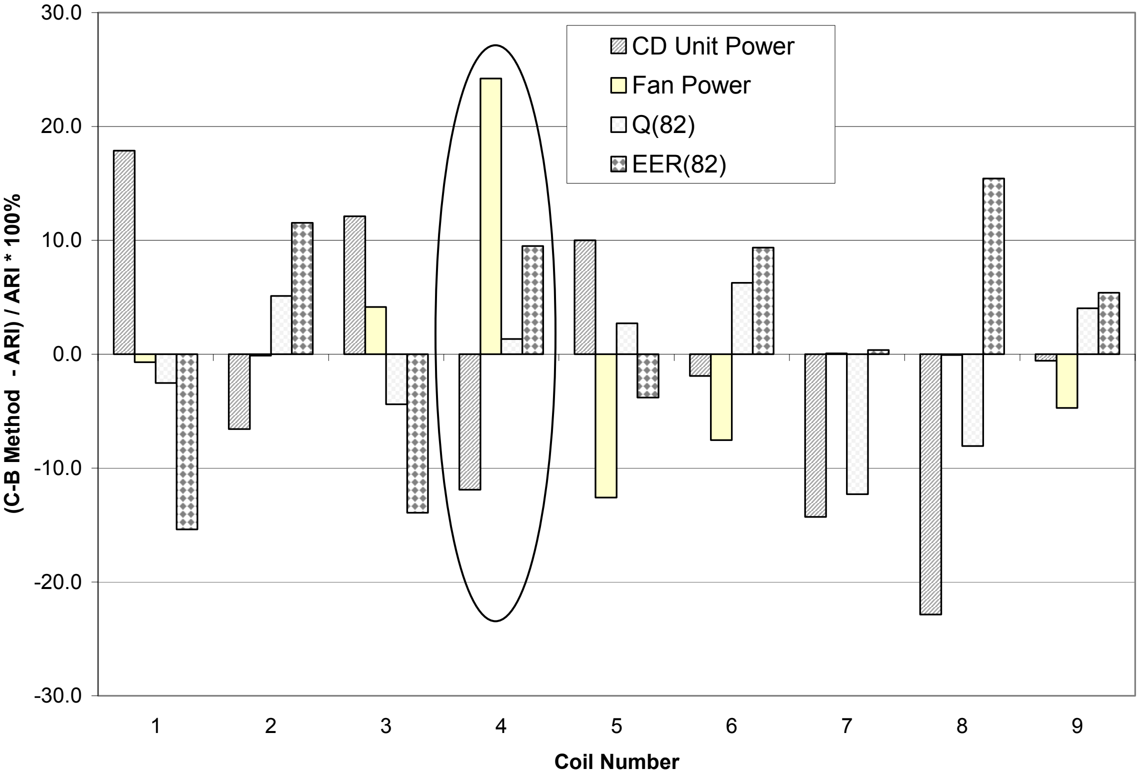

Figure 5.2.1: Percent differences between ARI Values and the C-B Method for the EER(82) calculation (Note: Coil 4 airflow was too high and results cannot be compared directly to ARI tests)

We may note that the largest EER disagreement was a 15.4 % underprediction and a 15.4 % over prediction for Coil 1 and Coil 8, respectively. For Coil 1 the 17.9 % higher power and the 2.5 % lower capacity caused the C-B Method EER(82) to be 15.4 % lower than the ARI Test EER(82). Since the evaporator saturation temperatures were equal for this coil, the 400 W difference in ARI Test and CD Unit linear fit power is the main contributor to the EER(82) difference. If the ARI Test CD Unit power were used in the C-B Method calculation of EER(82), the percent difference in EER(82) would only be -2.4 %.

Coil 8 had a 22.9 % under prediction in CD Unit power compared to the ARI Test results. The C-B Method's lower power was not completely mitigated by a lower capacity, resulting in the EER(82) being 15.4 % higher than the ARI Test EER(82). The lower evaporating temperature for the C-B Method would tend to produce a higher capacity than the ARI Test capacity, but this was not the case. According to the CD Unit capacity linear fit, a 1.3 ºC (2.4 ºF) lower evaporating temperature should increase capacity by 517 W (1765 Btu/h).

This does not equal the 1518 W (5179 Btu/h) difference between the C-B Method and ARI Test capacities. If the ARI Test value of power were used with the C-B Method capacity, the resulting EER(82) percent difference would be -8.1 %.

The C-B Method produced a 13.9 % underprediction of EER(82) for Coil 3. The ARI Test and C-B Method evaporating temperature were within 3.6 %. The CD Unit power and the ARI Test power differed by 12.1 %. The higher C-B Method power and the lower C-B Method capacity produced the 13.9 % lower EER(82). If the ARI Test power were used with the C-B Method capacity, the EER(82) difference would be -4.9 %.

From examining Table 5.2.1, the clear factor in EER(82) disagreement is the system power difference between actual tests and the power fits. This is true for all cases except Coil 7. For Coil 7, the evaporating temperatures differed by almost 19 %. The C-B Method's lower evaporating temperature should produce a higher capacity than the ARI Test evaporating temperature, but this was not the case. The lower evaporating temperature produced a 12.3 % lower capacity which was combined with a 14.3 % lower CD Unit power to produce an almost equivalent EER(82).

Table 5.2.1: Mixed system B-Test comparison of ARI tested and C-B Method results

Coil	T_{evap} °C (°F)			CD Unit Power W			Fan Power W			*Q*(82)[c] W (Btu/h)			EER(82) W/W (Btu/W h)		
	C-B Method	ARI Test	Difference (C-B Method - ARI)	C-B Method	ARI Test	Percent Diff %	C-B Method	ARI Test	Percent Diff %	C-B Method	ARI Test	Percent Diff %	C-B Method	ARI Test	Percent Diff %
1	7.94 (46.3)	7.94 (46.3)	0.0 (0.0)	2530	2146	17.9	365	368	-0.7	9763 (33313)	10017 (34178)	-2.5	3.37 (11.51)	3.99 (13.60)	-15.4
2	5.0 (41.0)	6.50 (43.7)	-1.5 (-2.7)	1953	2090	-6.6	294	294	-0.1	6895 (23525)	6559 (22381)	5.1	3.07 (10.47)	2.75 (9.39)	11.5
3	7.72 (45.9)	6.83 (44.3)	0.9 (1.6)	2528	2255	12.1	348	334	4.1	9717 (33155)	10164 (34680)	-4.4	3.38 (11.53)	3.92 (13.39)	-13.9
4[d]	8.89 (48.0)	9.72 (49.5)	-0.8 (-1.5)	1471	1670	-11.9	288	232	24.2	5410 (18458)	5338 (18215)	1.3	3.07 (10.49)	2.81 (9.58)	9.5
5	8.50 (47.3)	9.67 (49.4)	-1.2 (-2.1)	2024	1840	10.0	271	310	-12.6	7402 (25258)	7207 (24591)	2.7	3.23 (11.01)	3.35 (11.44)	-3.8
6	5.39 (41.7)	6.50 (43.7)	-1.1 (-2.0)	4257	4340	-1.9	784[a]	848[b]	-7.5	16593 (56616)	15613 (53274)	6.3	3.29 (11.23)	3.01 (10.27)	9.4
7	2.50 (36.5)	7.22 (45.0)	-4.7 (-8.5)	2897	3380	-14.3	440[a]	439[b]	0.1	9236 (31513)	10529 (35926)	-12.3	2.77 (9.44)	2.76 (9.41)	0.4
8	5.06 (41.1)	6.39 (43.5)	-1.3 (-2.4)	3196	4143	-22.9	507	507	-0.1	11500 (39238)	12508 (42680)	-8.1	3.11 (10.60)	2.69 (9.18)	15.4
9	5.39 (41.7)	5.89 (42.6)	-0.5 (-0.9)	1943	1954	-0.6	364[a]	382[b]	-4.7	7253 (24749)	6972 (23790)	4.0	3.14 (10.73)	2.98 (10.18)	5.4

a) Fan power measured by NIST. b) Fan power measured by ARI contracted testing facility. c) *Q*(82) included the fan heat correction for coils with no fan.
d) NIST airflow was 262 m^3/h (154 scfm) higher than the ARI tested airflow for Coil 4.

5.3: SEER comparison

Table 5.3.1 presents SEER values from the ARI database and the C-B Method for the 99th percentile cyclic degradation coefficients. With the exception of Coil 6, where the predicted SEER exceeds the measured SEER by 0.6 %, the SEER values obtained from the C-B Method are lower than the measured values by as much as 27 %. Four C-B Method SEERs agreed to within ±5 % of the measured SEERs. Figure 5.3.1 shows that this level of agreement can be attributed to offsetting errors between EERs and SEER/EER Multipliers, (1-0.5 C_D), especially considering the large differences in cyclic degradation coefficient between the NIST 99th percentile and ARI database. These large differences in degradation coefficient indicate that more information is needed to accurately determine a representative C_D value. Clearly, the use of a fixed value for the degradation coefficient cannot reliably reproduce ARI database values.

Table 5.3.1: SEERs from ARI value and C-B Method

Coil	SEER from ARI values Btu/(W·h)	SEER from C-B Method using 99th percentile C_d	SEER (1) Diff %	ARI SEER/EER Multiplier(2) (1-0.5 C_d)	NIST 99th Percentile SEER/EER Multiplier (1-0.5 C_d)	(ARI - NIST 99th) SEER/EER Multiplier
1	13.87	10.13	-27.0	0.931	0.880	0.051
2	9.63	9.22	-4.3	0.983	0.880	0.103
3	13.33	10.14	-23.9	0.964	0.880	0.084
4*	9.79	9.23	-5.7	0.980	0.880	0.100
5	10.01	9.68	-3.3	0.876	0.880	-0.004
6	9.82	9.88	0.6	0.976	0.880	0.096
7	9.56	8.31	-13.1	0.977	0.880	0.097
8	10.17	9.32	-8.4	0.949	0.880	0.069
9	9.78	9.44	-3.5	0.961	0.880	0.081

(1) SEER Diff = 100% (NIST – ARI)/ARI

(2) ARI SEER/EER multiplier was calculated from SEER = (1-0.5 C_d)EER(82)

*Coil 4 airflow was too high and results cannot be compared directly to ARI tests.

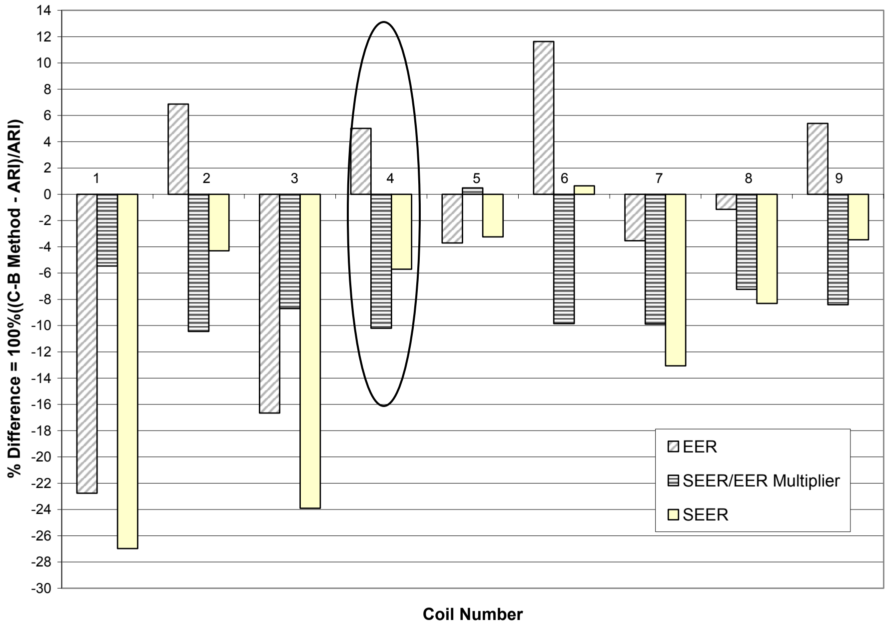

Figure 5.3.1: ARI Values and C-B Method SEER/EER Multiplier, EER, and SEER

6: GENERATING AN EVAPORATOR CAPACITY LINE USING EVAP-COND

In this study, we developed evaporator capacity lines based on measured capacities at several different evaporator exit saturation temperatures with constant superheat and inlet quality. Controlling these three parameters makes coil tests more time consuming than complete system tests. For this reason, we explored the possibility to minimize the laboratory effort by using an evaporator simulation model. A simulation model can be tuned to predict the measured capacity, which can then be used to provide capacities at other saturation temperatures needed to generate the evaporator capacity line. To demonstrate this approach, we used the EVAP-COND finned-tube heat exchanger simulation package (NIST 2003).

EVAP-COND uses coil design parameters (including refrigerant circuitry) and refrigerant and air parameters as input to calculate the capacity of the heat exchanger. The model allows the user to tune its prediction to experimental data by adjusting the correction factors for the air-side heat transfer coefficient, refrigerant-side heat transfer coefficient, and refrigerant-side pressure drop. In our case, we considered Coil 9 and selected appropriate values for these factors, shown in Table 6.1, so the model predictions agreed with the test results at the 7.4 ºC (45.4 ˚F) saturation temperature. Simulations at additional saturation temperatures allowed generation of a linear capacity fit for the coil.

Table 6.1: EVAP-COND correction parameters for Coil 9

T_{evap} ºC (ºF)	R	ΔP	A	*q* Predicted W (Btu/h)	*q* Measured W (Btu/h)	q_{diff} %
7.4 (45.4)	1.15	2.00	1.30	6249 (21323)	6242 (21300)	0.1

R - refrigerant-side heat transfer coefficient correction factor
ΔP - refrigerant pressure drop correction factor
A - air-side heat transfer coefficient correction factor
*q*diff = 100%(Predicted-Measured)/Measured

Figure 6.1 shows cooling capacities for Coil 9 from the laboratory measurements, the EVAP-COND simulations, and the corresponding capacity lines as a function of evaporating temperature. The capacity lines almost overlap. Consequently, the C-B Method performance predictions for mixed system using Coil 9 were within 0.5 % for the two capacity lines, as shown in Figure 6.2.

It is possible that the approach presented here could be extended to other evaporators that use the same air-side and refrigerant-side heat transfer surfaces; i.e., once EVAP-COND adjustable factors for air-side heat transfer, refrigerant-side heat transfer, and refrigerant pressure drop are determined for one coil, they could be applied to other coils using the same surfaces.

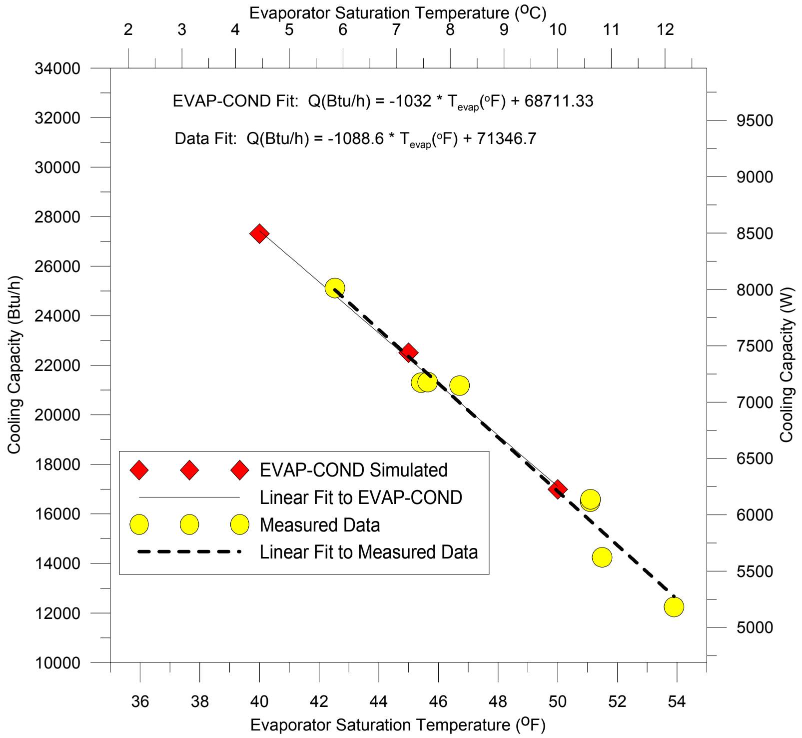

Figure 6.1: Coil 9 simulated and measured cooling capacity

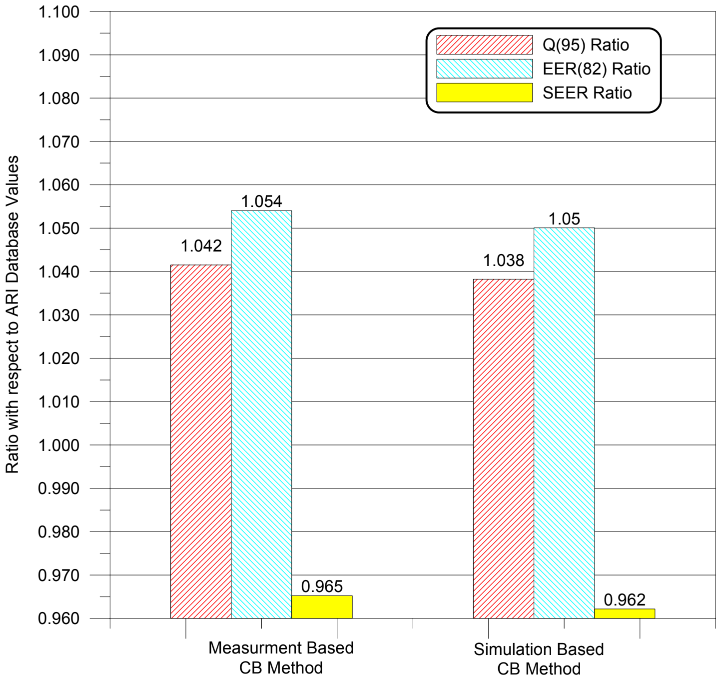

Figure 6.2: C-B Method *Q*(95), EER(82) and SEER ratio with respect to the ARI database using the measured and simulated Coil 9 capacity

7: UNCERTAINTY OF THE C-B METHOD

7.1: Uncertainty of the evaporator capacity linear fit

We used Coil 9 data as an example to evaluate the uncertainty of the evaporator capacity linear fit. This is the uncertainty that would result if someone used this linear fit to calculate capacity at a known evaporator temperature. The data set used to generate the linear fit consisted of 8 tests. A linear equation has two adjustable parameters; therefore, the fit had 6 degrees of freedom (DOF= *n*-2). Table 7.1.1 summarizes the linear fit parameters (slope and intercept) and related fit statistics.

Table 7.1.1: Coil 9 evaporator linear fit equation statistics

Correlation Coefficient R^2	DOF Adjusted R^2	Fit Standard Error, W (Btu/h)	F-Value	n = 8 data points DOF = n-2 = 6	
0.972835	0.961969	226.28 (772.093)	214.872		
Parameter	Value	Standard Error	t-value	95 % Confidence Limits on the Mean Value Minimum	 Maximum
B (intercept), W (Btu/h)	20909.6 (71346.5)	1058.35 (3611.22)	19.757	18309.1 (62473.4)	23510.1 (80219.6)
A (slope), W/ºC (Btu/h ºF)	-574.32 (-1088.7)	39.18 (74.27)	-14.659	-670.56 (-1271.2)	-478.0 (-906.2)
S_{xx}	108.0774				
Mean T_{evap}	9.2 (48.5)	Mean *q*	5440 (18562.8)		

At a 95 % confidence level, the linear intercept is equal to 20909.6 ± 2600.45 W (71346.5 ± 8873.1 Btu/h), and the linear slope is equal to -574.32 ± 39.18 W/ºC (-1088.7 ± 182.5 Btu/h ºF). The confidence bands are determined by subtracting the minimum 95 % limit from the maximum 95 % limit and dividing by two (or taking the fit standard error and multiplying by the appropriate t-value). With confidence limits as a percentage value, the linear intercept is 20909.6 W (71346.5 Btu/h) ± 12.4 %, and the linear slope is -574.32 W/ºC (-1088.7 Btu/h ºF) ± 16.8 %.

For capacity predictions using the linear correlation, the confidence interval for the mean value at a particular point is given by (Ott 1984):

$$\pm t \cdot \hat{\sigma}\sqrt{\frac{1}{n}+\frac{(x-\bar{x})^2}{S_{xx}}} \tag{7.1.1}$$

where $\hat{\sigma} = \sqrt{\frac{SSE}{n-2}}$ = fit standard error

$$S_{xx} = \sum\left(x^2\right) - \frac{\left(\sum x\right)^2}{n}$$

t - two tailed t-value for the appropriate confidence level with DOF = n - 2

$\hat{\sigma}$ - estimated standard deviation equal to the fit standard error

$\bar{x}$ - mean value of the x-variables or, in this case, the mean value of the evaporating temperatures used to generate the linear fit

x - independent variable or, in this case, the evaporator temperature

At a 95 % confidence level, the t-value for six DOF is 2.447 from a table of the percentage points of the t-distribution (Ott 1984). From Table 7.1.1, the fit standard error was 226.28 W (772.093 Btu/h), and S_{xx} was 33.36 °C^2 (108.08 °F^2). Substituting these values into Equation 7.1.1 yields:

$$\pm 2.447 \cdot 772.093 \sqrt{0.125 + \frac{(x - 48.485)^2}{108.08}} \qquad 7.1.2$$

Knowing the confidence interval for a given confidence level and the predicted value, we can calculate the upper and lower confidence bands for the mean value of the cooling capacity sampled multiple times at a particular value of the evaporator saturation temperature within the range of the evaporator saturation temperature data. Figure 7.1.1 plots the evaporator capacity line, 90 % and 95 % confidence bands, and 5 % offset lines for Coil 9. The figure shows that the 90% and 95% confidence lines are very close to each other; they are within the ± 5 % offset lines for the majority of the saturation temperature range except the lowest and highest saturation temperatures due to the smaller number of data points associated with the end points of the temperature range.

Once the rater has used the C-B Method (Equation 4.1.2) to determine the evaporating temperature for the condensing unit and the mixed evaporator, the analysis of section 7.1 provides the uncertainty in the mean value of the cooling capacity sampled at that particular evaporator temperature. For Coil 9 and its CD Unit, the evaporating temperature was 6.2 ºC (43.2 ºF) which produced a cooling capacity, *q*(95), of 7114 W (24 273 Btu/h) with an uncertainty of ± 341 W (1164 Btu/h) or ± 4.8 % on the mean value at a 95 % confidence level. Subtracting the fan heat, which has a ± 3 % uncertainty, yields the numbers seen in Table 5.1.1 or a rated *Q*(95) of 6749 W (23 030 Btu/h) ± 341 W (1165 Btu/h) (± 5.1 %) at a 95 % confidence level. Table 7.1.2 summarizes the uncertainty results for the remaining evaporators.

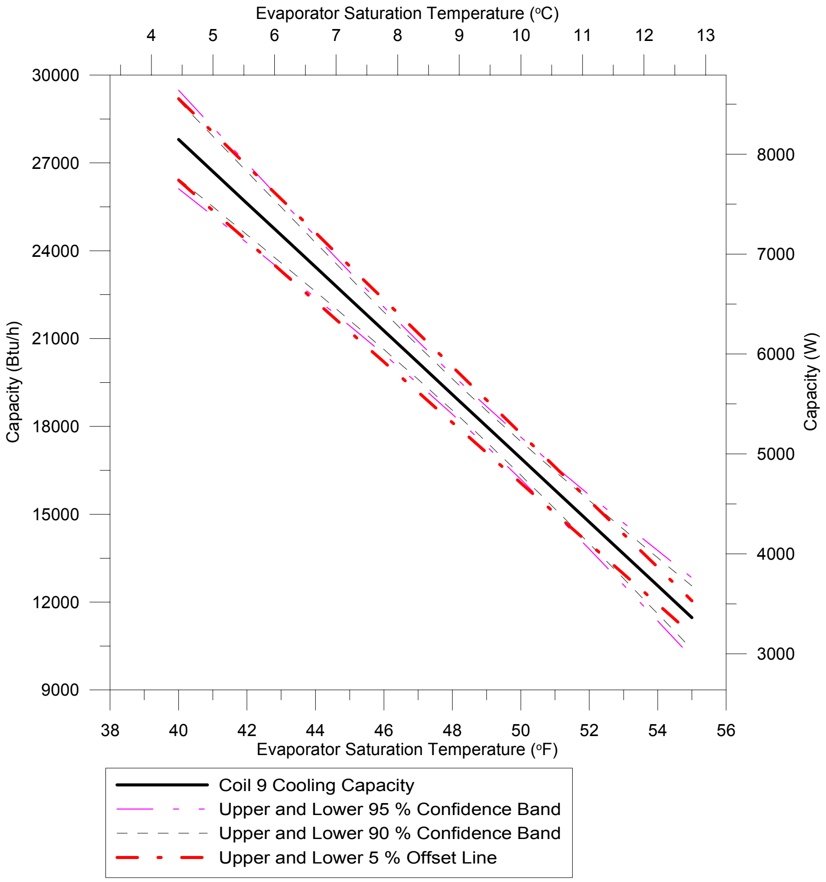

Figure 7.1.1: Coil 9 evaporator cooling capacity, confidence and error bands on the mean predicted value of the cooling capacity sampled at a particular evaporator saturation temperature

Table 7.1.2: Evaporator $Q(95)$ linear fit uncertainty

Coil	T_{evap} °C (°F)	$Q(95)$ W (Btu/h)	95 % Confidence Level on the Mean, Uncertainty $Q(95)$	% Uncertainty
1	8.11 (46.60)	9624 (32839)	541 (1847)	5.6
2	5.84 (42.51)	6344 (21647)	334 (1138)	5.3
3	7.93 (46.27)	9585 (32705)	267 (910)	2.8
4*	9.94 (49.89)	4894 (16700)	127 (434)	2.6
5	9.43 (48.98)	6917 (23601)	192 (655)	2.8
6	6.2 (43.19)	15756 (53761)	939 (3205)	6.0
7	4.5 (40.17)	8340 (28456)	124 (424)	1.5
8	5.9 (42.6)	10878 (37115)	260 (886)	2.4
9	6.2 (43.24)	6749 (23030)	342 (1166)	5.1

*Coil 4 airflow was too high and results cannot be compared directly to ARI tests.

7.2: Uncertainty of C-B Method *Q*(95) and EER

The ARI database, *q*(95), *q*(82) and *p*(82) linear fits of Table 4.1.1, NIST capacity linear fits of Table 3.4.1, Equation 4.1.2, and fan heat were used to calculate the uncertainty in the C-B Method *Q*(95) and EER.

$$q_{\mathrm{CD}} = A_{CD}T_{evap} + B_{CD} = q_{\mathrm{mixed}} = A_{mixed}T_{evap} + B_{mixed} \tag{4.1.1}$$

$$T_{evap} = \frac{B_{mixed} - B_{CD}}{A_{CD} - A_{mixed}} \tag{4.1.2}$$

$$p_{\mathrm{CD}} = b_{CD} + a_{CD}T_{\mathrm{evap}} \tag{4.1.4}$$

Substituting Equation 4.1.2 into Equation 4.1.1 and 4.1.4 yields an expression for the cooling capacity and CD Unit power of the mixed system.

$$q_{CD} = q_{mixed} = A_{CD}\left(\frac{B_{mixed} - B_{CD}}{A_{CD} - A_{mixed}}\right) + B_{CD} \tag{7.2.1}$$

$$p_{\mathrm{CD}} = b_{CD} + a_{CD}\left(\frac{B_{mixed} - B_{CD}}{A_{CD} - A_{mixed}}\right) \tag{7.2.2}$$

The fit standard errors for the CD Unit capacity and power linear coefficients are unknown. If we assume the fit standard error for the CD Unit capacity is similar (the same percentage) to that obtained for the evaporator tests, power coefficient uncertainties are 3 %, power and capacity fits have no covariance, and the covariance of the slope and intercept are equal for the CD Unit and evaporator tests, then we may calculate an uncertainty for the mixed system capacity and power.

In general the capacity is a function of the four linear fit coefficients and the power is a function of six linear fit coefficients:

$$q_{CD} = q_{mixed} = f(A_{CD}, B_{CD}, A_{mixed}, B_{mixed}) \tag{7.2.3}$$

$$q_{CD} = q_{mixed} = f(a_{CD}, b_{CD}, A_{CD}, B_{CD}, A_{mixed}, B_{mixed}) \tag{7.2.4}$$

Since the slope and intercept are not independent in Equations 7.2.1 and 7.2.2, we must include covariance in the form of a correlation coefficient (Coleman and Steele 1989). In general terms this becomes:

$$\begin{aligned} U_q^{\,2} = {} & \left(\frac{\partial q}{\partial A_{CD}}U_{A_{CD}}\right)^2 + \left(\frac{\partial q}{\partial B_{CD}}U_{B_{CD}}\right)^2 + \left(\frac{\partial q}{\partial A_{mixed}}U_{A_{mixed}}\right)^2 + \left(\frac{\partial q}{\partial B_{mixed}}U_{B_{mixed}}\right)^2 \\ & + 2\left(\frac{\partial q}{\partial A_{CD}}\right)\left(\frac{\partial q}{\partial B_{CD}}\right)\rho_{A_{CD}B_{CD}}U_{A_{CD}}U_{B_{CD}} + 2\left(\frac{\partial q}{\partial A_{mixed}}\right)\left(\frac{\partial q}{\partial B_{mixed}}\right)\rho_{A_{mixed}B_{mixed}}U_{A_{mixed}}U_{B_{mixed}} \end{aligned} \tag{7.2.5}$$

Here the partial derivatives are taken from Equation 7.2.1 with respect to the various coefficients. A similar procedure is necessary for the CD Unit power equation with the addition of the two extra terms for the power equation linear fit coefficients. The fan power and resulting heat were assumed to have an uncertainty of ±3 %. The fan heat must be subtracted from the cooling capacity, and the fan power must be added to the CD Unit power with their variances added to produce the cooling capacity and total power final values and associated uncertainties.

EER is the ratio of $Q(82)$ and $P(82)$.

$$\mathrm{EER} = \frac{Q(82)}{P(82)} \tag{1.1}$$

The propagation of the capacity uncertainty and the power uncertainty through Equation 1.1 produces a resulting uncertainty in the EER. We assumed no covariance between capacity and power. The resulting uncertainty in EER is shown below in Table 7.2.1.

Table 7.2.1: C-B Method $Q(95)$, $Q(82)$, $P(82)$, and EER uncertainty at the 95 % confidence level on the mean value

Coil	$T_{evap}(82)$	$T_{evap}(95)$	$Q(95)$ W (Btu/h)	*% $U_{Q(95)}$	$Q(82)$ W (Btu/h)	[a]% $U_{Q(82)}$	$P(82)$ W	% $U_{P(82)}$	EER W/W (Btu/W h)	% U_{EER}
1	7.9 (46.3)	8.1 (46.6)	9624 (32839)	15.3	9763 (33313)	15.7	2895	3.7	3.37 (11.51)	16.1
2	5.0 (41.0)	5.8 (42.5)	6344 (21647)	4.4	6895 (23525)	4.5	2246	9.7	3.07 (10.47)	10.7
3	7.7 (45.9)	7.9 (46.3)	9585 (32705)	8.3	9717 (33155)	8.5	2876	2.8	3.38 (11.53)	9.0
4*	8.9 (48.0)	9.9 (49.9)	4894 (16700)	7.5	5410 (18458)	6.2	1760	3.4	3.07 (10.49)	7.1
5	8.5 (47.3)	9.4 (49.0)	6917 (23601)	8.2	7402 (25258)	7.0	2295	5.8	3.23 (11.01)	9.1
6	5.4 (41.7)	6.2 (43.2)	15756 (53761)	9.0	16593 (56616)	8.1	5041	4.1	3.29 (11.23)	9.1
7	2.5 (36.5)	4.5 (40.2)	8340 (28456)	6.3	9236 (31513)	4.6	3337	2.5	2.77 (9.44)	5.2
8	5.1 (41.1)	5.9 (42.6)	10877 (37115)	5.2	11500 (39238)	5.6	3703	16.9	3.11 (10.60)	17.8
9	5.4 (41.7)	6.2 (43.2)	6749 (23030)	10.8	7253 (24749)	9.3	2307	3.3	3.14 (10.73)	9.9

[a] U: uncertainty

*Coil 4 airflow was too high and results cannot be compared directly to ARI tests.

The uncertainty values may be skewed higher by the assumption of equal percentage uncertainties for the evaporator and CD Unit linear fit capacity coefficients. It is likely that the manufacturers of the CD Units have much larger data sets than those collected in this work; therefore, the uncertainty percentages may be lower than those presented in Table 7.2.1.

8: CONCLUDING REMARKS

This report examines the application of the C-B Method to determine $Q(95)$ and SEER of mixed air conditioners was studied on a sample of eight mixed systems. An independent certification laboratory performed mixed system tests and shipped the mixed evaporators to NIST for testing in NIST's environmental chambers. We implemented the C-B Method for

Q(95) and SEER ratings using condensing unit performance correlations obtained from ARI, the evaporator capacity correlations developed at NIST, and the 99th percentile value of cyclic degradation coefficients identified for the equipment studied. We compared the obtained *Q*(95) and SEER ratings to the test-obtained values from the certification laboratory (referred to as ARI values).

The C-B Method produced *Q*(95) results that were within ± 5 % of the ARI tested values for five of eight coils. Among the remaining cases, one *Q*(95) was overpredicted by 9.4 % and two *Q*(95) were underpredicted by 13.6 % and 17.6 %. In two of the five cases with ± 5 % agreement, the good *Q*(95) predictions were obtained as a result of error offsetting between evaporator and condensing unit performance correlations with respect to the system tested capacities, as evidenced by the misprediction of the evaporator saturation temperature by the C-B Method in these two cases.

The *Q*(82) values from the C-B method were within ± 5 % of the ARI tested values for four of eight coils with six of eight coils being within ± 7 %. Of all the factors contributing to the differences in EER(82), the CD Unit power had the largest effect. Using the CD Unit linear fits for power, the C-B Method predicted EER(82) to within ± 5 % for only two coils. Using the ARI Test values for CD Unit power, the C-B Method predicted EER(82) to within ± 5 % for four of eight coils and within ± 8 % for six of eight coils. Clearly good representations of CD Unit power must be attained to produce consistently correct values of EER(82).

Regarding SEER values, four of eight predictions were within ± 5 % of the ARI tested values, but offsetting of errors played a role in this agreement due to conservative (99th percentile) selection of the cyclic degradation coefficient used by the C-B Method. For the same reason seven of eight SEER predictions were below the test-derived SEERs.

The uncertainty analysis of the C-B Method showed that the 95 % confidence level on the mean predictions averaged 3.8 % for A-Test capacity and 10.4 % for EER. The analysis also showed the importance of careful collection of data; when the evaporator capacity linear fits had a lower standard error, the uncertainty in capacity and EER for a given evaporator temperature was also low.

We demonstrated that EVAP-COND can be used effectively in developing evaporator capacity correlations, which will facilitate the use of the C-B Method.

The C-B Method does not have any inherent features that would produce a bias in predicting *Q*(95) and EER(82) values. The values obtained in this study for *Q*(95) and EER(82), under predictions or over predictions, are caused by random deviations between the obtained system test results and evaporator and condensing unit performance correlations.

Predicted values of SEER have strong under predicting tendencies due to the conservative 99th percentile selection of the cyclic degradation coefficient. The category of equipment involved in this study can have a C_D in the range from 0.09 to 0.25, with 0.24 being the 99th percentile value that was used in our SEER calculations. It appears that there is no other way to improve SEER predictions other than providing the matched system C_D value along with condensing unit performance correlations for the application of the C-B Method. It is reasonable to assume that a mixed system would have a C_D very similar to that of the matched system if only the evaporator and indoor fan are the replaced system components.

As compared to the traditional approach for rating mixed systems that is based on the matched system *Q*(95) and SEER values and adjusting them using coil capacity ratios (or similar scaling parameters), the C-B Method is an inherently more accurate methodology; the selected prediction problems encountered in this study should be studied further to tighten this procedure.

Some of the procedural issues that must be stipulated before a working standard is produced include the following:

1) Standard superheats for evaporator curve development with a method to accommodate different superheat for evaporator capacity determination
2) Liquid line temperatures for evaporator curve development
3) Cyclic degradation coefficients for comparable systems with different expansion devices
4) Cyclic degradation coefficient for matched system provided to coil manufacturers, or a method developed to determine a default value
5) Procedure for developing CD Unit curves; it should include a method for accommodating different superheats at the evaporator exit

As an alternative to the C-B Method, the traditional method for testing mixed systems could be revisited if the evaporator saturation temperature from the *Q*(95) matched system test was made available for the mixed system rater. This would facilitate an accurate estimation of the capacity ratio of the mixed and matched coils, which is used as the most influential scaling factor in the traditional rating method. This methodology does not require the matched system C_D since it is included in the matched system SEER, which is available for rating.

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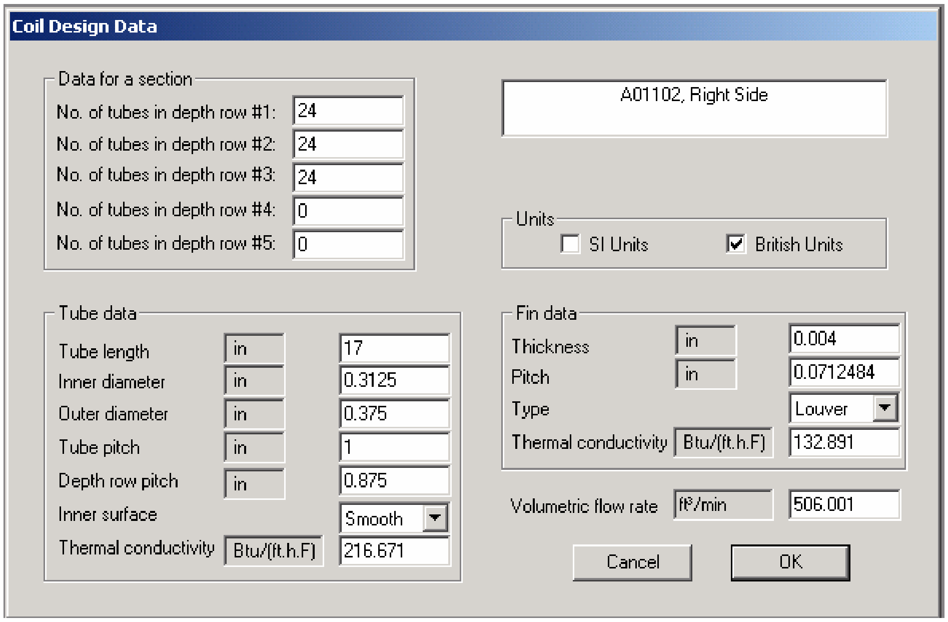
APPENDIX A: EVAPORATOR COIL DESCRIPTIONS

Appendix A presents design information for the nine mixed evaporators tested at NIST. It includes a picture, design data, and refrigerant circuitry representation in the input format of the EVAP-COND simulation package. General information and name designation for the mixed evaporators is given in Table 2.1.

Coil 1



Coil Design Data

Data for a section

No. of tubes in depth row #1: 24
No. of tubes in depth row #2: 24
No. of tubes in depth row #3: 24
No. of tubes in depth row #4: 0
No. of tubes in depth row #5: 0

A01102, Right Side

Units
☐ SI Units ☑ British Units

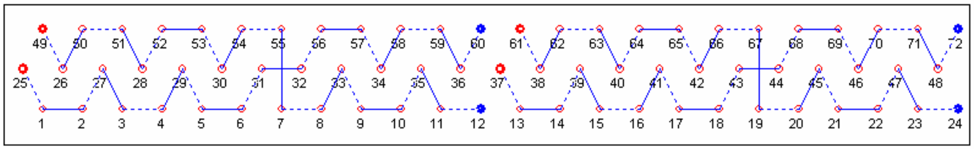
Tube data

Tube length	in	17
Inner diameter	in	0.3125
Outer diameter	in	0.375
Tube pitch	in	1
Depth row pitch	in	0.875
Inner surface		Smooth
Thermal conductivity	Btu/(ft.h.F)	216.671

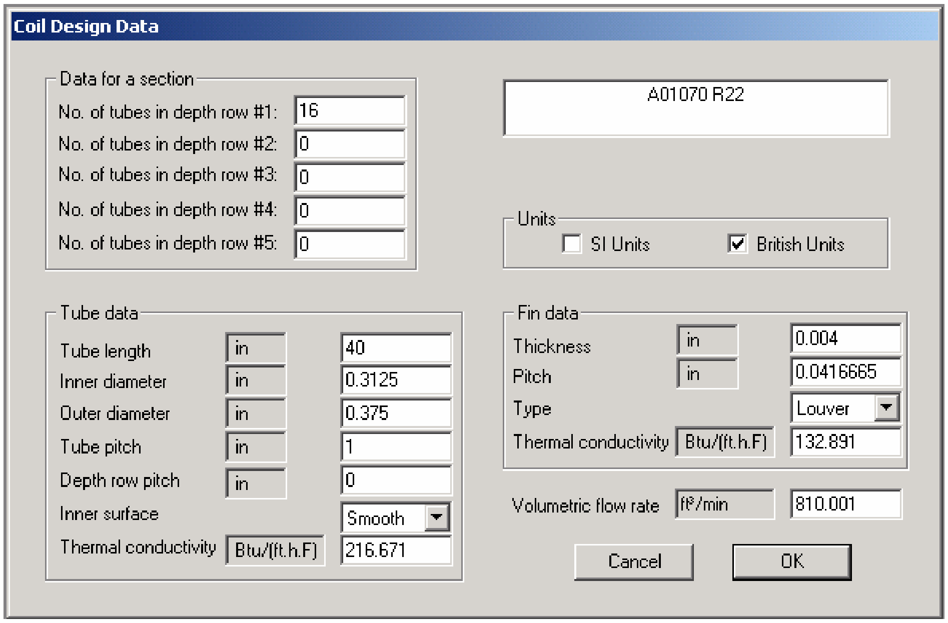
Fin data

Thickness	in	0.004
Pitch	in	0.0712484
Type		Louver
Thermal conductivity	Btu/(ft.h.F)	132.891

Volumetric flow rate ft³/min 506.001



Coil 2



Coil Design Data

Data for a section

No. of tubes in depth row #1: 16
No. of tubes in depth row #2: 0
No. of tubes in depth row #3: 0
No. of tubes in depth row #4: 0
No. of tubes in depth row #5: 0

A01070 R22

Units
☐ SI Units ☑ British Units

Tube data

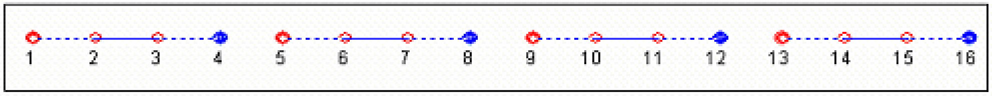
Tube length	in	40
Inner diameter	in	0.3125
Outer diameter	in	0.375
Tube pitch	in	1
Depth row pitch	in	0
Inner surface		Smooth
Thermal conductivity	Btu/(ft.h.F)	216.671

Fin data

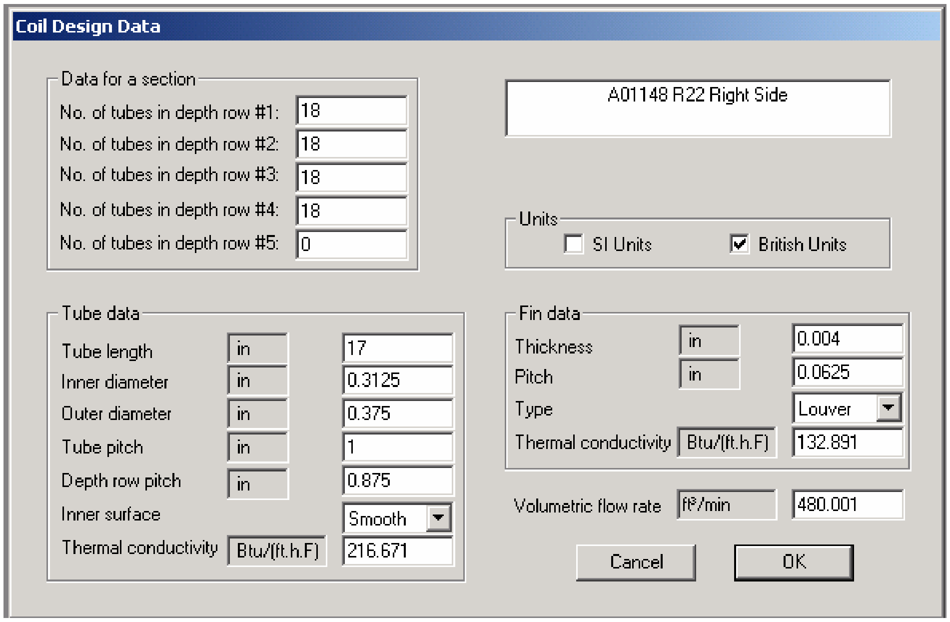
Thickness	in	0.004
Pitch	in	0.0416665
Type		Louver
Thermal conductivity	Btu/(ft.h.F)	132.891

Volumetric flow rate ft³/min 810.001

Coil circuitry



Coil 3



Coil Design Data

Data for a section

No. of tubes in depth row #1: 18

No. of tubes in depth row #2: 18

No. of tubes in depth row #3: 18

No. of tubes in depth row #4: 18

No. of tubes in depth row #5: 0

A01148 R22 Right Side

Units

☐ SI Units ☑ British Units

Tube data

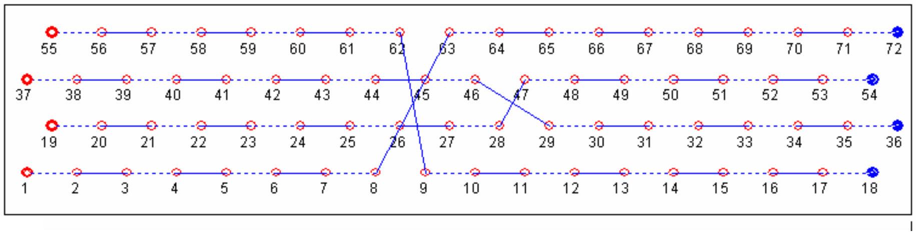
Tube length	in	17
Inner diameter	in	0.3125
Outer diameter	in	0.375
Tube pitch	in	1
Depth row pitch	in	0.875
Inner surface		Smooth
Thermal conductivity	Btu/(ft.h.F)	216.671

Fin data

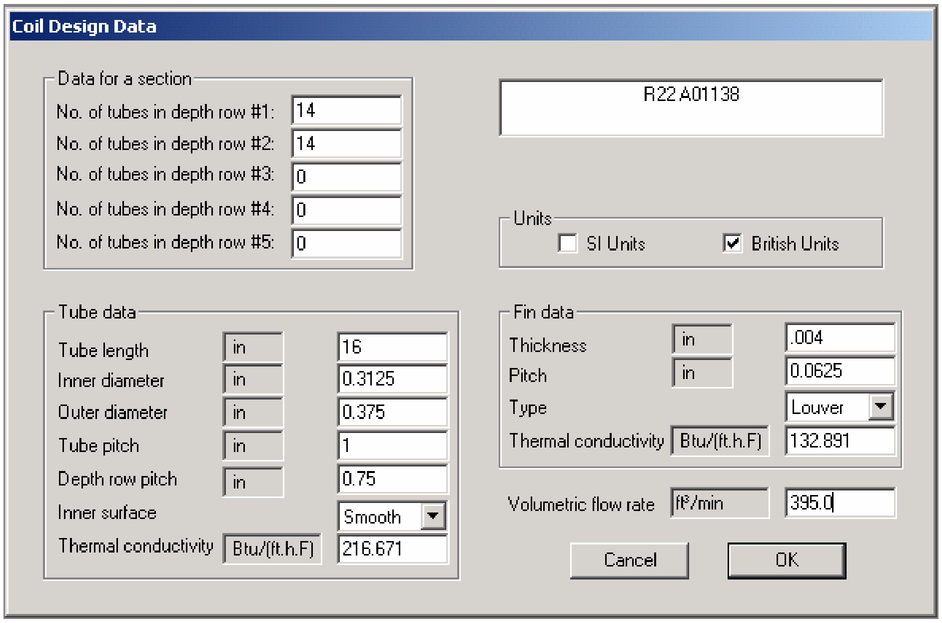
Thickness	in	0.004
Pitch	in	0.0625
Type		Louver
Thermal conductivity	Btu/(ft.h.F)	132.891

Volumetric flow rate ft³/min 480.001

Coil Circuitry (left slab)



Coil 4



Data for a section

No. of tubes in depth row #1: 14
No. of tubes in depth row #2: 14
No. of tubes in depth row #3: 0
No. of tubes in depth row #4: 0
No. of tubes in depth row #5: 0

R22 A01138

Units
☐ SI Units ☑ British Units

Tube data

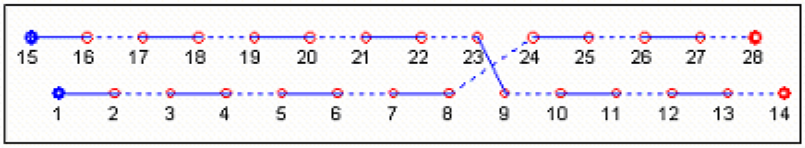
Tube length	in	16
Inner diameter	in	0.3125
Outer diameter	in	0.375
Tube pitch	in	1
Depth row pitch	in	0.75
Inner surface		Smooth
Thermal conductivity	Btu/(ft.h.F)	216.671

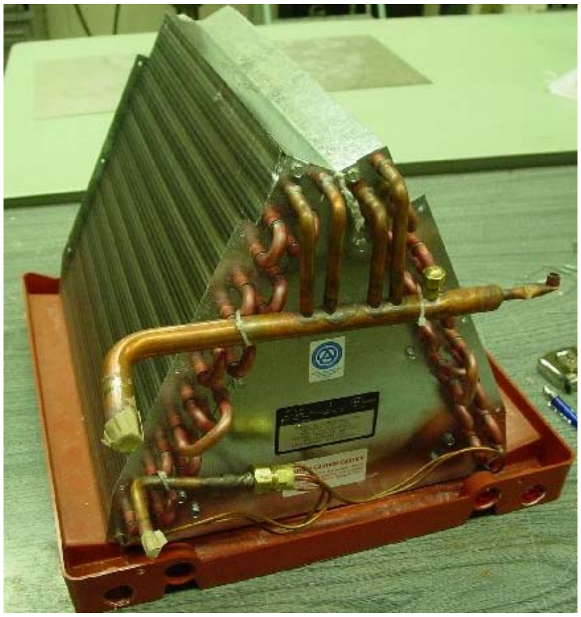
Fin data

Thickness	in	.004
Pitch	in	0.0625
Type		Louver
Thermal conductivity	Btu/(ft.h.F)	132.891

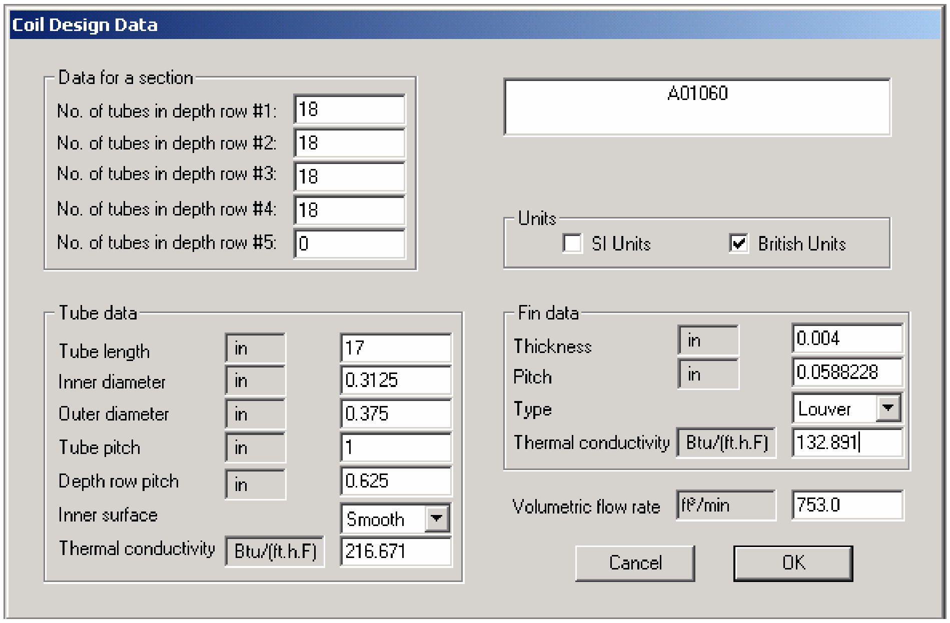
Volumetric flow rate ft³/min 395.0

Coil Circuitry (right slab as seen below)





Coil 5



Coil Design Data

Data for a section

No. of tubes in depth row #1: 18

No. of tubes in depth row #2: 18

No. of tubes in depth row #3: 18

No. of tubes in depth row #4: 18

No. of tubes in depth row #5: 0

A01060

Units

☐ SI Units ☑ British Units

Tube data

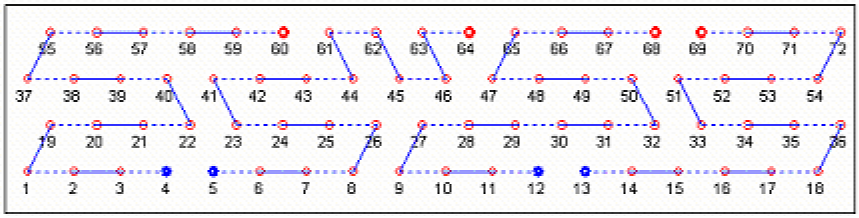
Tube length	in	17
Inner diameter	in	0.3125
Outer diameter	in	0.375
Tube pitch	in	1
Depth row pitch	in	0.625
Inner surface		Smooth
Thermal conductivity	Btu/(ft.h.F)	216.671

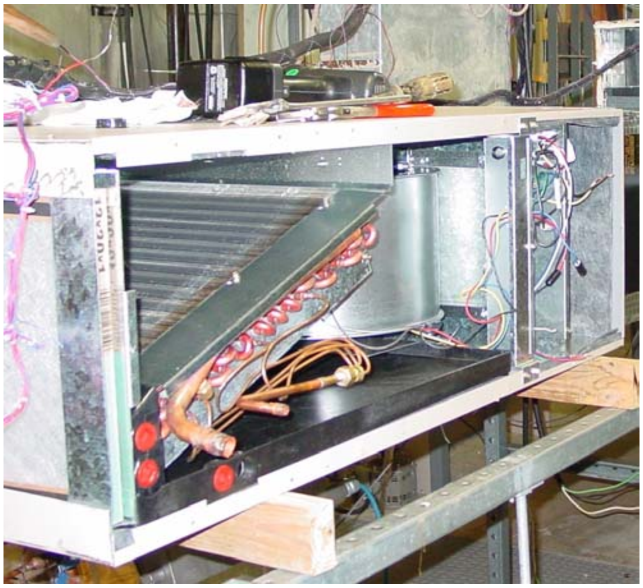
Fin data

Thickness	in	0.004
Pitch	in	0.0588228
Type		Louver
Thermal conductivity	Btu/(ft.h.F)	132.891

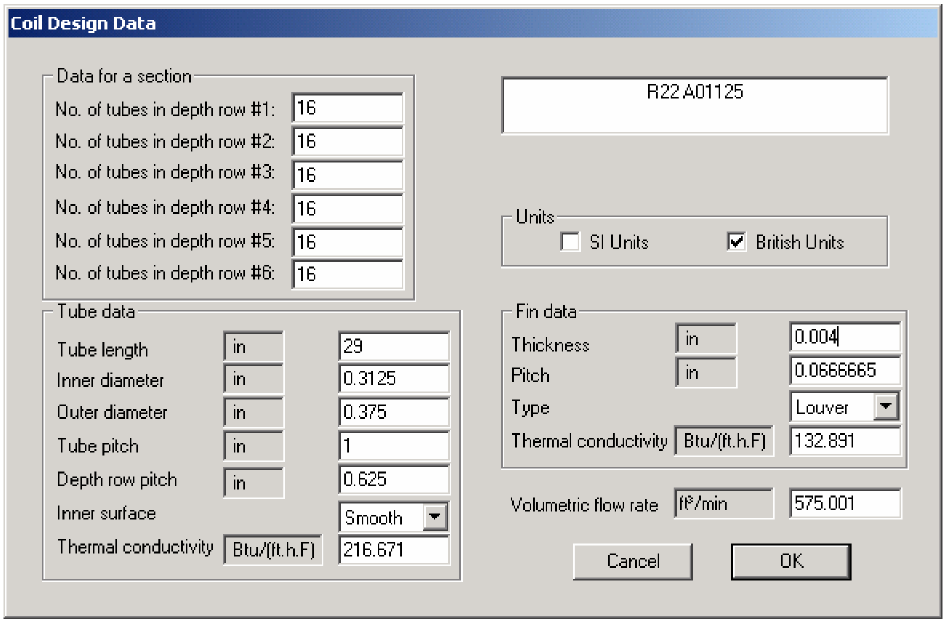
Volumetric flow rate ft³/min 753.0

Coil circuitry





Coil 6



Coil Design Data

Data for a section
No. of tubes in depth row #1: 16
No. of tubes in depth row #2: 16
No. of tubes in depth row #3: 16
No. of tubes in depth row #4: 16
No. of tubes in depth row #5: 16
No. of tubes in depth row #6: 16

R22 A01125

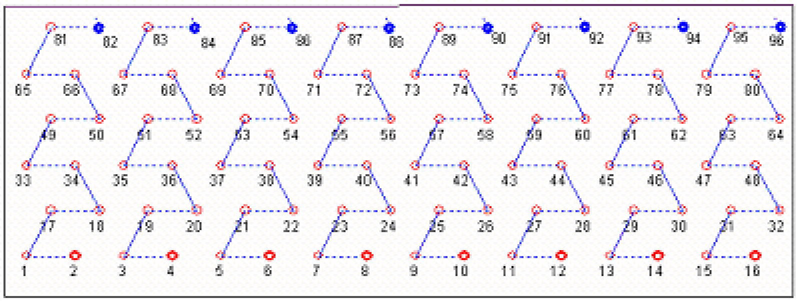
Units
☐ SI Units ☑ British Units

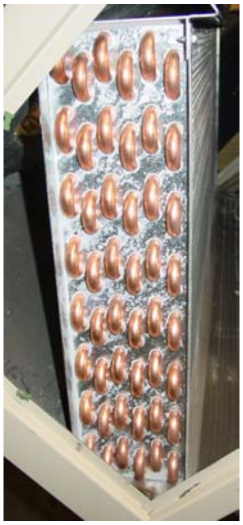
Tube data
Tube length: in 29
Inner diameter: in 0.3125
Outer diameter: in 0.375
Tube pitch: in 1
Depth row pitch: in 0.625
Inner surface: Smooth
Thermal conductivity: Btu/(ft.h.F) 216.671

Fin data
Thickness: in 0.004
Pitch: in 0.0666665
Type: Louver
Thermal conductivity: Btu/(ft.h.F) 132.891

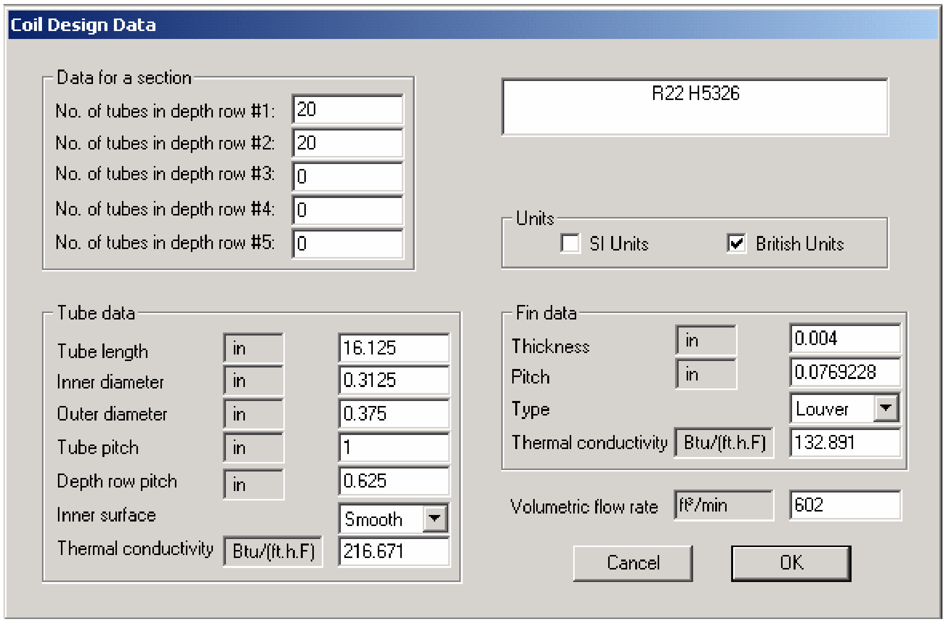
Volumetric flow rate: ft³/min 575.001

Coil circuitry





Coil 7



Data for a section

No. of tubes in depth row #1: 20

No. of tubes in depth row #2: 20

No. of tubes in depth row #3: 0

No. of tubes in depth row #4: 0

No. of tubes in depth row #5: 0

R22 H5326

Units

☐ SI Units ☑ British Units

Tube data

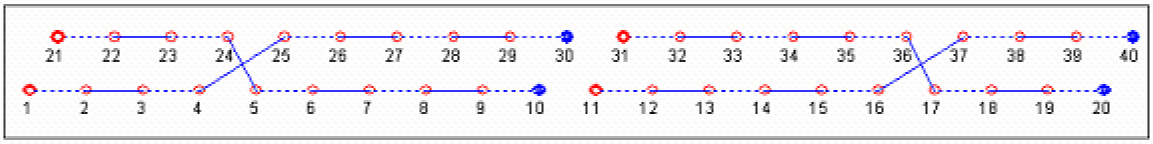
Tube length	in	16.125
Inner diameter	in	0.3125
Outer diameter	in	0.375
Tube pitch	in	1
Depth row pitch	in	0.625
Inner surface		Smooth
Thermal conductivity	Btu/(ft.h.F)	216.671

Fin data

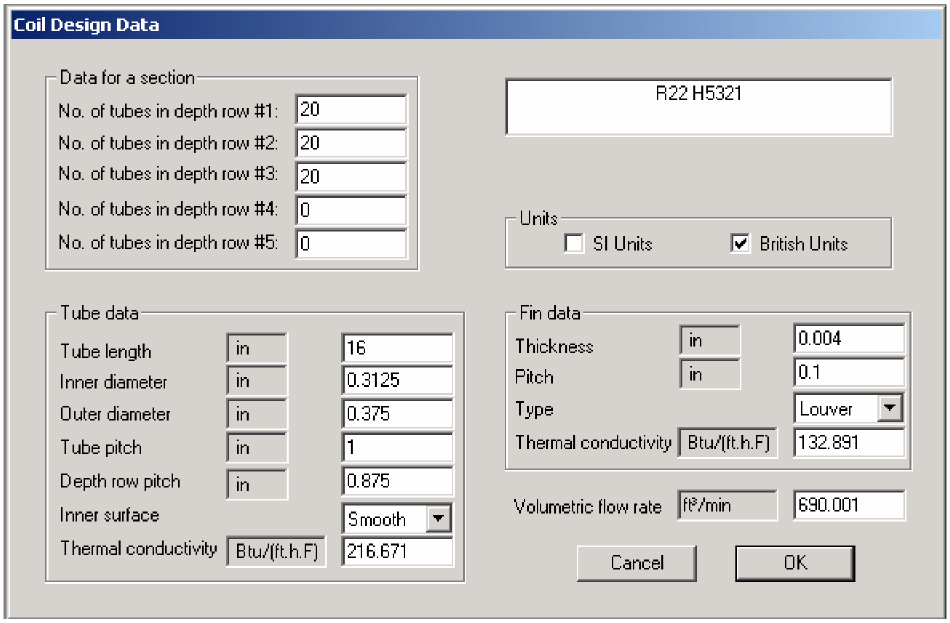
Thickness	in	0.004
Pitch	in	0.0769228
Type		Louver
Thermal conductivity	Btu/(ft.h.F)	132.891

Volumetric flow rate ft³/min 602

Coil circuitry (left or right slab)



Coil 8



Coil Design Data

Data for a section

No. of tubes in depth row #1: 20

No. of tubes in depth row #2: 20

No. of tubes in depth row #3: 20

No. of tubes in depth row #4: 0

No. of tubes in depth row #5: 0

R22 H5321

Units

☐ SI Units ☑ British Units

Tube data

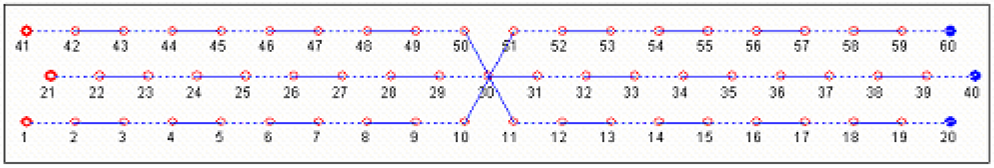
Tube length	in	16
Inner diameter	in	0.3125
Outer diameter	in	0.375
Tube pitch	in	1
Depth row pitch	in	0.875
Inner surface		Smooth
Thermal conductivity	Btu/(ft.h.F)	216.671

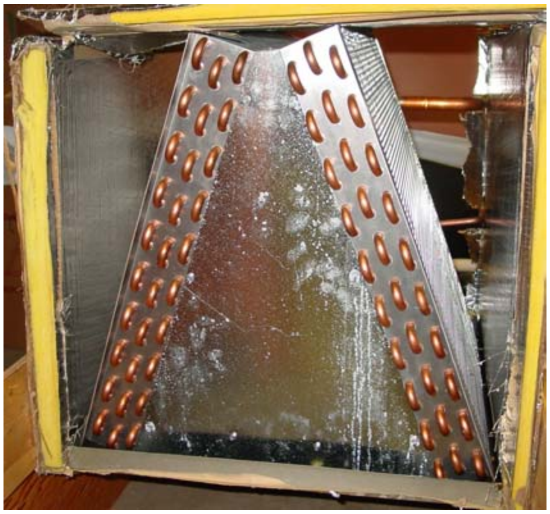
Fin data

Thickness	in	0.004
Pitch	in	0.1
Type		Louver
Thermal conductivity	Btu/(ft.h.F)	132.891

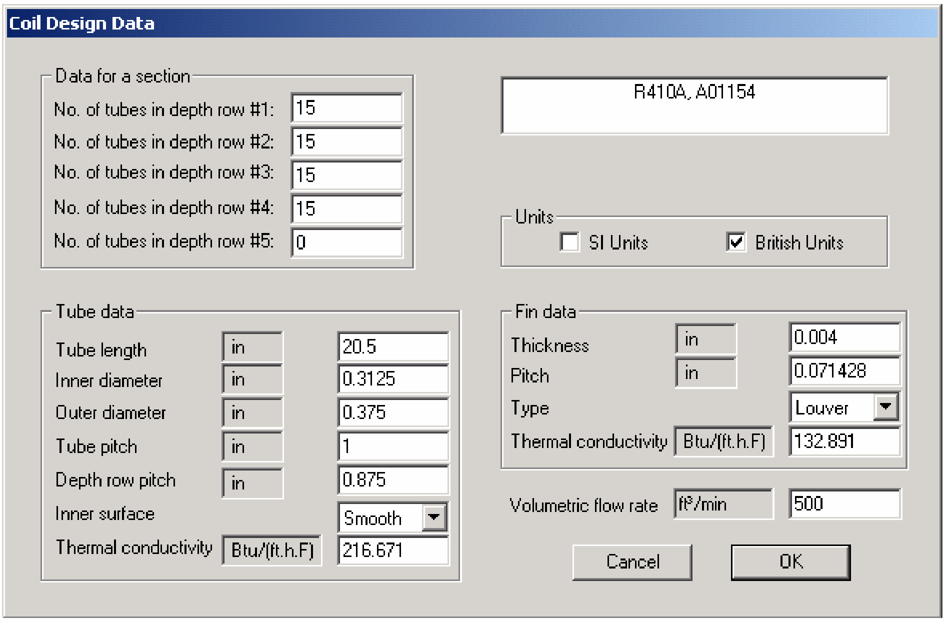
Volumetric flow rate ft³/min 690.001

Coil circuitry (left slab)





Coil 9



Coil Design Data

Data for a section

No. of tubes in depth row #1: 15

No. of tubes in depth row #2: 15

No. of tubes in depth row #3: 15

No. of tubes in depth row #4: 15

No. of tubes in depth row #5: 0

R410A, A01154

Units

☐ SI Units ☑ British Units

Tube data

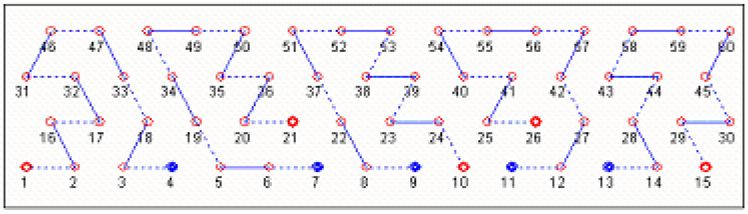
Tube length	in	20.5
Inner diameter	in	0.3125
Outer diameter	in	0.375
Tube pitch	in	1
Depth row pitch	in	0.875
Inner surface		Smooth
Thermal conductivity	Btu/(ft.h.F)	216.671

Fin data

Thickness	in	0.004
Pitch	in	0.071428
Type		Louver
Thermal conductivity	Btu/(ft.h.F)	132.891

Volumetric flow rate ft³/min 500

Coil circuitry



APPENDIX B: UNCERTAINTY ANALYSIS

A. 1 General Remarks

The uncertainty analysis was performed to gain knowledge about the uncertainty of the measured and calculated data. This Appendix presents the major equations used for the uncertainty analysis.

A. 2 Theory

The uncertainty of a quantity *R* calculated from *n* independent measurements x_i is a function of the individual uncertainty of each measurement.

$$R = f(x_1, x_2, x_3, \ldots\ldots, x_n) \tag{A.1}$$

When each measurement, x_i, has a given uncertainty, dx_i, the maximum uncertainty of *R* is given by:

$$E_R = \left|\frac{\partial f}{\partial x_1}\mathrm{d}x_1\right| + \left|\frac{\partial f}{\partial x_2}\mathrm{d}x_2\right| + \left|\frac{\partial f}{\partial x_3}\mathrm{d}x_3\right| + \ldots\ldots + \left|\frac{\partial f}{\partial x_n}\mathrm{d}x_n\right|. \tag{A.2}$$

However, using the maximum error to judge the uncertainty of a calculated quantity is not common. Usually the standard deviation (root sum square) is regarded to be a much better approach to a quantity's uncertainty.

$$E_R = \sqrt{\left(\frac{\partial f}{\partial x_1}\mathrm{d}x_1\right)^2 + \left(\frac{\partial f}{\partial x_2}\mathrm{d}x_2\right)^2 + \left(\frac{\partial f}{\partial x_3}\mathrm{d}x_3\right)^2 + \ldots\ldots + \left(\frac{\partial f}{\partial x_n}\mathrm{d}x_n\right)^2} \tag{A.3}$$

The absolute error calculated with equation (A.3) is often converted to a relative error having the units of percent.

$$e_R = \frac{E_R}{R}100 \tag{A.4}$$

A. 3 Temperature Measurements

Most of the temperature measurements performed for these tests were determined by thermocouples. Their voltage signals were measured with the data acquisition system and then converted into a temperature.

The equation used in the test rig's control program to convert the voltage signals into temperatures was a sixth degree polynomial of the form:

$$\vartheta = f(V) = \frac{9}{5}(A + BV + CV^2 + DV^3 + EV^4 + FV^5 + GV^6) + 32 \tag{A.5}$$

where:

ϑ = temperature (°F)
V = measured voltage (μV)

If one premises that the uncertainty of the equation itself can be neglected, only one derivation is needed to evaluate the uncertainty in the temperature measurements.

$$\frac{\partial \vartheta}{\partial V} = \frac{9}{5}\left(B + 2CV + 3DV^2 + 4EV^3 + 5FV^4 + 6GV^5\right) \tag{A.6}$$

According to the manufacturer of the voltmeter, the 95 % uncertainty of the voltage measurement (*VM*) was: $E_{VM} = dV(VM) = \pm 0.007\,\%\,\textit{of reading} + 5\,\mu V$.

The measurement of a temperature (ϑ) actually is the measurement of the difference to a reference temperature. The data acquisition system provided temperature compensation to 0 °C (32 °F) with a given uncertainty of: E_{TC} = dTC = ± 0.2236 °C = ± 0.4025 °F.

Rewriting equation A.3 for the measurement of the absolute temperature gives:

$$\vartheta = f(V) \tag{A.7}$$

$$E_{\mathrm{T}} = \sqrt{\left(\frac{\partial \vartheta}{\partial V}\mathrm{d}VM\right)^2 + \left(\mathrm{d}TC\right)^2} \tag{A.8}$$

In addition to the common thermocouple measurements, the dew-point temperature in the air duct was measured to evaluate the humidity ratio of the moist air in the duct.

The manufacturer of the dew-point hygrometer specified the 95 % uncertainty in this measurement to be: $E_{T_{\mathrm{dew}}} = \mathrm{d}T_{\mathrm{dew}} = \pm 0.05\,\%\,\textit{of reading}$.

A. 4 Temperature Difference Measurements

The evaluation of the uncertainty of a temperature difference ($\Delta\vartheta$) measurement using a thermopile is slightly more complicated than that for a normal temperature measurement. The uncertainty evaluation is presented using the air duct temperature difference as an example, because this shows the most complicated case. Again there are two independent uncertainties being part of the measurement uncertainty. The first is the uncertainty caused by the voltage signal measurement, discussed in section A.3. The cause for the second uncertainty influencing the measurement of a temperature difference is the nonlinear character of the temperature/voltage function (see equation A.5). The nonlinearity requires temperature at one end of the thermopile used for the temperature difference measurement to be known.

The temperature difference across the indoor coil was calculated using both the voltage signals of the temperature difference measurement (ΔV) and the average voltage signal

($V_{\text{av.}}$) of the entering temperature measurement of the air duct. The equation used to do so was:

$$\Delta\vartheta = f(V_{\text{av.}} + \Delta V) - f(V_{\text{av.}}) \tag{A.9}$$

The entering temperature was measured using 25 thermocouples equally distributed over the air duct's cross section. The average of the 25 temperature signals was considered to be the entering temperature. For the uncertainty in this average entering temperature the average voltage measurement uncertainty $E_{VM,\text{av.}}$ of the 25 measurements was calculated.

$$E_{VM,\text{av.}} = \text{d}V_{\text{av}}(VM) = \sum_{x=1}^{25} \frac{\text{d}V_{\text{av.}}(VM_x)}{25} \tag{A.10}$$

All 25 thermocouples were connected to the same temperature compensation. This means the overall uncertainty of the air's average entering temperature voltage signal $V_{\text{av.}}$ was:

$$dV_{\text{av.}} = \sqrt{{E_{VM,\text{av.}}}^2 + {E_{TC}}^2} = \sqrt{(\text{d}V_{\text{av.}}(VM))^2 + (\text{d}V_{\text{av.}}(TC))^2} \tag{A.11}$$

To evaluate equation A.11 the uncertainty in the temperature compensation must be rewritten to have the unit of μV. Using equation A.5 one finds that an uncertainty of $E_{TC} = \text{d}TC = \pm 0.2236°C = \pm\, 0.4025\ {}^{O}F$ in the temperature compensation to 0 °C (32 °F) is equivalent to a voltage signal uncertainty of $\text{d}V_{\text{av.}}(TC) = \pm\ 8.6264\ \mu V$. As already mentioned, the uncertainty of the voltage signal measurement was given from manufacturer data.

The nonlinearity of the voltage/temperature function (A.5) causes an uncertainty *dslope* in the temperature difference that depends on the uncertainty in the entering temperature voltage signal $V_{\text{av.}}$.

$$E_{slope} = \text{d}slope = \left|(\vartheta(V_{\text{av.}} + dV) - \vartheta(V_{\text{av.}}))\right.$$

$$\left. - (\vartheta(V_{\text{av.}} + \text{d}V_{\text{av.}} + \Delta V) - \vartheta(V_{\text{av.}} + \text{d}V_{\text{av.}}))\right| \tag{A.12}$$

where:

$V_{\text{av.}}$ = entering temperature voltage signal (μV)
$\text{d}V_{\text{av.}}$ = uncertainty of the entering temperature voltage signal (μV)
ΔV = temperature difference voltage signal (μV)

Remembering that an additional uncertainty in the temperature difference is caused by the voltage measurement of the temperature difference voltage signal (ΔV), the uncertainty of the air duct temperature difference is given to be:

$$E_{\Delta\vartheta} = \mathrm{d}\Delta\vartheta = \left[\left(\frac{\partial\vartheta}{\partial V}\mathrm{d}\Delta V\right)^2 + \mathrm{d}slope^2\right]^{1/2} \tag{A.13}$$

A. 5 Uncertainty of the Air Side Capacity

The air side capacity of the heat pump was evaluated using the equation:

$$\dot{Q}_\mathrm{C} = \dot{Q}_\mathrm{S} + \dot{Q}_\mathrm{L} \tag{A.14}$$

where:

$\dot{Q}_\mathrm{S}$ = sensible capacity, kW (*Btu/h*)

$\dot{Q}_\mathrm{L}$ = latent capacity, kW (*Btu/h*)

The sensible capacity is the heat needed to cool or heat the moist air passing the heat pump's indoor coil. The latent capacity is the heat rejected by water vapor condensing on the air coil. Condensation does not occur in the heating mode.

The two different capacities were calculated separately and then added (A.14). Therefore the uncertainty of the air-side capacity can be written as:

$$E_{\dot{Q}_\mathrm{C}} = \left[\left(\frac{\partial\dot{Q}_\mathrm{C}}{\partial\dot{Q}_\mathrm{S}}\mathrm{d}\dot{Q}_\mathrm{S}\right)^2 + \left(\frac{\partial\dot{Q}_\mathrm{C}}{\partial\dot{Q}_\mathrm{L}}\mathrm{d}\dot{Q}_\mathrm{L}\right)^2\right]^{1/2} = \left(\mathrm{d}\dot{Q}_\mathrm{S}{}^2 + \mathrm{d}\dot{Q}_\mathrm{L}{}^2\right)^{1/2} \tag{A.15}$$

The equations for both the sensible and latent capacities and their uncertainties are presented on the following pages.

A. 5. 1 Uncertainty of the Sensible Capacity

According to ASHRAE Standard 116-1993 the sensible capacity Q_S is given by:

$$\dot{Q}_\mathrm{S} = 3600 C_\mathrm{D} A_\mathrm{n}\left(0.24 + 0.444 W_\mathrm{av.}\right)\left(\vartheta_\mathrm{l} - \vartheta\right)_\mathrm{e}\left[\frac{2 g_\mathrm{C}\,\Delta p_\mathrm{n}\,\rho_\mathrm{nact}}{144\left(1-\beta^2\right)}\right]^{1/2} \tag{A.16}$$

where:

C_D = nozzle discharge coefficient (0.986)

A_n = nozzle throat area, m^2 (ft^2)

$W_\mathrm{av.}$ = $(W_\mathrm{e} + W_\mathrm{l}) / 2$ average humidity ratio, kg H_2O/ kg dry air (*lb* H_2O*/lb dry air*)

$\vartheta_\mathrm{l} - \vartheta_\mathrm{e}$ = indoor coil air temperature rise, °C ($^\mathrm{O}F$)

g_C = gravity constant (32.174 $ft \cdot lb_\mathrm{m} / lb_\mathrm{f} \cdot s^2$)

Δp_n = static pressure drop across nozzle, kPa (*psia*)

ρ_nact = density of the moist air, kg/m^3 (lb / ft^3)

144 = unit conversion factor from in^2 to ft^2
β = area relation factor (0.250723)

The partial derivatives required for the uncertainty analysis of Q_S are:

$$\frac{\partial \dot{Q}_S}{\partial A_n} = 3600 C_D \left(0.24 + 0.444 W_{av.}\right)\left(\vartheta_l - \vartheta_e\right)\left[\frac{2 g_C \,\Delta p_n \,\rho_{nact}}{144\left(1-\beta^2\right)}\right]^{1/2} \tag{A.17}$$

$$\frac{\partial \dot{Q}_S}{\partial W_e} = 1800 C_D \, A_n \, 0.444\left(\vartheta_l - \vartheta_e\right)\left[\frac{2 g_C \,\Delta p_n \,\rho_{nact}}{144\left(1-\beta^2\right)}\right]^{1/2} \tag{A.18}$$

$$\frac{\partial \dot{Q}_S}{\partial W_l} = 1800 C_D \, A_n \, 0.444\left(\vartheta_l - \vartheta_e\right)\left[\frac{2 g_C \,\Delta p_n \,\rho_{nact}}{144\left(1-\beta^2\right)}\right]^{1/2} \tag{A.19}$$

$$\frac{\partial \dot{Q}_S}{\partial\left(\vartheta_l - \vartheta_e\right)} = 3600 C_D \, A_n \left(0.24 + 0.444 W_{av.}\right)\left[\frac{2 g_C \,\Delta p_n \,\rho_{nact}}{144\left(1-\beta^2\right)}\right]^{1/2} \tag{A.20}$$

$$\frac{\partial \dot{Q}_S}{\partial \Delta p_n} = 1800 C_D \, A_n \left(0.24 + 0.444 W_{av.}\right)\left(\vartheta_l - \vartheta_e\right)\left[\frac{2 g_C \,\rho_{nact}}{144\left(1-\beta^2\right)\Delta p_n}\right]^{1/2} \tag{A.21}$$

$$\frac{\partial \dot{Q}_S}{\partial \rho_{nact}} = 1800 C_D \, A_n \left(0.24 + 0.444 W_{av.}\right)\left(\vartheta_l - \vartheta_e\right)\left[\frac{2 g_C \,\Delta p_n}{144\left(1-\beta^2\right)\rho_{nact}}\right]^{1/2} \tag{A.22}$$

$$\frac{\partial \dot{Q}_S}{\partial \beta} = 3600 C_D \, A_n \left(0.24 + 0.444 W_{av.}\right)\left(\vartheta_l - \vartheta_e\right)\beta\left[\frac{2 g_C \,\Delta p_n \,\rho_{nact}}{144\left(1-\beta^2\right)^3}\right]^{1/2} \tag{A.23}$$

Using the above partial derivatives for rewriting equation A.3 gives:

$$\begin{aligned} E_{Q_S} = \Bigg[& \left(\frac{\partial \dot{Q}_S}{\partial A_n} \mathrm{d}A_n\right)^2 + \left(\frac{\partial \dot{Q}_S}{\partial W_e} \mathrm{d}W_e\right)^2 + \left(\frac{\partial \dot{Q}_S}{\partial W_l} \mathrm{d}W_l\right)^2 + \left(\frac{\partial \dot{Q}_S}{\partial \Delta p_n} \mathrm{d}\Delta p_n\right)^2 + \\ & + \left(\frac{\partial \dot{Q}_S}{\partial (\vartheta_l - \vartheta_e)} \mathrm{d}(\vartheta_l - \vartheta_e)\right)^2 + \left(\frac{\partial \dot{Q}_S}{\partial \rho_{nact}} \mathrm{d}\rho_{nact}\right)^2 + \left(\frac{\partial \dot{Q}_S}{\partial \beta} \mathrm{d}\beta\right)\Bigg]^{1/2} \end{aligned} \tag{A.24}$$

Equation A.24 can be evaluated to give the uncertainty of $\dot{Q}_S$ if each of the individual uncertainties is known. However, A, β , W_e , W_l and ρ_{nact} are calculated quantities, so their uncertainties were not known, but had to be calculated using equation A.3.

The flow in the air duct was measured using a venturi tube measurement. The nozzle throat area A_n, which is part of equation A.16, was calculated from the throat diameter. Thus its uncertainty can be evaluated very easily.

$$A_n = \frac{\pi d_n^{\ 2}}{4} \tag{A.25}$$

$$E_{A_n} = \frac{\partial A_n}{\partial d_n} \mathrm{d}d_n = \frac{\pi d_n}{2} \mathrm{d}d_n \tag{A.26}$$

The uncertainty of the throat diameter was given to be: $E_{dn} = dd_n = \pm 0.254$ mm = ± 0.01 in.

The area ratio factor β was calculated using the equation:

$$\beta = \frac{A_n}{A_{en}} = \frac{d_n^{\ 2}}{d_{en}^{\ 2}} \tag{A.27}$$

Again, both areas were calculated using their diameter given by the manufacturer of the venturi tube. The partial derivatives used to evaluate the uncertainty in β were:

$$\frac{\partial \beta}{\partial d_n} = 2 \frac{d_n}{d_{en}^{\ 2}} \tag{A.28}$$

$$\frac{\partial \beta}{\partial d_{en}} = -2 \frac{d_n^{\ 2}}{d_{en}^{\ 3}} \tag{A.29}$$

Using these derivatives to rewrite A.3 gives:

$$E_\beta = \left[\left(2 \left(d_n \middle/ d_{en}^{\ 2} \right) \mathrm{d}d_n \right)^2 + \left(-2 \left(d_n^{\ 2} \middle/ d_{en}^{\ 3} \right) \mathrm{d}d_{en} \right)^2 \right]^{1/2} \tag{A.30}$$

The required uncertainty in the inlet diameter was also $\mathrm{E}_{\mathrm{d}_{\mathrm{en}}} = \mathrm{dd}_{\mathrm{en}} = \pm 0.254 \text{ mm} = \pm\ 0.01 \text{ in}$.

The humidity ratios W_e and W_l are a function of the water vapor pressure p_w and the atmospheric pressure p.

$$W = 0.62198 \frac{p_w}{p - p_w} \tag{A.31}$$

The factor 0.62198 comes from the ratio of the mole weights of the two components, water and air.

The required partial derivatives of equation A.31 are:

$$\frac{\partial W}{\partial p} = 0.62198 \frac{p_w}{(p - p_w)^2} \tag{A.32}$$

$$\frac{\partial W}{\partial p_w} = 0.62198 \frac{p}{(p - p_w)^2} \tag{A.33}$$

They lead to the uncertainty in *W*:

$$E_W = dW = \left[\left(\frac{\partial W}{\partial p} \mathrm{d}p \right)^2 + \left(\frac{\partial W}{\partial p_w} \mathrm{d}p_w \right)^2 \right]^{1/2} \tag{A.34}$$

Unfortunately the water saturation pressure is a calculated quantity itself, which means its uncertainty had to be calculated.

The equation that was used to calculate the saturation pressure from the dew-point temperature, T_{dew}, (°R), is given below. The equation was assumed to cause no additional uncertainties.

$$p_w = EXP\left[\frac{C_8}{T_{\mathrm{dew}}} + C_9 + C_{10} T_{\mathrm{dew}} + C_{11} T_{\mathrm{dew}}{}^2 + C_{12} T_{\mathrm{dew}}{}^3 + C_{13} \ln T_{\mathrm{dew}} \right] \tag{A.35}$$

The partial derivative of equation A.35 with respect to T_{dew} is:

$$\frac{\partial p_w}{\partial T_{\mathrm{dew}}} = \left[\frac{-C_8}{T_{\mathrm{dew}}{}^2} + C_{10} + 2C_{11} T_{\mathrm{dew}} + 3C_{12} T_{\mathrm{dew}}{}^2 + \frac{C_{13}}{T_{\mathrm{dew}}} \right] p_w \tag{A.36}$$

The uncertainty in p_W is now given by:

$$E_{p_w} = \mathrm{d}p_w = \frac{\partial p_w}{\partial T_{\mathrm{dew}}} \mathrm{d}T_{\mathrm{dew}} \tag{A.37}$$

As already mentioned in section A.3, the uncertainty of the dew-point temperature measurement was given to be: $\mathrm{E}_{\mathrm{T}_{\mathrm{dew}}} = \mathrm{dT}_{\mathrm{dew}} = \pm 0.05\,\%\ \text{of reading}$.

Finally, the uncertainty in the moist air's density ρ_{nact} had to be evaluated. The density was calculated using the ideal gas equation and the humidity ratio.

$$\rho_{\mathrm{nact}} = \frac{p_n 144(1 + W)}{R_a T_n (1 + 1.6078W)} \tag{A.38}$$

The factor 1.6078 is the ratio of the molar weights of air and water.

The partial derivatives of the A.38 are:

$$\frac{\partial \rho_{\text{nact}}}{\partial p_{\text{n}}} = \frac{144(1+W)}{RT_{\text{n}}(1+1.6078W)} \tag{A.39}$$

$$\frac{\partial \rho_{\text{nact}}}{\partial T_{\text{n}}} = \frac{-p_{\text{n}}144(1+W)}{RT_{\text{n}}^{2}(1+1.6078W)} \tag{A.40}$$

$$\frac{\partial \rho_{\text{nact}}}{\partial W} = \frac{-0.6078p_{\text{n}}144}{RT_{\text{n}}(1+1.6078W)^{2}} \tag{A.41}$$

Rewriting equation A.3 with the above partial derivatives gives:

$$E_{\rho_{\text{nact}}} = \left[\left(\frac{\partial \rho_{\text{nact}}}{\partial \text{p}_{\text{n}}}\text{d}p_{\text{n}}\right)^{2} + \left(\frac{\partial \rho_{\text{nact}}}{\partial T_{\text{n}}}\text{d}T_{\text{n}}\right)^{2} + \left(\frac{\partial \rho_{\text{nact}}}{\partial W}\text{d}W\right)^{2}\right] \tag{A.42}$$

The pressure p_{n} in the nozzle throat was calculated as the difference of atmospheric pressure and nozzle pressure drop. The uncertainty of the nozzle pressure can be derived as follows:

$$p_{\text{n}} = p_{\text{atm}} - \Delta p \tag{A.43}$$

$$E_{p_{\text{n}}} = \text{d}p_{\text{n}} = \left[(\text{d}p_{\text{atm}})^{2} + (\text{d}\Delta p)^{2}\right]^{1/2} \tag{A.44}$$

The uncertainties of the pressure measurements were given from manufacturer data: $\text{E}_{\text{p}_{\text{atm}}} = \text{dp}_{\text{atm}} = \pm 0.3429\,\text{mmHg} = \pm\,0.0135\text{ in Hg}$ and $\text{E}_{\text{Dp}_{\text{n}}} = \text{dDp}_{\text{n}} = \pm 2.489\text{ mmH}_2\text{O} = \pm\,0.098\text{ in H}_2\text{O}$.

A. 5. 2 Uncertainty of the Latent Capacity

The latent cooling capacity (ASHRAE Standard 116-1983) is given by:

$$\dot{\text{Q}}_{\text{L}} = 6360060C_{\text{D}}A_{\text{n}}(W_{\text{e}} - W_{\text{l}})\left[\frac{2g_{\text{C}}\,\Delta p_{\text{n}}\,\rho_{\text{nact}}}{144(1-\beta^{2})}\right]^{1/2} \tag{A.44}$$

where:

C_{D} = nozzle discharge coefficient (0.986)
A_{n} = nozzle throat area (ft^2)
W_{e} = entering humidity ratio (lb H_2O/lb dry air)
W_{l} = leaving humidity ratio (lb H_2O/lb dry air)
g_{C} = gravity constant (32.174 $\text{ft}\cdot\text{lb}_{\text{m}}/\text{lb}_{\text{f}}\cdot\text{s}^2$)
Δp_{n} = static pressure drop across nozzle (psia)

ρ_nact = density of the moist air ($\mathrm{lb} / \mathrm{ft}^3$)
144 = unit conversion factor from in^2 to ft^2
β = area relation factor (0.250723)

The partial derivatives of this equation are:

$$\frac{\partial \dot{\mathrm{Q}}_\mathrm{L}}{\partial A_\mathrm{n}} = 6360060 C_\mathrm{D} \left(W_\mathrm{e} - W\right)_\mathrm{l} \left[\frac{2 g_\mathrm{C}\, \Delta p_\mathrm{n}\, \rho_\mathrm{nact}}{144\left(1-\beta^2\right)}\right]^{1/2} \tag{A.45}$$

$$\frac{\partial \dot{\mathrm{Q}}_\mathrm{L}}{\partial W_\mathrm{e}} = 6360060 C_\mathrm{D}\, A_\mathrm{n} \left[\frac{2 g_\mathrm{C}\, \Delta p_\mathrm{n}\, \rho_\mathrm{nact}}{144\left(1-\beta^2\right)}\right]^{1/2} \tag{A.46}$$

$$\frac{\partial \dot{\mathrm{Q}}_\mathrm{L}}{\partial W_\mathrm{l}} = -6360060 C_\mathrm{D}\, A_\mathrm{n} \left[\frac{2 g_\mathrm{C}\, \Delta p_\mathrm{n}\, \rho_\mathrm{nact}}{144\left(1-\beta^2\right)}\right]^{1/2} \tag{A.47}$$

$$\frac{\partial \dot{\mathrm{Q}}_\mathrm{L}}{\partial \Delta p_\mathrm{n}} = 3180060 C_\mathrm{D}\, A_\mathrm{n} \left(W_\mathrm{e} - W_l\right) \left[\frac{2 g_\mathrm{C}\, \rho_\mathrm{nact}}{144\left(1-\beta^2\right)\Delta p_\mathrm{n}}\right]^{1/2} \tag{A.48}$$

$$\frac{\partial \dot{\mathrm{Q}}_\mathrm{L}}{\partial \rho_\mathrm{nact}} = 3180060 C_\mathrm{D}\, A_\mathrm{n} \left(W_\mathrm{e} - W\right)_\mathrm{l} \left[\frac{2 g_\mathrm{C}\, \Delta p_\mathrm{n}}{144\left(1-\beta^2\right)\rho_\mathrm{nact}}\right]^{1/2} \tag{A.49}$$

$$\frac{\partial \dot{\mathrm{Q}}_\mathrm{L}}{\partial \beta} = 6360060 C_\mathrm{D}\, A_\mathrm{n} \left(W_\mathrm{e} - W_\mathrm{l}\right)\beta \left[\frac{2 g_\mathrm{C}\, \Delta p_\mathrm{n}\, \rho_\mathrm{nact}}{144\left(1-\beta^2\right)^3}\right]^{1/2} \tag{A.50}$$

If the above derivatives are used to rewrite equation A.3, one obtains the uncertainty of the latent capacity:

$$\begin{aligned} E_{\mathrm{Q_L}} = \Bigg[& \left(\frac{\partial \dot{\mathrm{Q}}_\mathrm{L}}{\partial A_\mathrm{n}} \mathrm{d}A_\mathrm{n}\right)^2 + \left(\frac{\partial \dot{\mathrm{Q}}_\mathrm{L}}{\partial W_\mathrm{e}} \mathrm{d}W_\mathrm{e}\right)^2 + \left(\frac{\partial \dot{\mathrm{Q}}_\mathrm{L}}{\partial W_\mathrm{l}} \mathrm{d}W_\mathrm{l}\right)^2 + \\ & + \left(\frac{\partial \dot{\mathrm{Q}}_\mathrm{L}}{\partial \Delta p_\mathrm{n}} \mathrm{d}\Delta p_\mathrm{n}\right)^2 + \left(\frac{\partial \dot{\mathrm{Q}}_\mathrm{L}}{\partial \rho_\mathrm{nact}} \mathrm{d}\rho_\mathrm{nact}\right)^2 + \left(\frac{\partial \dot{\mathrm{Q}}_\mathrm{L}}{\partial \beta} \mathrm{d}\beta\right)^2 \Bigg]^{1/2} \end{aligned} \tag{A.51}$$

In this equation, all the needed uncertainties are known. Either because the quantities are directly measured or their uncertainties have already been calculated in Appendix A.4.1.

The final step was calculating the uncertainty of the air side capacity by using the now known uncertainties of sensible and latent capacity in equation A.15.

APPENDIX C: COOLING MEASUREMENT SUMMARY SHEETS

Coil 1

R22, A01102, No Fan

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a031216a.dat   SUMMARY FILENAME: a031216a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 35172.37  1870.22
    Indoor Dry-Bulb : 79.847   0.35    Sensible Cap (Btu/h): 27501.92   541.05
Indoor Inlet Dew (F): 60.414   0.55      Latent Cap (Btu/h):  7670.45  1669.75
Indoor Exit Dry-Bulb: 57.177   0.59     EvapAir Delta T (F):  24.64     0.44
 Indoor Exit Dew (F): 56.227   0.95  Air/Ref Cap Prcnt Diff:   3.16     7.82
                                        Sensible Heat Ratio:   0.782    0.0357
 Indoor Airflow (CFM):  995.24   7.59          SCFM per Ton:  345.94
Indoor Airflow (SCFM): 1013.97   7.68      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011194
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009608
 Barometric Pressure (in HG):  29.96       Nozzle Temp (F):  56.87   0.55
   Air Chamber Nozzle Pressure Drop (in Water):  1.332    0.020
  Evaporator Coil Air Pressure Drop (in Water):  0.200    0.007
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  258.17    3.898       Ref-side Cap (Btu/h) : 36280.23  2439.34
        Upstream Temp (F):  106.25    0.476         Ref-side Cap (tons):     3.02     0.20
                                               Refrigerant Mdot (lbm/h):   575.01    39.17
                                             Coriolis Density (lbm/ft3):    82.26     0.77
    Upstream R22 Tsat (F):  115.23    1.159
   Average Subcooling (F):    8.98    1.231

Evap Exit Pressure (psia):   94.11    1.213
     Evap Exit Avg Temp  :   57.64    4.189
       Exit Superheat (F):   10.52    3.862
       Evap Exit Tsat (F):   47.13    0.761
```

```
               DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a031218a.dat   SUMMARY FILENAME: a031218a.sum
                                                                  Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 38226.98  1139.85
    Indoor Dry-Bulb : 80.193   0.40    Sensible Cap (Btu/h): 29108.93   735.90
Indoor Inlet Dew (F): 60.613   0.63      Latent Cap (Btu/h):  9118.05   921.08
Indoor Exit Dry-Bulb: 55.959   1.09     EvapAir Delta T (F):  26.11     0.66
 Indoor Exit Dew (F): 55.653   0.55  Air/Ref Cap Prcnt Diff:   4.70     2.57
                                        Sensible Heat Ratio:   0.761    0.0210
 Indoor Airflow (CFM): 1001.86  17.80          SCFM per Ton:  317.85
Indoor Airflow (SCFM): 1012.53  17.34      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011395
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009507
 Barometric Pressure (in HG):  29.65       Nozzle Temp (F):  55.66   0.92
   Air Chamber Nozzle Pressure Drop (in Water):  1.339    0.046
  Evaporator Coil Air Pressure Drop (in Water):  0.211    0.006
--------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  269.72    2.680       Ref-side Cap (Btu/h) : 40021.38  1132.54
        Upstream Temp (F):  104.33    0.781         Ref-side Cap (tons):     3.34     0.09
                                                 Refrigerant Mdot (lbm/h):   628.23    17.22
                                               Coriolis Density (lbm/ft3):    81.73     0.52
    Upstream R22 Tsat (F):  118.61    0.771
   Average Subcooling (F):   14.27    0.991

Evap Exit Pressure (psia):   91.05    1.456
     Evap Exit Avg Temp  :   56.59    2.244
       Exit Superheat (F):   11.41    1.933
       Evap Exit Tsat (F):   45.18    0.937
```

```
              DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a031218b.dat   SUMMARY FILENAME: a031218b.sum
                                                                 Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 28751.99  1236.15
    Indoor Dry-Bulb : 80.040   0.64    Sensible Cap (Btu/h): 23904.52   675.89
Indoor Inlet Dew (F): 60.201   0.85      Latent Cap (Btu/h):  4847.46  1439.20
Indoor Exit Dry-Bulb: 60.446   0.55     EvapAir Delta T (F):  21.55     0.65
 Indoor Exit Dew (F): 57.614   0.40  Air/Ref Cap Prcnt Diff:   1.70    10.06
                                        Sensible Heat Ratio:   0.831    0.0432
 Indoor Airflow (CFM): 1004.88  19.23          SCFM per Ton:  420.26
Indoor Airflow (SCFM): 1006.94  18.75      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011227
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010217
 Barometric Pressure (in HG):  29.65       Nozzle Temp (F):  59.90   0.78
   Air Chamber Nozzle Pressure Drop (in Water):  1.336    0.050
  Evaporator Coil Air Pressure Drop (in Water):  0.186    0.006
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  263.16    3.898       Ref-side Cap (Btu/h) : 29238.19  2647.34
        Upstream Temp (F):  106.15    0.476         Ref-side Cap (tons):     2.44     0.22
                                                Refrigerant Mdot (lbm/h):   463.18    41.95
                                              Coriolis Density (lbm/ft3):    82.34     0.44
   Upstream R22 Tsat (F):  116.70    1.142
  Average Subcooling (F):   10.55    1.129

Evap Exit Pressure (psia):   97.30    1.092
     Evap Exit Avg Temp  :   60.43    4.243
       Exit Superheat (F):   11.32    4.689
       Evap Exit Tsat (F):   49.11    0.668
```

```
                DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
          DATA FILENAME: a040105a.dat   SUMMARY FILENAME: a040105a.sum
                                                                      Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 42951.53  1660.25
    Indoor Dry-Bulb : 80.221   0.58    Sensible Cap (Btu/h): 31907.84  1084.17
Indoor Inlet Dew (F): 60.321   0.90      Latent Cap (Btu/h): 11043.69  1769.65
Indoor Exit Dry-Bulb: 53.609   0.78     EvapAir Delta T (F):  28.59     0.88
 Indoor Exit Dew (F): 54.113   0.58  Air/Ref Cap Prcnt Diff:   4.12     6.78
                                    Sensible Heat Ratio:   0.743    0.0319
 Indoor Airflow (CFM):  994.75  11.31          SCFM per Ton:  283.38
Indoor Airflow (SCFM): 1014.32  11.62      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011218
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.008935
 Barometric Pressure (in HG):  29.80       Nozzle Temp (F):  53.84   1.11
   Air Chamber Nozzle Pressure Drop (in Water):  1.332    0.030
  Evaporator Coil Air Pressure Drop (in Water):  0.233    0.010
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  247.77    3.289       Ref-side Cap (Btu/h) : 44718.18  2028.31
        Upstream Temp (F):  103.08    0.651         Ref-side Cap (tons):     3.73     0.17
                                             Refrigerant Mdot (lbm/h):   697.60    32.61
                                           Coriolis Density (lbm/ft3):    81.39     0.58
    Upstream R22 Tsat (F):  112.09    1.010
   Average Subcooling (F):    9.01    1.335

Evap Exit Pressure (psia):   82.17    1.334
     Evap Exit Avg Temp  :   55.72    4.586
       Exit Superheat (F):   16.47    4.310
       Evap Exit Tsat (F):   39.25    0.928
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040106a.dat   SUMMARY FILENAME: a040106a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 29066.22  1028.82
    Indoor Dry-Bulb : 80.127   0.53    Sensible Cap (Btu/h): 23807.89  1479.10
Indoor Inlet Dew (F): 60.391   1.19      Latent Cap (Btu/h):  5258.33  1463.71
Indoor Exit Dry-Bulb: 60.618   0.78     EvapAir Delta T (F):  21.40     1.30
 Indoor Exit Dew (F): 57.586   0.55  Air/Ref Cap Prcnt Diff:  -0.33     7.26
                                        Sensible Heat Ratio:   0.819    0.0450
 Indoor Airflow (CFM): 1003.02  11.71          SCFM per Ton:  417.11
Indoor Airflow (SCFM): 1010.32  11.26      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011239
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010148
 Barometric Pressure (in HG):  29.82       Nozzle Temp (F):  60.17   0.69
   Air Chamber Nozzle Pressure Drop (in Water):  1.337    0.030
  Evaporator Coil Air Pressure Drop (in Water):  0.205    0.006
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  277.93    2.680       Ref-side Cap (Btu/h) : 28969.38  2550.83
        Upstream Temp (F):  106.41    1.016         Ref-side Cap (tons):     2.41     0.21
                                               Refrigerant Mdot (lbm/h):   459.52    39.02
                                             Coriolis Density (lbm/ft3):    82.58     0.25
    Upstream R22 Tsat (F):  120.95    0.754
   Average Subcooling (F):   14.53    1.221

Evap Exit Pressure (psia):   97.68    1.092
     Evap Exit Avg Temp  :   60.34    6.253
       Exit Superheat (F):   11.01    5.661
       Evap Exit Tsat (F):   49.33    0.666
```

```
                    DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040106b.dat   SUMMARY FILENAME: a040106b.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 43160.68  1322.97
    Indoor Dry-Bulb : 80.200   0.56    Sensible Cap (Btu/h): 31693.62  1212.47
Indoor Inlet Dew (F): 60.615   0.79      Latent Cap (Btu/h): 11467.06  1103.23
Indoor Exit Dry-Bulb: 53.835   0.82     EvapAir Delta T (F):  28.28     0.88
 Indoor Exit Dew (F): 54.234   0.88  Air/Ref Cap Prcnt Diff:   3.83     7.30
                                        Sensible Heat Ratio:   0.734    0.0240
 Indoor Airflow (CFM):  998.32   8.90          SCFM per Ton:  283.18
Indoor Airflow (SCFM): 1018.50   9.47      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011330
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.008969
 Barometric Pressure (in HG):  29.82       Nozzle Temp (F):  53.90   0.79
   Air Chamber Nozzle Pressure Drop (in Water):  1.342    0.024
  Evaporator Coil Air Pressure Drop (in Water):  0.227    0.006
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  256.74    6.334       Ref-side Cap (Btu/h) : 44811.32  2412.50
        Upstream Temp (F):  105.66    1.212         Ref-side Cap (tons):     3.73     0.20
                                               Refrigerant Mdot (lbm/h):   708.12    37.74
                                             Coriolis Density (lbm/ft3):    82.23     0.65
    Upstream R22 Tsat (F):  114.80    1.885
   Average Subcooling (F):    9.14    1.941

Evap Exit Pressure (psia):   83.48    1.698
     Evap Exit Avg Temp  :   55.55    6.429
       Exit Superheat (F):   15.39    6.523
       Evap Exit Tsat (F):   40.16    1.166
```

```
                     DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040106c.dat   SUMMARY FILENAME: a040106c.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 37684.76  2294.76
    Indoor Dry-Bulb : 80.306   0.53    Sensible Cap (Btu/h): 29012.99  1198.92
Indoor Inlet Dew (F): 60.153   1.06      Latent Cap (Btu/h):  8671.77  1663.84
Indoor Exit Dry-Bulb: 56.339   0.90     EvapAir Delta T (F):  25.92     0.88
 Indoor Exit Dew (F): 55.373   0.66  Air/Ref Cap Prcnt Diff:   1.68     6.76
                                        Sensible Heat Ratio:   0.770    0.0305
 Indoor Airflow (CFM): 1001.35  10.45          SCFM per Ton:  323.93
Indoor Airflow (SCFM): 1017.26   9.57      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011142
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009355
 Barometric Pressure (in HG):  29.82       Nozzle Temp (F):  55.99   0.88
   Air Chamber Nozzle Pressure Drop (in Water):  1.344    0.027
  Evaporator Coil Air Pressure Drop (in Water):  0.217    0.005
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  261.11    2.680       Ref-side Cap (Btu/h) : 38311.76  1857.38
        Upstream Temp (F):  105.03    1.061         Ref-side Cap (tons):     3.19     0.15
                                               Refrigerant Mdot (lbm/h):   603.49    30.41
                                             Coriolis Density (lbm/ft3):    82.11     0.52
    Upstream R22 Tsat (F):  116.10    0.790
   Average Subcooling (F):   11.07    0.938

Evap Exit Pressure (psia):   89.86    1.456
     Evap Exit Avg Temp  :   57.73    3.112
       Exit Superheat (F):   13.31    2.874
       Evap Exit Tsat (F):   44.42    0.945
```

Coil 2
R22, A01070, No Fan

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040116a.dat   SUMMARY FILENAME: a040116a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 20154.12   719.94
    Indoor Dry-Bulb : 79.789   0.60    Sensible Cap (Btu/h): 17010.06   488.46
Indoor Inlet Dew (F): 60.417   0.50      Latent Cap (Btu/h):  3144.06   761.03
Indoor Exit Dry-Bulb: 62.508   0.74     EvapAir Delta T (F):  19.09     0.44
 Indoor Exit Dew (F): 58.360   0.40  Air/Ref Cap Prcnt Diff:   1.37     3.74
                                        Sensible Heat Ratio:   0.844    0.0335
 Indoor Airflow (CFM):  809.55   6.98          SCFM per Ton:  481.49
Indoor Airflow (SCFM):  808.66   7.38      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011315
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010499
 Barometric Pressure (in HG):  29.65       Nozzle Temp (F):  61.60   0.91
   Air Chamber Nozzle Pressure Drop (in Water):  0.866    0.015
  Evaporator Coil Air Pressure Drop (in Water):  0.075    0.005
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  262.38    1.340       Ref-side Cap (Btu/h) : 20429.82   535.58
        Upstream Temp (F):  103.41    0.677         Ref-side Cap (tons):     1.70     0.04
                                               Refrigerant Mdot (lbm/h):   319.23     9.16
                                             Coriolis Density (lbm/ft3):    81.95     0.16
    Upstream R22 Tsat (F):  116.47    0.394
   Average Subcooling (F):   13.06    0.505

Evap Exit Pressure (psia):   90.62    0.485
     Evap Exit Avg Temp  :   59.63    1.905
       Exit Superheat (F):   14.72    2.148
       Evap Exit Tsat (F):   44.91    0.313
```

```
          DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040116a.dat   SUMMARY FILENAME: a040116a.sum
                                                                    Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 20154.12   719.94
    Indoor Dry-Bulb : 79.789   0.60    Sensible Cap (Btu/h): 17010.06   488.46
Indoor Inlet Dew (F): 60.417   0.50      Latent Cap (Btu/h):  3144.06   761.03
Indoor Exit Dry-Bulb: 62.508   0.74     EvapAir Delta T (F):  19.09     0.44
 Indoor Exit Dew (F): 58.360   0.40  Air/Ref Cap Prcnt Diff:   1.37     3.74
                                        Sensible Heat Ratio:   0.844    0.0335
 Indoor Airflow (CFM):  809.55   6.98          SCFM per Ton:  481.49
Indoor Airflow (SCFM):  808.66   7.38      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011315
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010499
 Barometric Pressure (in HG):  29.65       Nozzle Temp (F):  61.60   0.91
   Air Chamber Nozzle Pressure Drop (in Water):  0.866    0.015
  Evaporator Coil Air Pressure Drop (in Water):  0.075    0.005
--------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  262.38    1.340       Ref-side Cap (Btu/h) : 20429.82   535.58
        Upstream Temp (F):  103.41    0.677         Ref-side Cap (tons):     1.70     0.04
                                                Refrigerant Mdot (lbm/h):   319.23     9.16
                                              Coriolis Density (lbm/ft3):    81.95     0.16
    Upstream R22 Tsat (F):  116.47    0.394
   Average Subcooling (F):   13.06    0.505

Evap Exit Pressure (psia):   90.62    0.485
     Evap Exit Avg Temp  :   59.63    1.905
       Exit Superheat (F):   14.72    2.148
       Evap Exit Tsat (F):   44.91    0.313
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040116b.dat   SUMMARY FILENAME: a040116b.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 12918.77   789.67
    Indoor Dry-Bulb : 79.796   0.56    Sensible Cap (Btu/h): 12648.04   554.30
Indoor Inlet Dew (F): 60.435   0.84      Latent Cap (Btu/h):   270.73  1125.53
Indoor Exit Dry-Bulb: 67.321   0.86     EvapAir Delta T (F):  14.26     0.65
 Indoor Exit Dew (F): 60.263   0.66  Air/Ref Cap Prcnt Diff:   1.07     6.01
                                        Sensible Heat Ratio:   0.979    0.0856
 Indoor Airflow (CFM):  813.14   9.68          SCFM per Ton:  747.34
Indoor Airflow (SCFM):  804.56   9.01      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011322
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.011251
 Barometric Pressure (in HG):  29.65       Nozzle Temp (F):  66.36   1.64
   Air Chamber Nozzle Pressure Drop (in Water):  0.866    0.020
  Evaporator Coil Air Pressure Drop (in Water):  0.066    0.005
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  264.15    0.731       Ref-side Cap (Btu/h) : 13054.22   511.78
        Upstream Temp (F):  104.96    0.542         Ref-side Cap (tons):     1.09     0.04
                                               Refrigerant Mdot (lbm/h):   205.56     8.43
                                             Coriolis Density (lbm/ft3):    82.60     0.32
    Upstream R22 Tsat (F):  116.99    0.214
   Average Subcooling (F):   12.03    0.614

Evap Exit Pressure (psia):   97.48    1.092
     Evap Exit Avg Temp  :   65.53    1.224
       Exit Superheat (F):   16.32    1.741
       Evap Exit Tsat (F):   49.21    0.666
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040119a.dat   SUMMARY FILENAME: a040119a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 24917.81   718.96
    Indoor Dry-Bulb : 79.836   0.39    Sensible Cap (Btu/h): 19597.48   514.71
Indoor Inlet Dew (F): 60.327   0.80      Latent Cap (Btu/h):  5320.33   650.76
Indoor Exit Dry-Bulb: 59.747   0.72     EvapAir Delta T (F):  21.91     0.44
 Indoor Exit Dew (F): 56.767   0.50  Air/Ref Cap Prcnt Diff:   2.24     3.20
                                        Sensible Heat Ratio:   0.787    0.0238
 Indoor Airflow (CFM):  808.89   8.66          SCFM per Ton:  391.26
Indoor Airflow (SCFM):  812.44   8.25      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011277
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009905
 Barometric Pressure (in HG):  29.65       Nozzle Temp (F):  58.93   0.65
   Air Chamber Nozzle Pressure Drop (in Water):  0.869    0.018
  Evaporator Coil Air Pressure Drop (in Water):  0.078    0.006
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  267.30    0.974       Ref-side Cap (Btu/h) : 25473.46   406.33
        Upstream Temp (F):  105.31    0.610         Ref-side Cap (tons):     2.12     0.03
                                               Refrigerant Mdot (lbm/h):   401.83     6.23
                                             Coriolis Density (lbm/ft3):    82.41     0.36
    Upstream R22 Tsat (F):  117.91    0.282
   Average Subcooling (F):   12.60    0.661

Evap Exit Pressure (psia):   83.58    0.485
     Evap Exit Avg Temp  :   54.97    2.180
       Exit Superheat (F):   14.74    2.108
       Evap Exit Tsat (F):   40.22    0.333
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040119b.dat   SUMMARY FILENAME: a040119b.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 20189.62  1211.57
    Indoor Dry-Bulb : 79.724   0.56    Sensible Cap (Btu/h): 16949.08   903.59
Indoor Inlet Dew (F): 60.387   1.22      Latent Cap (Btu/h):  3240.53  1052.94
Indoor Exit Dry-Bulb: 62.620   0.61     EvapAir Delta T (F):  19.01     0.87
 Indoor Exit Dew (F): 58.265   0.66  Air/Ref Cap Prcnt Diff:   0.36     7.19
                                        Sensible Heat Ratio:   0.840    0.0486
 Indoor Airflow (CFM):  810.32   9.82          SCFM per Ton:  481.09
Indoor Airflow (SCFM):  809.42   9.70      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011302
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010463
 Barometric Pressure (in HG):  29.65       Nozzle Temp (F):  61.61   0.55
   Air Chamber Nozzle Pressure Drop (in Water):  0.868    0.021
  Evaporator Coil Air Pressure Drop (in Water):  0.075    0.004
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  265.97    1.462      Ref-side Cap (Btu/h) : 20258.54   775.30
        Upstream Temp (F):  105.55    0.519        Ref-side Cap (tons):     1.69     0.06
                                               Refrigerant Mdot (lbm/h):   319.95    11.72
                                             Coriolis Density (lbm/ft3):    82.53     0.56
    Upstream R22 Tsat (F):  117.52    0.425
   Average Subcooling (F):   11.97    0.670

Evap Exit Pressure (psia):   90.71    0.607
     Evap Exit Avg Temp  :   59.55    1.869
       Exit Superheat (F):   14.58    1.791
       Evap Exit Tsat (F):   44.97    0.391
```

```
                DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
          DATA FILENAME: a040121a.dat   SUMMARY FILENAME: a040121a.sum
                                                                    Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 13113.32   956.28
    Indoor Dry-Bulb : 80.145   0.30    Sensible Cap (Btu/h): 12617.08   431.95
Indoor Inlet Dew (F): 60.711   0.69      Latent Cap (Btu/h):   496.25   974.54
Indoor Exit Dry-Bulb: 67.736   0.55     EvapAir Delta T (F):  14.16     0.44
 Indoor Exit Dew (F): 60.395   0.53  Air/Ref Cap Prcnt Diff:  -3.01     8.47
                                        Sensible Heat Ratio:   0.963    0.0714
 Indoor Airflow (CFM):  809.05   8.27          SCFM per Ton:  739.70
Indoor Airflow (SCFM):  808.33   8.12      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011319
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.011190
 Barometric Pressure (in HG):  29.95       Nozzle Temp (F):  66.56   0.72
   Air Chamber Nozzle Pressure Drop (in Water):  0.865    0.017
  Evaporator Coil Air Pressure Drop (in Water):  0.066    0.006
--------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  259.38    1.218       Ref-side Cap (Btu/h) : 12712.62   464.37
        Upstream Temp (F):  104.33    0.435         Ref-side Cap (tons):     1.06     0.04
                                             Refrigerant Mdot (lbm/h):   199.55     7.33
                                           Coriolis Density (lbm/ft3):    82.36     0.16
    Upstream R22 Tsat (F):  115.59    0.361
   Average Subcooling (F):   11.26    0.607

Evap Exit Pressure (psia):   99.70    0.607
     Evap Exit Avg Temp  :   65.65    0.892
       Exit Superheat (F):   15.10    1.143
       Evap Exit Tsat (F):   50.56    0.365
```

Coil 3
R22, A01148, No Fan

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040205a.dat   SUMMARY FILENAME: a040205a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 41040.73  1364.36
    Indoor Dry-Bulb : 79.463   0.23    Sensible Cap (Btu/h): 27659.16   873.81
Indoor Inlet Dew (F): 60.632   0.44      Latent Cap (Btu/h): 13381.57   655.21
Indoor Exit Dry-Bulb: 55.072   0.38     EvapAir Delta T (F):  26.26     0.44
 Indoor Exit Dew (F): 52.370   0.41  Air/Ref Cap Prcnt Diff:   2.87     4.66
                                        Sensible Heat Ratio:   0.674    0.0119
 Indoor Airflow (CFM):  929.07  19.21          SCFM per Ton:  280.16
Indoor Airflow (SCFM):  958.17  19.81      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011184
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.008256
 Barometric Pressure (in HG):  30.22       Nozzle Temp (F):  55.25   0.88
   Air Chamber Nozzle Pressure Drop (in Water):  1.175    0.048
  Evaporator Coil Air Pressure Drop (in Water):  0.358    0.016
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  273.51    2.193       Ref-side Cap (Btu/h) : 42213.99   650.68
       Upstream Temp (F):  105.26    0.520         Ref-side Cap (tons):     3.52     0.05
                                              Refrigerant Mdot (lbm/h):   665.74    10.62
                                            Coriolis Density (lbm/ft3):    82.17     0.33
    Upstream R22 Tsat (F):  119.69    0.625
   Average Subcooling (F):   14.43    0.947

Evap Exit Pressure (psia):   83.57    0.728
     Evap Exit Avg Temp  :   57.45    2.513
       Exit Superheat (F):   17.24    2.347
       Evap Exit Tsat (F):   40.22    0.498
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040209a.dat   SUMMARY FILENAME: a040209a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 30896.46   694.06
    Indoor Dry-Bulb : 79.728   0.51    Sensible Cap (Btu/h): 22952.69   764.15
Indoor Inlet Dew (F): 60.549   0.38      Latent Cap (Btu/h):  7943.77   517.21
Indoor Exit Dry-Bulb: 59.655   0.39     EvapAir Delta T (F):  22.04     0.86
 Indoor Exit Dew (F): 55.835   0.32  Air/Ref Cap Prcnt Diff:  -1.06     2.84
                                        Sensible Heat Ratio:   0.743    0.0153
 Indoor Airflow (CFM):  925.27  13.65          SCFM per Ton:  367.48
Indoor Airflow (SCFM):  946.16  13.96      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011135
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009375
 Barometric Pressure (in HG):  30.26       Nozzle Temp (F):  60.01   0.28
   Air Chamber Nozzle Pressure Drop (in Water):  1.156    0.034
  Evaporator Coil Air Pressure Drop (in Water):  0.348    0.012
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  267.52    0.731      Ref-side Cap (Btu/h) : 30568.21   436.20
        Upstream Temp (F):  104.48    0.480        Ref-side Cap (tons):     2.55     0.04
                                               Refrigerant Mdot (lbm/h):   480.19     7.69
                                             Coriolis Density (lbm/ft3):    81.94     0.38
   Upstream R22 Tsat (F):  117.97    0.212
  Average Subcooling (F):   13.49    0.586

Evap Exit Pressure (psia):   97.44    0.485
     Evap Exit Avg Temp  :   60.39    2.736
       Exit Superheat (F):   11.20    2.884
       Evap Exit Tsat (F):   49.19    0.297
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040209b.dat   SUMMARY FILENAME: a040209b.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 41393.85   883.37
    Indoor Dry-Bulb : 80.019   0.52    Sensible Cap (Btu/h): 27938.72   683.02
Indoor Inlet Dew (F): 60.502   0.30      Latent Cap (Btu/h): 13455.14   489.03
Indoor Exit Dry-Bulb: 55.085   0.39     EvapAir Delta T (F):  26.72     0.44
 Indoor Exit Dew (F): 52.064   0.34  Air/Ref Cap Prcnt Diff:  -0.24     2.76
                                        Sensible Heat Ratio:   0.675    0.0102
 Indoor Airflow (CFM):  920.26  12.52          SCFM per Ton:  275.80
Indoor Airflow (SCFM):  951.37  12.85      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011116
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.008151
 Barometric Pressure (in HG):  30.26       Nozzle Temp (F):  54.73   0.65
   Air Chamber Nozzle Pressure Drop (in Water):  1.156    0.031
  Evaporator Coil Air Pressure Drop (in Water):  0.349    0.014
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  274.99    1.340       Ref-side Cap (Btu/h) : 41292.35   720.00
        Upstream Temp (F):  105.87    0.909         Ref-side Cap (tons):     3.44     0.06
                                               Refrigerant Mdot (lbm/h):   653.21    10.26
                                             Coriolis Density (lbm/ft3):    82.34     0.60
    Upstream R22 Tsat (F):  120.11    0.380
   Average Subcooling (F):   14.24    1.163

Evap Exit Pressure (psia):   83.38    0.971
     Evap Exit Avg Temp  :   53.47    4.966
       Exit Superheat (F):   13.38    4.716
       Evap Exit Tsat (F):   40.09    0.667
```

```
                 DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
          DATA FILENAME: a040210a.dat   SUMMARY FILENAME: a040210a.sum
                                                                       Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 35323.45  1001.75
    Indoor Dry-Bulb : 79.862   0.41    Sensible Cap (Btu/h): 24841.59   604.71
Indoor Inlet Dew (F): 60.568   0.68      Latent Cap (Btu/h): 10481.86  1001.13
Indoor Exit Dry-Bulb: 57.472   0.54     EvapAir Delta T (F):  24.22     0.65
 Indoor Exit Dew (F): 54.086   0.29  Air/Ref Cap Prcnt Diff:   3.52     4.05
                                        Sensible Heat Ratio:   0.703    0.0216
 Indoor Airflow (CFM):  906.77   6.99          SCFM per Ton:  316.85
Indoor Airflow (SCFM):  932.67   7.17      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011150
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.008794
 Barometric Pressure (in HG):  30.24       Nozzle Temp (F):  56.84   0.75
   Air Chamber Nozzle Pressure Drop (in Water):  1.117    0.017
  Evaporator Coil Air Pressure Drop (in Water):  0.334    0.007
--------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  268.66    0.974      Ref-side Cap (Btu/h) : 36563.86   598.74
        Upstream Temp (F):  104.33    0.498        Ref-side Cap (tons):     3.05     0.05
                                               Refrigerant Mdot (lbm/h):   573.95     9.71
                                             Coriolis Density (lbm/ft3):    81.89     0.36
    Upstream R22 Tsat (F):  118.30    0.281
   Average Subcooling (F):   13.97    0.508

Evap Exit Pressure (psia):   90.59    0.485
     Evap Exit Avg Temp  :   59.09    2.837
       Exit Superheat (F):   14.20    2.837
       Evap Exit Tsat (F):   44.89    0.313
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040211a.dat   SUMMARY FILENAME: a040211a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 28797.52   635.22
    Indoor Dry-Bulb : 79.830   0.53    Sensible Cap (Btu/h): 22212.84   940.77
Indoor Inlet Dew (F): 60.172   0.50      Latent Cap (Btu/h):  6584.67   551.13
Indoor Exit Dry-Bulb: 60.467   0.32     EvapAir Delta T (F):  21.15     0.86
 Indoor Exit Dew (F): 56.318   0.29  Air/Ref Cap Prcnt Diff:   0.04     2.65
                                        Sensible Heat Ratio:   0.771    0.0215
 Indoor Airflow (CFM):  936.15  14.99          SCFM per Ton:  397.62
Indoor Airflow (SCFM):  954.21  15.48      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011025
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009579
 Barometric Pressure (in HG):  30.15       Nozzle Temp (F):  59.73   0.65
   Air Chamber Nozzle Pressure Drop (in Water):  1.180    0.038
  Evaporator Coil Air Pressure Drop (in Water):  0.340    0.010
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  266.91    0.853       Ref-side Cap (Btu/h) : 28808.32   546.01
        Upstream Temp (F):  104.74    0.367         Ref-side Cap (tons):     2.40     0.05
                                               Refrigerant Mdot (lbm/h):   453.13     8.79
                                             Coriolis Density (lbm/ft3):    82.05     0.40
    Upstream R22 Tsat (F):  117.80    0.247
   Average Subcooling (F):   13.06    0.367

Evap Exit Pressure (psia):   98.26    0.607
     Evap Exit Avg Temp  :   62.18    2.732
       Exit Superheat (F):   12.49    2.732
       Evap Exit Tsat (F):   49.69    0.369
```

```
              DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040211b.dat   SUMMARY FILENAME: a040211b.sum
                                                                       Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 36747.94   789.39
    Indoor Dry-Bulb : 80.029   0.45    Sensible Cap (Btu/h): 25913.75   926.16
Indoor Inlet Dew (F): 60.367   0.36      Latent Cap (Btu/h): 10834.19   457.19
Indoor Exit Dry-Bulb: 57.210   0.23     EvapAir Delta T (F):  24.69     0.65
 Indoor Exit Dew (F): 53.785   0.32  Air/Ref Cap Prcnt Diff:  -0.41     3.06
                                        Sensible Heat Ratio:   0.705    0.0118
 Indoor Airflow (CFM):  930.35  10.67          SCFM per Ton:  311.64
Indoor Airflow (SCFM):  954.35  12.08      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011103
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.008723
 Barometric Pressure (in HG):  30.15       Nozzle Temp (F):  56.70   0.60
   Air Chamber Nozzle Pressure Drop (in Water):  1.172    0.028
  Evaporator Coil Air Pressure Drop (in Water):  0.343    0.012
--------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  269.10    0.974       Ref-side Cap (Btu/h) : 36596.26   594.50
        Upstream Temp (F):  104.40    0.520         Ref-side Cap (tons):     3.05     0.05
                                               Refrigerant Mdot (lbm/h):   574.65     9.71
                                             Coriolis Density (lbm/ft3):    81.89     0.19
    Upstream R22 Tsat (F):  118.43    0.281
   Average Subcooling (F):   14.03    0.731

Evap Exit Pressure (psia):   90.35    0.728
     Evap Exit Avg Temp  :   56.66    3.573
       Exit Superheat (F):   11.93    3.494
       Evap Exit Tsat (F):   44.73    0.471
```

Coil 4
R22, A01138, No Fan

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040219x.dat   SUMMARY FILENAME: a040219x.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 26783.74  1883.79
    Indoor Dry-Bulb : 79.733   0.75    Sensible Cap (Btu/h): 18268.01   480.03
Indoor Inlet Dew (F): 60.591   0.85      Latent Cap (Btu/h):  8515.73  1438.99
Indoor Exit Dry-Bulb: 60.736   0.27     EvapAir Delta T (F):  20.89     0.44
 Indoor Exit Dew (F): 54.512   0.22  Air/Ref Cap Prcnt Diff:  -3.06     7.01
                                        Sensible Heat Ratio:   0.682    0.0356
 Indoor Airflow (CFM):  784.16   9.68          SCFM per Ton:  356.16
Indoor Airflow (SCFM):  794.93  10.13      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011259
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009013
 Barometric Pressure (in HG):  29.98       Nozzle Temp (F):  60.11   0.55
   Air Chamber Nozzle Pressure Drop (in Water):  0.825    0.020
  Evaporator Coil Air Pressure Drop (in Water):  0.103    0.005
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  272.62    0.974      Ref-side Cap (Btu/h) : 25954.80   364.19
        Upstream Temp (F):  106.07    0.198        Ref-side Cap (tons):     2.16     0.03
                                               Refrigerant Mdot (lbm/h):   410.99     5.50
                                             Coriolis Density (lbm/ft3):    82.36     0.16
    Upstream R22 Tsat (F):  119.44    0.278
   Average Subcooling (F):   13.37    0.301

Evap Exit Pressure (psia):   82.89    0.485
     Evap Exit Avg Temp  :   53.49    3.724
       Exit Superheat (F):   13.74    3.640
       Evap Exit Tsat (F):   39.75    0.335
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040223a.dat   SUMMARY FILENAME: a040223a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 22035.41   717.30
    Indoor Dry-Bulb : 79.831   0.38    Sensible Cap (Btu/h): 16037.57   564.10
Indoor Inlet Dew (F): 60.757   0.25      Latent Cap (Btu/h):  5997.85   366.03
Indoor Exit Dry-Bulb: 63.300   0.29     EvapAir Delta T (F):  18.31     0.43
 Indoor Exit Dew (F): 56.680   0.24  Air/Ref Cap Prcnt Diff:  -1.11     3.19
                                        Sensible Heat Ratio:   0.728    0.0115
 Indoor Airflow (CFM):  797.03  14.29          SCFM per Ton:  433.12
Indoor Airflow (SCFM):  795.33  14.25      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011454
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009873
 Barometric Pressure (in HG):  29.65       Nozzle Temp (F):  62.30   0.82
   Air Chamber Nozzle Pressure Drop (in Water):  0.839    0.030
  Evaporator Coil Air Pressure Drop (in Water):  0.102    0.008
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  271.21    0.731       Ref-side Cap (Btu/h) : 21790.52   420.49
        Upstream Temp (F):  104.30    0.520         Ref-side Cap (tons):     1.82     0.04
                                               Refrigerant Mdot (lbm/h):   342.00     6.96
                                             Coriolis Density (lbm/ft3):    82.11     0.16
    Upstream R22 Tsat (F):  119.04    0.209
   Average Subcooling (F):   14.73    0.614

Evap Exit Pressure (psia):   90.96    0.243
     Evap Exit Avg Temp  :   56.93    4.399
       Exit Superheat (F):   11.80    4.399
       Evap Exit Tsat (F):   45.12    0.156
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040225a.dat   SUMMARY FILENAME: a040225a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 18269.45  1171.80
    Indoor Dry-Bulb : 80.022   0.51    Sensible Cap (Btu/h): 14746.16   529.64
Indoor Inlet Dew (F): 60.413   0.20      Latent Cap (Btu/h):  3523.29   695.37
Indoor Exit Dry-Bulb: 64.826   0.28     EvapAir Delta T (F):  16.93     0.43
 Indoor Exit Dew (F): 58.000   0.61  Air/Ref Cap Prcnt Diff:  -3.42     5.96
                                        Sensible Heat Ratio:   0.807    0.0264
 Indoor Airflow (CFM):  782.66   8.87          SCFM per Ton:  519.44
Indoor Airflow (SCFM):  790.82   9.75      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011122
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010188
 Barometric Pressure (in HG):  30.15       Nozzle Temp (F):  64.41   0.64
   Air Chamber Nozzle Pressure Drop (in Water):  0.819    0.019
  Evaporator Coil Air Pressure Drop (in Water):  0.101    0.006
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  267.89    0.487      Ref-side Cap (Btu/h) : 17640.72   256.55
        Upstream Temp (F):  104.71    0.520        Ref-side Cap (tons):     1.47     0.02
                                               Refrigerant Mdot (lbm/h):   277.43     4.21
                                             Coriolis Density (lbm/ft3):    82.22     0.16
    Upstream R22 Tsat (F):  118.08    0.141
   Average Subcooling (F):   13.37    0.590

Evap Exit Pressure (psia):   97.83    0.243
     Evap Exit Avg Temp  :   62.27    0.682
       Exit Superheat (F):   12.84    0.694
       Evap Exit Tsat (F):   49.43    0.148
```

```
             DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040226x.dat   SUMMARY FILENAME: a040226x.sum
                                                                     Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 22162.66   746.55
    Indoor Dry-Bulb : 79.824   0.48    Sensible Cap (Btu/h): 16293.07   683.39
Indoor Inlet Dew (F): 60.511   0.30      Latent Cap (Btu/h):  5869.59   264.85
Indoor Exit Dry-Bulb: 62.849   0.23     EvapAir Delta T (F):  18.75     0.65
 Indoor Exit Dew (F): 56.419   0.24  Air/Ref Cap Prcnt Diff:  -2.32     4.07
                                        Sensible Heat Ratio:   0.735    0.0134
 Indoor Airflow (CFM):  783.74  11.71          SCFM per Ton:  427.28
Indoor Airflow (SCFM):  789.14  11.92      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011249
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009689
 Barometric Pressure (in HG):  29.92       Nozzle Temp (F):  62.38   0.74
   Air Chamber Nozzle Pressure Drop (in Water):  0.819    0.024
  Evaporator Coil Air Pressure Drop (in Water):  0.102    0.006
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  269.24    0.731       Ref-side Cap (Btu/h) : 21646.36   359.14
        Upstream Temp (F):  105.78    0.649         Ref-side Cap (tons):     1.80     0.03
                                               Refrigerant Mdot (lbm/h):   342.26     5.68
                                             Coriolis Density (lbm/ft3):    82.45     0.22
    Upstream R22 Tsat (F):  118.47    0.211
   Average Subcooling (F):   12.69    0.511

Evap Exit Pressure (psia):   90.58    0.243
     Evap Exit Avg Temp  :   59.46    0.975
       Exit Superheat (F):   14.58    1.131
       Evap Exit Tsat (F):   44.88    0.157
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: b040225b.dat   SUMMARY FILENAME: b040225b.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 26781.23   822.37
    Indoor Dry-Bulb : 80.166   0.54    Sensible Cap (Btu/h): 18704.64   613.34
Indoor Inlet Dew (F): 60.286   0.36      Latent Cap (Btu/h):  8076.59   295.67
Indoor Exit Dry-Bulb: 60.610   0.30     EvapAir Delta T (F):  21.40     0.44
 Indoor Exit Dew (F): 54.447   0.26  Air/Ref Cap Prcnt Diff:  -2.53     4.62
                                        Sensible Heat Ratio:   0.698    0.0098
 Indoor Airflow (CFM):  779.61  15.74          SCFM per Ton:  356.06
Indoor Airflow (SCFM):  794.65  16.13      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011071
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.008940
 Barometric Pressure (in HG):  30.15       Nozzle Temp (F):  60.23   0.76
   Air Chamber Nozzle Pressure Drop (in Water):  0.820    0.033
  Evaporator Coil Air Pressure Drop (in Water):  0.105    0.009
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  270.17    0.974      Ref-side Cap (Btu/h) : 26102.18  1283.93
        Upstream Temp (F):  106.27    0.609        Ref-side Cap (tons):     2.18     0.11
                                               Refrigerant Mdot (lbm/h):   413.75    20.15
                                             Coriolis Density (lbm/ft3):    82.51     0.32
    Upstream R22 Tsat (F):  118.74    0.280
   Average Subcooling (F):   12.47    0.542

Evap Exit Pressure (psia):   83.86    0.485
     Evap Exit Avg Temp  :   54.70    3.049
       Exit Superheat (F):   14.28    3.049
       Evap Exit Tsat (F):   40.41    0.332
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: b040226b.dat   SUMMARY FILENAME: b040226b.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 16953.69   572.29
    Indoor Dry-Bulb : 80.011   0.45    Sensible Cap (Btu/h): 14077.80   482.68
Indoor Inlet Dew (F): 60.711   0.16      Latent Cap (Btu/h):  2875.89   368.36
Indoor Exit Dry-Bulb: 65.498   0.29     EvapAir Delta T (F):  16.19     0.43
 Indoor Exit Dew (F): 58.787   0.25  Air/Ref Cap Prcnt Diff:  -2.57     4.27
                                        Sensible Heat Ratio:   0.830    0.0187
 Indoor Airflow (CFM):  788.03  16.16          SCFM per Ton:  558.45
Indoor Airflow (SCFM):  788.99  15.66      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011330
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010566
 Barometric Pressure (in HG):  29.92       Nozzle Temp (F):  65.08   0.69
   Air Chamber Nozzle Pressure Drop (in Water):  0.823    0.033
  Evaporator Coil Air Pressure Drop (in Water):  0.099    0.005
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  271.82    0.487      Ref-side Cap (Btu/h) : 16516.48   372.06
        Upstream Temp (F):  104.56    0.366        Ref-side Cap (tons):     1.38     0.03
                                               Refrigerant Mdot (lbm/h):   259.56     5.68
                                             Coriolis Density (lbm/ft3):    82.29     0.10
    Upstream R22 Tsat (F):  119.21    0.139
   Average Subcooling (F):   14.65    0.463

Evap Exit Pressure (psia):   99.80    0.485
     Evap Exit Avg Temp  :   63.23    0.685
       Exit Superheat (F):   12.61    0.938
       Evap Exit Tsat (F):   50.62    0.291
```

Coil 5

R22, A01060, Fan: 273 Watts

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040302a.dat   SUMMARY FILENAME: a040302a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 27580.34   853.16
    Indoor Dry-Bulb : 80.145   0.29    Sensible Cap (Btu/h): 18827.50   513.83
Indoor Inlet Dew (F): 60.357   0.36      Latent Cap (Btu/h):  8752.84   468.87
Indoor Exit Dry-Bulb: 59.345   0.23     EvapAir Delta T (F):  22.72     0.44
 Indoor Exit Dew (F): 53.644   0.22  Air/Ref Cap Prcnt Diff:  -1.58     4.17
                                        Sensible Heat Ratio:   0.683    0.0121
 Indoor Airflow (CFM):  740.22   7.76          SCFM per Ton:  327.76
Indoor Airflow (SCFM):  753.31   7.78      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011164
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.008728
 Barometric Pressure (in HG):  29.98       Nozzle Temp (F):  58.15   0.32
   Air Chamber Nozzle Pressure Drop (in Water):  0.739    0.015
  Evaporator Coil Air Pressure Drop (in Water):  0.124    0.028
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  268.54    0.731       Ref-side Cap (Btu/h) : 27142.87   616.61
        Upstream Temp (F):  105.08    0.584         Ref-side Cap (tons):     2.26     0.05
                                               Refrigerant Mdot (lbm/h):   427.67     9.16
                                             Coriolis Density (lbm/ft3):    82.27     0.29
    Upstream R22 Tsat (F):  118.27    0.211
   Average Subcooling (F):   13.19    0.661

Evap Exit Pressure (psia):   90.74    0.485
     Evap Exit Avg Temp  :   59.50    2.420
       Exit Superheat (F):   14.52    2.420
       Evap Exit Tsat (F):   44.99    0.313
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040303a.dat   SUMMARY FILENAME: a040303a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 32329.27   833.92
    Indoor Dry-Bulb : 80.024   0.52    Sensible Cap (Btu/h): 20840.09   612.93
Indoor Inlet Dew (F): 60.435   0.21      Latent Cap (Btu/h): 11489.18   334.36
Indoor Exit Dry-Bulb: 56.983   0.27     EvapAir Delta T (F):  24.98     0.44
 Indoor Exit Dew (F): 51.431   0.18  Air/Ref Cap Prcnt Diff:  -0.37     2.91
                                        Sensible Heat Ratio:   0.645    0.0055
 Indoor Airflow (CFM):  745.45   9.82          SCFM per Ton:  281.75
Indoor Airflow (SCFM):  759.07   9.93      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011245
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.008071
 Barometric Pressure (in HG):  29.85       Nozzle Temp (F):  55.80   0.42
   Air Chamber Nozzle Pressure Drop (in Water):  0.749    0.020
  Evaporator Coil Air Pressure Drop (in Water):  0.136    0.041
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  269.50    1.218       Ref-side Cap (Btu/h) : 32208.02   435.83
        Upstream Temp (F):  104.63    0.910         Ref-side Cap (tons):     2.68     0.04
                                             Refrigerant Mdot (lbm/h):   506.34     6.41
                                           Coriolis Density (lbm/ft3):    81.99     0.30
   Upstream R22 Tsat (F):  118.55    0.351
  Average Subcooling (F):   13.91    1.170

Evap Exit Pressure (psia):   83.54    0.607
     Evap Exit Avg Temp  :   52.65    6.498
       Exit Superheat (F):   12.45    6.498
       Evap Exit Tsat (F):   40.20    0.416
```

```
                 DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040304a.dat   SUMMARY FILENAME: a040304a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 27488.36   891.82
    Indoor Dry-Bulb : 79.846   0.71    Sensible Cap (Btu/h): 18592.08   788.83
Indoor Inlet Dew (F): 60.399   0.31      Latent Cap (Btu/h):  8896.27   337.31
Indoor Exit Dry-Bulb: 59.306   0.39     EvapAir Delta T (F):  22.46     0.87
 Indoor Exit Dew (F): 53.625   0.36  Air/Ref Cap Prcnt Diff:  -1.74     3.39
                                        Sensible Heat Ratio:   0.676    0.0109
 Indoor Airflow (CFM):  746.16   7.72          SCFM per Ton:  328.46
Indoor Airflow (SCFM):  752.41   7.79      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011269
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.008790
 Barometric Pressure (in HG):  29.75       Nozzle Temp (F):  58.88   0.37
   Air Chamber Nozzle Pressure Drop (in Water):  0.744    0.015
  Evaporator Coil Air Pressure Drop (in Water):  0.140    0.024
--------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  269.51    1.096       Ref-side Cap (Btu/h) : 27008.54   440.01
        Upstream Temp (F):  104.56    0.520         Ref-side Cap (tons):     2.25     0.04
                                               Refrigerant Mdot (lbm/h):   424.44     6.59
                                             Coriolis Density (lbm/ft3):    82.02     0.38
    Upstream R22 Tsat (F):  118.55    0.316
   Average Subcooling (F):   13.99    0.598

Evap Exit Pressure (psia):   90.05    0.243
     Evap Exit Avg Temp  :   59.41    5.210
       Exit Superheat (F):   14.87    5.052
       Evap Exit Tsat (F):   44.54    0.157
```

```
                 DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: b040303b.dat   SUMMARY FILENAME: b040303b.sum
                                                                    Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 23217.01   492.17
    Indoor Dry-Bulb : 79.842   0.67    Sensible Cap (Btu/h): 16981.94   465.27
Indoor Inlet Dew (F): 60.418   0.12      Latent Cap (Btu/h):  6235.07   176.50
Indoor Exit Dry-Bulb: 61.269   0.35     EvapAir Delta T (F):  20.49     0.43
 Indoor Exit Dew (F): 55.823   0.20  Air/Ref Cap Prcnt Diff:  -1.71     2.83
                                        Sensible Heat Ratio:   0.731    0.0106
 Indoor Airflow (CFM):  747.39   4.97          SCFM per Ton:  389.23
Indoor Airflow (SCFM):  753.05   5.01      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011238
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009502
 Barometric Pressure (in HG):  29.85       Nozzle Temp (F):  60.81   0.64
   Air Chamber Nozzle Pressure Drop (in Water):  0.745    0.010
  Evaporator Coil Air Pressure Drop (in Water):  0.146    0.014
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  272.97    0.853       Ref-side Cap (Btu/h) : 22818.98   413.37
        Upstream Temp (F):  104.56    0.416         Ref-side Cap (tons):     1.90     0.03
                                               Refrigerant Mdot (lbm/h):   358.60     6.78
                                             Coriolis Density (lbm/ft3):    82.08     0.37
    Upstream R22 Tsat (F):  119.54    0.243
   Average Subcooling (F):   14.98    0.448

Evap Exit Pressure (psia):   98.39    0.485
     Evap Exit Avg Temp  :   64.17    1.260
       Exit Superheat (F):   14.40    1.260
       Evap Exit Tsat (F):   49.77    0.294
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040305a.dat   SUMMARY FILENAME: a040305a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 32479.54  1003.87
    Indoor Dry-Bulb : 79.740   0.52    Sensible Cap (Btu/h): 20659.92   970.81
Indoor Inlet Dew (F): 60.443   0.46      Latent Cap (Btu/h): 11819.62   344.26
Indoor Exit Dry-Bulb: 56.551   0.39     EvapAir Delta T (F):  24.94     1.08
 Indoor Exit Dew (F): 51.099   0.32  Air/Ref Cap Prcnt Diff:  -0.93     3.45
                                        Sensible Heat Ratio:   0.636    0.0130
 Indoor Airflow (CFM):  743.16   7.82          SCFM per Ton:  278.47
Indoor Airflow (SCFM):  753.71   7.68      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011286
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.007999
 Barometric Pressure (in HG):  29.75       Nozzle Temp (F):  56.13   0.55
   Air Chamber Nozzle Pressure Drop (in Water):  0.742    0.015
  Evaporator Coil Air Pressure Drop (in Water):  0.151    0.028
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  269.37    0.853       Ref-side Cap (Btu/h) : 32175.10   333.48
        Upstream Temp (F):  104.35    0.967         Ref-side Cap (tons):     2.68     0.03
                                               Refrigerant Mdot (lbm/h):   505.11     5.68
                                             Coriolis Density (lbm/ft3):    81.88     0.33
    Upstream R22 Tsat (F):  118.51    0.246
   Average Subcooling (F):   14.16    1.177

Evap Exit Pressure (psia):   83.93    0.364
     Evap Exit Avg Temp  :   54.32    3.954
       Exit Superheat (F):   13.86    3.954
       Evap Exit Tsat (F):   40.46    0.249
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040308a.dat   SUMMARY FILENAME: a040308a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 22605.73   521.66
    Indoor Dry-Bulb : 79.710   0.39    Sensible Cap (Btu/h): 16356.36   502.56
Indoor Inlet Dew (F): 60.687   0.30      Latent Cap (Btu/h):  6249.36   290.00
Indoor Exit Dry-Bulb: 61.590   0.11     EvapAir Delta T (F):  19.86     0.43
 Indoor Exit Dew (F): 56.086   0.16  Air/Ref Cap Prcnt Diff:  -1.31     2.36
                                        Sensible Heat Ratio:   0.724    0.0103
 Indoor Airflow (CFM):  742.04   6.90          SCFM per Ton:  397.08
Indoor Airflow (SCFM):  748.02   6.88      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011336
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009585
 Barometric Pressure (in HG):  29.88       Nozzle Temp (F):  61.04   0.10
   Air Chamber Nozzle Pressure Drop (in Water):  0.735    0.013
  Evaporator Coil Air Pressure Drop (in Water):  0.161    0.015
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  270.28    0.731       Ref-side Cap (Btu/h) : 22309.53   298.84
        Upstream Temp (F):  105.69    0.237         Ref-side Cap (tons):     1.86     0.02
                                               Refrigerant Mdot (lbm/h):   352.58     4.76
                                             Coriolis Density (lbm/ft3):    82.32     0.18
    Upstream R22 Tsat (F):  118.77    0.210
   Average Subcooling (F):   13.08    0.386

Evap Exit Pressure (psia):   98.45    0.364
     Evap Exit Avg Temp  :   63.73    0.793
       Exit Superheat (F):   13.92    0.657
       Evap Exit Tsat (F):   49.81    0.221
```

Coil 6
R22, A01125, Fan: 768 Watts

```
                  DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
        DATA FILENAME: c040406c.dat   SUMMARY FILENAME: c040406c.sum
                                                                 Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 37805.35  4574.21
    Indoor Dry-Bulb : 79.347   3.97    Sensible Cap (Btu/h): 26735.16  4315.08
Indoor Inlet Dew (F): 60.944   0.45      Latent Cap (Btu/h): 11070.19  1947.82
Indoor Exit Dry-Bulb: 60.804   1.28     EvapAir Delta T (F):  20.91     3.44
 Indoor Exit Dew (F): 55.682   1.19  Air/Ref Cap Prcnt Diff:  -0.44    13.23
                                        Sensible Heat Ratio:   0.707    0.0418
 Indoor Airflow (CFM): 1149.21  25.49          SCFM per Ton:  368.71
Indoor Airflow (SCFM): 1161.61  28.57      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011438
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009440
 Barometric Pressure (in HG):  29.89       Nozzle Temp (F):  60.06   1.13
   Air Chamber Nozzle Pressure Drop (in Water):  0.918    0.043
  Evaporator Coil Air Pressure Drop (in Water):  1.700    0.000
--------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  266.79    3.350       Ref-side Cap (Btu/h) : 37608.27   993.66
        Upstream Temp (F):  104.78    1.051         Ref-side Cap (tons):     3.13     0.08
                                               Refrigerant Mdot (lbm/h):   591.66    13.92
                                             Coriolis Density (lbm/ft3):    81.51     0.28
    Upstream R22 Tsat (F):  117.76    0.973
   Average Subcooling (F):   12.98    1.617

Evap Exit Pressure (psia):  101.49    1.638
     Evap Exit Avg Temp  :   65.58    5.368
       Exit Superheat (F):   13.95    4.545
       Evap Exit Tsat (F):   51.63    0.974
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040407a.dat   SUMMARY FILENAME: a040407a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 43850.60  5098.57
    Indoor Dry-Bulb : 79.491   3.63    Sensible Cap (Btu/h): 29605.56  5146.04
Indoor Inlet Dew (F): 60.528   0.70      Latent Cap (Btu/h): 14245.04  1882.32
Indoor Exit Dry-Bulb: 58.585   1.12     EvapAir Delta T (F):  23.15     3.89
 Indoor Exit Dew (F): 53.483   1.08  Air/Ref Cap Prcnt Diff:   0.37    13.50
                                        Sensible Heat Ratio:   0.675    0.0485
 Indoor Airflow (CFM): 1144.88  18.17          SCFM per Ton:  318.18
Indoor Airflow (SCFM): 1162.70  18.00      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011283
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.008714
 Barometric Pressure (in HG):  29.85       Nozzle Temp (F):  57.15   1.38
   Air Chamber Nozzle Pressure Drop (in Water):  0.915    0.029
  Evaporator Coil Air Pressure Drop (in Water):  1.700    0.000
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  268.66    2.741      Ref-side Cap (Btu/h) : 43985.34  1308.50
        Upstream Temp (F):  105.44    1.872        Ref-side Cap (tons):     3.67     0.11
                                                 Refrigerant Mdot (lbm/h):   694.28    21.62
                                             Coriolis Density (lbm/ft3):    81.89     0.33
   Upstream R22 Tsat (F):  118.30    0.791
  Average Subcooling (F):   12.87    1.662

Evap Exit Pressure (psia):   95.81    1.395
     Evap Exit Avg Temp  :   62.16    4.507
       Exit Superheat (F):   13.98    3.719
       Evap Exit Tsat (F):   48.19    0.864
```

```
              DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
        DATA FILENAME: d040406d.dat   SUMMARY FILENAME: d040406d.sum
                                                                      Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 37704.09  1035.50
    Indoor Dry-Bulb : 79.017   0.79    Sensible Cap (Btu/h): 26399.92   873.21
Indoor Inlet Dew (F): 61.007   0.41      Latent Cap (Btu/h): 11304.17   631.67
Indoor Exit Dry-Bulb: 60.679   0.43     EvapAir Delta T (F):  20.73     0.76
 Indoor Exit Dew (F): 55.613   0.34  Air/Ref Cap Prcnt Diff:  -0.30     3.53
                                    Sensible Heat Ratio:   0.700    0.0088
 Indoor Airflow (CFM): 1143.97  24.09          SCFM per Ton:  368.25
Indoor Airflow (SCFM): 1157.04  24.16      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011464
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009416
 Barometric Pressure (in HG):  29.89       Nozzle Temp (F):  59.74   0.64
   Air Chamber Nozzle Pressure Drop (in Water):  0.910    0.038
  Evaporator Coil Air Pressure Drop (in Water):  1.700    0.000
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  266.07    0.670      Ref-side Cap (Btu/h) : 37587.47   526.25
        Upstream Temp (F):  104.36    0.401        Ref-side Cap (tons):     3.13     0.04
                                              Refrigerant Mdot (lbm/h):   590.11     7.69
                                            Coriolis Density (lbm/ft3):    81.47     0.27
    Upstream R22 Tsat (F):  117.55    0.195
   Average Subcooling (F):   13.19    0.542

Evap Exit Pressure (psia):  101.34    0.485
     Evap Exit Avg Temp  :   65.33    1.689
       Exit Superheat (F):   13.80    1.545
       Evap Exit Tsat (F):   51.54    0.288
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040402.dat   SUMMARY FILENAME: a040402.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 40037.46  1134.23
    Indoor Dry-Bulb : 79.643   0.37    Sensible Cap (Btu/h): 28653.79   899.47
Indoor Inlet Dew (F): 60.353   0.49      Latent Cap (Btu/h): 11383.68   598.35
Indoor Exit Dry-Bulb: 59.392   0.35     EvapAir Delta T (F):  22.52     0.55
 Indoor Exit Dew (F): 54.835   0.37  Air/Ref Cap Prcnt Diff:   0.26     3.31
                                        Sensible Heat Ratio:   0.716    0.0107
 Indoor Airflow (CFM): 1150.15  21.70          SCFM per Ton:  346.57
Indoor Airflow (SCFM): 1156.30  21.69      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011288
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009225
 Barometric Pressure (in HG):  29.65       Nozzle Temp (F):  58.74   0.46
   Air Chamber Nozzle Pressure Drop (in Water):  0.915    0.034
  Evaporator Coil Air Pressure Drop (in Water):  1.715    0.000
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  269.74    1.157       Ref-side Cap (Btu/h) : 40140.11   525.17
        Upstream Temp (F):  104.20    0.668         Ref-side Cap (tons):     3.35     0.04
                                               Refrigerant Mdot (lbm/h):   629.67     7.24
                                             Coriolis Density (lbm/ft3):    81.40     0.19
    Upstream R22 Tsat (F):  118.61    0.333
   Average Subcooling (F):   14.41    0.720

Evap Exit Pressure (psia):   97.93    0.667
     Evap Exit Avg Temp  :   63.23    0.965
       Exit Superheat (F):   13.74    0.708
       Evap Exit Tsat (F):   49.49    0.406
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040406a.dat   SUMMARY FILENAME: a040406a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 28898.20  1928.90
    Indoor Dry-Bulb : 79.742   0.41    Sensible Cap (Btu/h): 23756.23   986.39
Indoor Inlet Dew (F): 60.351   0.22      Latent Cap (Btu/h):  5141.97  2225.49
Indoor Exit Dry-Bulb: 63.430   0.22     EvapAir Delta T (F):  18.63     0.75
 Indoor Exit Dew (F): 57.963   1.02  Air/Ref Cap Prcnt Diff:  -0.64     7.75
                                        Sensible Heat Ratio:   0.822    0.0644
 Indoor Airflow (CFM): 1149.71  20.13          SCFM per Ton:  480.72
Indoor Airflow (SCFM): 1157.67  19.85      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011195
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010264
 Barometric Pressure (in HG):  29.89       Nozzle Temp (F):  61.80   0.46
   Air Chamber Nozzle Pressure Drop (in Water):  0.915    0.031
  Evaporator Coil Air Pressure Drop (in Water):  1.700    0.000
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  274.96    1.279       Ref-side Cap (Btu/h) : 28706.78   937.54
        Upstream Temp (F):  105.07    0.511         Ref-side Cap (tons):     2.39     0.08
                                               Refrigerant Mdot (lbm/h):   452.28    14.65
                                             Coriolis Density (lbm/ft3):    81.89     0.38
    Upstream R22 Tsat (F):  120.10    0.363
   Average Subcooling (F):   15.04    0.649

Evap Exit Pressure (psia):  107.81    0.303
     Evap Exit Avg Temp  :   70.32    0.946
       Exit Superheat (F):   15.03    0.948
       Evap Exit Tsat (F):   55.29    0.172
```

```
                DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: b040402b.dat   SUMMARY FILENAME: b040402b.sum
                                                                       Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 39504.41   778.58
    Indoor Dry-Bulb : 79.763   0.63    Sensible Cap (Btu/h): 28482.79   688.71
Indoor Inlet Dew (F): 60.350   0.36      Latent Cap (Btu/h): 11021.62   799.76
Indoor Exit Dry-Bulb: 59.632   0.26     EvapAir Delta T (F):  22.39     0.43
 Indoor Exit Dew (F): 55.021   0.24  Air/Ref Cap Prcnt Diff:   0.42     1.91
                                        Sensible Heat Ratio:   0.721    0.0173
 Indoor Airflow (CFM): 1150.36  15.38          SCFM per Ton:  351.11
Indoor Airflow (SCFM): 1155.87  15.45      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011287
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009288
 Barometric Pressure (in HG):  29.65       Nozzle Temp (F):  59.01   0.32
   Air Chamber Nozzle Pressure Drop (in Water):  0.915    0.024
  Evaporator Coil Air Pressure Drop (in Water):  1.715    0.000
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  269.24    0.974       Ref-side Cap (Btu/h) : 39670.12   616.85
        Upstream Temp (F):  104.51    0.652         Ref-side Cap (tons):     3.31     0.05
                                               Refrigerant Mdot (lbm/h):   623.27     9.62
                                             Coriolis Density (lbm/ft3):    81.43     0.27
    Upstream R22 Tsat (F):  118.47    0.281
   Average Subcooling (F):   13.96    0.793

Evap Exit Pressure (psia):   98.41    0.485
     Evap Exit Avg Temp  :   63.64    0.929
       Exit Superheat (F):   13.86    0.709
       Evap Exit Tsat (F):   49.78    0.294
```

```
             DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
          DATA FILENAME: b040407b.dat   SUMMARY FILENAME: b040407b.sum
                                                                   Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 29255.90   822.80
    Indoor Dry-Bulb : 79.329   0.59    Sensible Cap (Btu/h): 22885.70   580.88
Indoor Inlet Dew (F): 60.954   0.52      Latent Cap (Btu/h):  6370.21   425.88
Indoor Exit Dry-Bulb: 63.454   0.37     EvapAir Delta T (F):  18.12     0.22
 Indoor Exit Dew (F): 58.003   0.42  Air/Ref Cap Prcnt Diff:   1.42     2.38
                                        Sensible Heat Ratio:   0.782    0.0113
 Indoor Airflow (CFM): 1140.82  24.11          SCFM per Ton:  470.27
Indoor Airflow (SCFM): 1146.51  24.02      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011457
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010293
 Barometric Pressure (in HG):  29.85       Nozzle Temp (F):  62.10   0.62
   Air Chamber Nozzle Pressure Drop (in Water):  0.900    0.038
  Evaporator Coil Air Pressure Drop (in Water):  1.700    0.000
--------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  273.21    1.340      Ref-side Cap (Btu/h) : 29670.07   566.32
        Upstream Temp (F):  104.45    0.510        Ref-side Cap (tons):     2.47     0.05
                                             Refrigerant Mdot (lbm/h):   466.02     8.15
                                           Coriolis Density (lbm/ft3):    81.61     0.36
    Upstream R22 Tsat (F):  119.61    0.382
   Average Subcooling (F):   15.15    0.739

Evap Exit Pressure (psia):  108.49    0.607
     Evap Exit Avg Temp  :   67.60    1.244
       Exit Superheat (F):   11.92    1.107
       Evap Exit Tsat (F):   55.68    0.342
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040410a.dat   SUMMARY FILENAME: a040410a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 41868.75  1269.75
    Indoor Dry-Bulb : 80.137   0.67    Sensible Cap (Btu/h): 29034.75   990.29
Indoor Inlet Dew (F): 60.569   0.12      Latent Cap (Btu/h): 12834.01   529.88
Indoor Exit Dry-Bulb: 59.695   0.19     EvapAir Delta T (F):  22.68     0.54
 Indoor Exit Dew (F): 54.315   0.11  Air/Ref Cap Prcnt Diff:   0.57     5.66
                                        Sensible Heat Ratio:   0.693    0.0079
 Indoor Airflow (CFM): 1148.39  30.81          SCFM per Ton:  333.47
Indoor Airflow (SCFM): 1163.50  31.34      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011299
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.008987
 Barometric Pressure (in HG):  29.85       Nozzle Temp (F):  58.29   0.44
   Air Chamber Nozzle Pressure Drop (in Water):  0.919    0.049
  Evaporator Coil Air Pressure Drop (in Water):  1.635    0.000
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  271.76    1.218       Ref-side Cap (Btu/h) : 42104.06  1447.15
        Upstream Temp (F):  105.80    0.768         Ref-side Cap (tons):     3.51     0.12
                                             Refrigerant Mdot (lbm/h):   665.81    23.54
                                           Coriolis Density (lbm/ft3):    82.00     0.58
   Upstream R22 Tsat (F):  119.19    0.349
  Average Subcooling (F):   13.39    0.856

Evap Exit Pressure (psia):   98.72    0.303
     Evap Exit Avg Temp  :   62.09    1.047
       Exit Superheat (F):   12.13    1.002
       Evap Exit Tsat (F):   49.97    0.184
```

Coil 7
R22, H5326, No Fan

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040506a.dat   SUMMARY FILENAME: a040506a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 29842.95   280.91
    Indoor Dry-Bulb : 80.478   0.22    Sensible Cap (Btu/h): 24549.15   294.40
Indoor Inlet Dew (F): 60.104   0.10      Latent Cap (Btu/h):  5293.80   140.99
Indoor Exit Dry-Bulb: 64.374   0.12     EvapAir Delta T (F):  18.49     0.11
 Indoor Exit Dew (F): 57.725   0.07  Air/Ref Cap Prcnt Diff:  -1.65     2.38
                                        Sensible Heat Ratio:   0.823    0.0044
 Indoor Airflow (CFM): 1203.06   9.21          SCFM per Ton:  484.88
Indoor Airflow (SCFM): 1205.86   9.40      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011097
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010177
 Barometric Pressure (in HG):  29.88       Nozzle Temp (F):  63.84   0.46
   Air Chamber Nozzle Pressure Drop (in Water):  0.997    0.015
  Evaporator Coil Air Pressure Drop (in Water):  0.224    0.010
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  269.40    0.487       Ref-side Cap (Btu/h) : 29350.36   597.02
        Upstream Temp (F):  104.63    0.304         Ref-side Cap (tons):     2.45     0.05
                                               Refrigerant Mdot (lbm/h):   461.40     8.79
                                             Coriolis Density (lbm/ft3):    81.70     0.33
    Upstream R22 Tsat (F):  118.51    0.140
   Average Subcooling (F):   13.89    0.363

Evap Exit Pressure (psia):   84.38    0.303
     Evap Exit Avg Temp  :   52.33    1.624
       Exit Superheat (F):   11.56    1.537
       Evap Exit Tsat (F):   40.77    0.206
```

```
                 DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040507a.dat   SUMMARY FILENAME: a040507a.sum
                                                                       Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 25857.20   551.41
    Indoor Dry-Bulb : 79.848   0.35    Sensible Cap (Btu/h): 22239.56   436.75
Indoor Inlet Dew (F): 60.543   0.10      Latent Cap (Btu/h):  3617.64   217.35
Indoor Exit Dry-Bulb: 65.465   0.23     EvapAir Delta T (F):  16.75     0.00
 Indoor Exit Dew (F): 58.962   0.11  Air/Ref Cap Prcnt Diff:  -1.85     2.08
                                        Sensible Heat Ratio:   0.860    0.0073
 Indoor Airflow (CFM): 1206.00  22.60          SCFM per Ton:  559.05
Indoor Airflow (SCFM): 1204.62  23.63      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011289
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010659
 Barometric Pressure (in HG):  29.85       Nozzle Temp (F):  64.90   0.46
   Air Chamber Nozzle Pressure Drop (in Water):  0.999    0.038
  Evaporator Coil Air Pressure Drop (in Water):  0.221    0.010
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  272.58    0.731       Ref-side Cap (Btu/h) : 25378.56   556.29
        Upstream Temp (F):  105.77    0.300         Ref-side Cap (tons):     2.11     0.05
                                             Refrigerant Mdot (lbm/h):   401.25     8.61
                                           Coriolis Density (lbm/ft3):    82.11     0.16
    Upstream R22 Tsat (F):  119.43    0.209
   Average Subcooling (F):   13.66    0.282

Evap Exit Pressure (psia):   90.38    0.364
     Evap Exit Avg Temp  :   56.10    0.960
       Exit Superheat (F):   11.35    0.862
       Evap Exit Tsat (F):   44.75    0.235
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040510a.dat   SUMMARY FILENAME: a040510a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 22002.44   704.07
    Indoor Dry-Bulb : 79.966   0.46    Sensible Cap (Btu/h): 20601.59   599.35
Indoor Inlet Dew (F): 60.200   0.06      Latent Cap (Btu/h):  1400.84   220.96
Indoor Exit Dry-Bulb: 66.622   0.23     EvapAir Delta T (F):  15.54     0.43
 Indoor Exit Dew (F): 59.592   0.06  Air/Ref Cap Prcnt Diff:  -4.94     3.95
                                        Sensible Heat Ratio:   0.936    0.0094
 Indoor Airflow (CFM): 1210.01  17.49          SCFM per Ton:  656.15
Indoor Airflow (SCFM): 1203.07  17.29      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011188
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010943
 Barometric Pressure (in HG):  29.75       Nozzle Temp (F):  65.48   0.59
   Air Chamber Nozzle Pressure Drop (in Water):  1.001    0.029
  Evaporator Coil Air Pressure Drop (in Water):  0.215    0.008
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  266.78    2.071       Ref-side Cap (Btu/h) : 20914.67   485.59
        Upstream Temp (F):  104.31    0.680         Ref-side Cap (tons):     1.74     0.04
                                               Refrigerant Mdot (lbm/h):   328.26     7.24
                                             Coriolis Density (lbm/ft3):    81.79     0.31
    Upstream R22 Tsat (F):  117.76    0.601
   Average Subcooling (F):   13.45    0.686

Evap Exit Pressure (psia):   98.08    0.546
     Evap Exit Avg Temp  :   63.42    1.807
       Exit Superheat (F):   13.85    1.659
       Evap Exit Tsat (F):   49.58    0.332
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040513a.dat   SUMMARY FILENAME: a040513a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 29846.20   378.77
    Indoor Dry-Bulb : 79.918   0.24    Sensible Cap (Btu/h): 24101.01   316.28
Indoor Inlet Dew (F): 60.550   0.10      Latent Cap (Btu/h):  5745.19   232.49
Indoor Exit Dry-Bulb: 64.014   0.17     EvapAir Delta T (F):  18.08     0.11
 Indoor Exit Dew (F): 58.012   0.08  Air/Ref Cap Prcnt Diff:  -0.50     3.91
                                        Sensible Heat Ratio:   0.808    0.0063
 Indoor Airflow (CFM): 1207.72  16.23          SCFM per Ton:  486.62
Indoor Airflow (SCFM): 1210.32  15.90      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011291
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010296
 Barometric Pressure (in HG):  29.85       Nozzle Temp (F):  63.29   0.62
   Air Chamber Nozzle Pressure Drop (in Water):  1.005    0.027
  Evaporator Coil Air Pressure Drop (in Water):  0.219    0.010
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  272.31    0.487       Ref-side Cap (Btu/h) : 29695.17   974.02
        Upstream Temp (F):  104.46    0.455         Ref-side Cap (tons):     2.47     0.08
                                               Refrigerant Mdot (lbm/h):   466.43    15.02
                                             Coriolis Density (lbm/ft3):    81.86     1.27
   Upstream R22 Tsat (F):  119.35    0.139
  Average Subcooling (F):   14.89    0.525

Evap Exit Pressure (psia):   83.66    0.485
     Evap Exit Avg Temp  :   55.15    1.583
       Exit Superheat (F):   14.88    1.532
       Evap Exit Tsat (F):   40.28    0.333
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: b040507b.dat   SUMMARY FILENAME: b040507b.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 21930.45   583.25
    Indoor Dry-Bulb : 79.714   0.18    Sensible Cap (Btu/h): 20248.31   604.31
Indoor Inlet Dew (F): 60.607   0.15      Latent Cap (Btu/h):  1682.14   243.13
Indoor Exit Dry-Bulb: 66.684   0.24     EvapAir Delta T (F):  15.32     0.33
 Indoor Exit Dew (F): 59.882   0.08  Air/Ref Cap Prcnt Diff:  -5.72     3.59
                                        Sensible Heat Ratio:   0.923    0.0096
 Indoor Airflow (CFM): 1206.24  18.32          SCFM per Ton:  656.24
Indoor Airflow (SCFM): 1199.31  18.21      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011350
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.011055
 Barometric Pressure (in HG):  29.76       Nozzle Temp (F):  65.62   0.14
   Air Chamber Nozzle Pressure Drop (in Water):  0.995    0.030
  Evaporator Coil Air Pressure Drop (in Water):  0.214    0.009
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  268.75    0.731       Ref-side Cap (Btu/h) : 20674.47   475.79
        Upstream Temp (F):  105.77    0.454         Ref-side Cap (tons):     1.72     0.04
                                               Refrigerant Mdot (lbm/h):   326.88     6.78
                                             Coriolis Density (lbm/ft3):    82.22     0.16
    Upstream R22 Tsat (F):  118.33    0.211
   Average Subcooling (F):   12.56    0.584

Evap Exit Pressure (psia):   98.92    0.182
     Evap Exit Avg Temp  :   63.26    0.613
       Exit Superheat (F):   13.17    0.613
       Evap Exit Tsat (F):   50.09    0.110
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: b040511b.dat   SUMMARY FILENAME: b040511b.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 25476.71   634.85
    Indoor Dry-Bulb : 80.144   0.24    Sensible Cap (Btu/h): 21755.04   534.33
Indoor Inlet Dew (F): 60.483   0.06      Latent Cap (Btu/h):  3721.67   200.30
Indoor Exit Dry-Bulb: 65.840   0.17     EvapAir Delta T (F):  16.35     0.22
 Indoor Exit Dew (F): 58.853   0.03  Air/Ref Cap Prcnt Diff:  -3.61     2.99
                                        Sensible Heat Ratio:   0.854    0.0060
 Indoor Airflow (CFM): 1207.11  13.97           SCFM per Ton:  568.77
Indoor Airflow (SCFM): 1207.54  13.81      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011245
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010599
 Barometric Pressure (in HG):  29.90       Nozzle Temp (F):  65.02   0.19
   Air Chamber Nozzle Pressure Drop (in Water):  1.002    0.023
  Evaporator Coil Air Pressure Drop (in Water):  0.213    0.009
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  271.40    0.731       Ref-side Cap (Btu/h) : 24555.06   415.26
        Upstream Temp (F):  106.02    0.354         Ref-side Cap (tons):     2.05     0.03
                                                Refrigerant Mdot (lbm/h):   388.73     6.59
                                              Coriolis Density (lbm/ft3):    82.22     0.41
    Upstream R22 Tsat (F):  119.09    0.209
   Average Subcooling (F):   13.07    0.224

Evap Exit Pressure (psia):   90.93    0.303
     Evap Exit Avg Temp  :   58.19    1.001
       Exit Superheat (F):   13.08    1.080
       Evap Exit Tsat (F):   45.11    0.195
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: b040513b.dat   SUMMARY FILENAME: b040513b.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 29800.83   455.45
    Indoor Dry-Bulb : 79.832   0.30    Sensible Cap (Btu/h): 24060.94   441.52
Indoor Inlet Dew (F): 60.562   0.05      Latent Cap (Btu/h):  5739.89   112.39
Indoor Exit Dry-Bulb: 63.937   0.19     EvapAir Delta T (F):  18.06     0.21
 Indoor Exit Dew (F): 58.025   0.05  Air/Ref Cap Prcnt Diff:  -1.08     3.85
                                        Sensible Heat Ratio:   0.807    0.0048
 Indoor Airflow (CFM): 1206.87  15.11          SCFM per Ton:  486.99
Indoor Airflow (SCFM): 1209.38  15.22      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011296
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010301
 Barometric Pressure (in HG):  29.85       Nozzle Temp (F):  63.32   0.46
   Air Chamber Nozzle Pressure Drop (in Water):  1.003    0.025
  Evaporator Coil Air Pressure Drop (in Water):  0.219    0.008
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  272.41    0.731      Ref-side Cap (Btu/h) : 29478.53   993.29
        Upstream Temp (F):  104.49    0.828        Ref-side Cap (tons):     2.46     0.08
                                               Refrigerant Mdot (lbm/h):   463.10    14.01
                                             Coriolis Density (lbm/ft3):    81.72     1.00
    Upstream R22 Tsat (F):  119.38    0.209
   Average Subcooling (F):   14.89    0.849

Evap Exit Pressure (psia):   83.74    0.303
     Evap Exit Avg Temp  :   54.77    1.352
       Exit Superheat (F):   14.43    1.352
       Evap Exit Tsat (F):   40.33    0.208
```

Coil 8
R22, H5321, No Fan

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040521a.dat   SUMMARY FILENAME: a040521a.sum
                                                                      Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 34023.81   981.82
    Indoor Dry-Bulb : 80.133   0.15    Sensible Cap (Btu/h): 29126.82   963.08
Indoor Inlet Dew (F): 60.562   0.02      Latent Cap (Btu/h):  4896.99   115.91
Indoor Exit Dry-Bulb: 63.116   0.15     EvapAir Delta T (F):  19.15     0.43
 Indoor Exit Dew (F): 58.688   0.03  Air/Ref Cap Prcnt Diff:   9.58     3.56
                                        Sensible Heat Ratio:   0.856    0.0036
 Indoor Airflow (CFM): 1375.64  17.99          SCFM per Ton:  486.97
Indoor Airflow (SCFM): 1380.73  17.33      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011300
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010557
 Barometric Pressure (in HG):  29.84       Nozzle Temp (F):  62.11   0.60
   Air Chamber Nozzle Pressure Drop (in Water):  1.304    0.033
  Evaporator Coil Air Pressure Drop (in Water):  0.312    0.015
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  265.11    0.670      Ref-side Cap (Btu/h) : 37280.82   519.41
        Upstream Temp (F):  106.24    0.313        Ref-side Cap (tons):     3.11     0.04
                                                Refrigerant Mdot (lbm/h):   590.85     8.43
                                              Coriolis Density (lbm/ft3):    72.75     0.43
    Upstream R22 Tsat (F):  117.27    0.195
   Average Subcooling (F):   11.03    0.384

Evap Exit Pressure (psia):   90.52    0.243
     Evap Exit Avg Temp  :   56.58    1.512
       Exit Superheat (F):   11.74    1.521
       Evap Exit Tsat (F):   44.84    0.157
```

```
                DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
          DATA FILENAME: a040525a.dat   SUMMARY FILENAME: a040525a.sum
                                                                       Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 41587.87   912.40
    Indoor Dry-Bulb : 80.121   0.31    Sensible Cap (Btu/h): 32532.92   869.32
Indoor Inlet Dew (F): 60.483   0.06      Latent Cap (Btu/h):  9054.96   215.10
Indoor Exit Dry-Bulb: 60.967   0.15     EvapAir Delta T (F):  21.33     0.43
 Indoor Exit Dew (F): 56.923   0.05  Air/Ref Cap Prcnt Diff:   2.90     2.82
                                        Sensible Heat Ratio:   0.782    0.0054
 Indoor Airflow (CFM): 1373.54  11.26          SCFM per Ton:  399.68
Indoor Airflow (SCFM): 1385.14  11.42      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011265
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009894
 Barometric Pressure (in HG):  29.85       Nozzle Temp (F):  60.03   0.16
   Air Chamber Nozzle Pressure Drop (in Water):  1.306    0.021
  Evaporator Coil Air Pressure Drop (in Water):  0.316    0.008
--------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  269.25    0.853      Ref-side Cap (Btu/h) : 42791.57   751.47
        Upstream Temp (F):  106.11    0.273        Ref-side Cap (tons):     3.57     0.06
                                              Refrigerant Mdot (lbm/h):   677.74    12.09
                                            Coriolis Density (lbm/ft3):    82.42     0.75
    Upstream R22 Tsat (F):  118.47    0.246
   Average Subcooling (F):   12.36    0.273

Evap Exit Pressure (psia):   84.72    0.243
     Evap Exit Avg Temp  :   53.52    2.057
       Exit Superheat (F):   12.52    2.016
       Evap Exit Tsat (F):   41.00    0.165
```

```
                  DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
        DATA FILENAME: a040526a.dat   SUMMARY FILENAME: a040526a.sum
                                                                   Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 29513.51   480.65
    Indoor Dry-Bulb : 79.841   0.15    Sensible Cap (Btu/h): 25443.70   460.28
Indoor Inlet Dew (F): 60.427   0.06      Latent Cap (Btu/h):  4069.81   275.45
Indoor Exit Dry-Bulb: 65.396   0.18     EvapAir Delta T (F):  16.71     0.22
 Indoor Exit Dew (F): 58.878   0.08  Air/Ref Cap Prcnt Diff:  -3.10     2.06
                                        Sensible Heat Ratio:   0.862    0.0083
 Indoor Airflow (CFM): 1388.51  16.29          SCFM per Ton:  561.88
Indoor Airflow (SCFM): 1381.91  16.94      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011291
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010674
 Barometric Pressure (in HG):  29.72       Nozzle Temp (F):  64.39   0.34
   Air Chamber Nozzle Pressure Drop (in Water):  1.317    0.031
  Evaporator Coil Air Pressure Drop (in Water):  0.312    0.016
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  269.95    0.731       Ref-side Cap (Btu/h) : 28597.29   566.54
        Upstream Temp (F):  105.86    0.390         Ref-side Cap (tons):     2.38     0.05
                                             Refrigerant Mdot (lbm/h):   452.35     8.52
                                           Coriolis Density (lbm/ft3):    82.50     0.25
    Upstream R22 Tsat (F):  118.67    0.210
   Average Subcooling (F):   12.82    0.390

Evap Exit Pressure (psia):   97.57    0.364
     Evap Exit Avg Temp  :   64.00    1.240
       Exit Superheat (F):   14.73    1.388
       Evap Exit Tsat (F):   49.27    0.222
```

```
               DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
          DATA FILENAME: a040527a.dat   SUMMARY FILENAME: a040527a.sum
                                                                       Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 41721.31  1434.02
    Indoor Dry-Bulb : 80.055   0.17    Sensible Cap (Btu/h): 33072.64   393.65
Indoor Inlet Dew (F): 60.304   0.60      Latent Cap (Btu/h):  8648.66  1514.12
Indoor Exit Dry-Bulb: 60.780   0.20     EvapAir Delta T (F):  21.55     0.22
 Indoor Exit Dew (F): 56.914   0.09  Air/Ref Cap Prcnt Diff:   3.26     5.66
                                        Sensible Heat Ratio:   0.793    0.0305
 Indoor Airflow (CFM): 1381.48  15.68          SCFM per Ton:  400.82
Indoor Airflow (SCFM): 1393.57  15.10      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011192
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009890
 Barometric Pressure (in HG):  29.85       Nozzle Temp (F):  59.86   0.53
   Air Chamber Nozzle Pressure Drop (in Water):  1.321    0.029
  Evaporator Coil Air Pressure Drop (in Water):  0.318    0.014
--------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  267.87    0.731      Ref-side Cap (Btu/h) : 43077.28  1092.28
        Upstream Temp (F):  105.13    0.543        Ref-side Cap (tons):     3.59     0.09
                                              Refrigerant Mdot (lbm/h):   678.91    17.22
                                            Coriolis Density (lbm/ft3):    82.18     0.34
   Upstream R22 Tsat (F):  118.07    0.211
  Average Subcooling (F):   12.94    0.684

Evap Exit Pressure (psia):   84.34    0.485
     Evap Exit Avg Temp  :   55.85    1.507
       Exit Superheat (F):   15.11    1.507
       Evap Exit Tsat (F):   40.74    0.330
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: b040527b.dat   SUMMARY FILENAME: b040527b.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 41707.19  1020.24
    Indoor Dry-Bulb : 79.862   0.19    Sensible Cap (Btu/h): 32752.75   819.05
Indoor Inlet Dew (F): 60.391   0.07      Latent Cap (Btu/h):  8954.44   263.78
Indoor Exit Dry-Bulb: 60.734   0.09     EvapAir Delta T (F):  21.32     0.32
 Indoor Exit Dew (F): 56.888   0.03  Air/Ref Cap Prcnt Diff:   3.12     3.21
                                        Sensible Heat Ratio:   0.785    0.0048
 Indoor Airflow (CFM): 1382.69  15.13          SCFM per Ton:  401.39
Indoor Airflow (SCFM): 1395.06  15.46      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011227
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009881
 Barometric Pressure (in HG):  29.85       Nozzle Temp (F):  59.77   0.14
   Air Chamber Nozzle Pressure Drop (in Water):  1.324    0.029
  Evaporator Coil Air Pressure Drop (in Water):  0.317    0.012
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  268.09    0.731       Ref-side Cap (Btu/h) : 43005.16   831.09
        Upstream Temp (F):  105.41    0.294         Ref-side Cap (tons):     3.58     0.07
                                               Refrigerant Mdot (lbm/h):   678.73    12.46
                                             Coriolis Density (lbm/ft3):    82.29     0.47
    Upstream R22 Tsat (F):  118.14    0.211
   Average Subcooling (F):   12.72    0.343

Evap Exit Pressure (psia):   84.17    0.243
     Evap Exit Avg Temp  :   54.43    1.860
       Exit Superheat (F):   13.81    1.943
       Evap Exit Tsat (F):   40.63    0.165
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040603a.dat   SUMMARY FILENAME: a040603a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 34980.44   729.98
    Indoor Dry-Bulb : 80.150   0.25    Sensible Cap (Btu/h): 29184.59   705.22
Indoor Inlet Dew (F): 60.541   0.06      Latent Cap (Btu/h):  5795.86   519.27
Indoor Exit Dry-Bulb: 63.310   0.17     EvapAir Delta T (F):  18.99     0.32
 Indoor Exit Dew (F): 58.331   0.24  Air/Ref Cap Prcnt Diff:   2.84     2.75
                                        Sensible Heat Ratio:   0.834    0.0126
 Indoor Airflow (CFM): 1390.38  10.12          SCFM per Ton:  478.63
Indoor Airflow (SCFM): 1395.23  10.23      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011288
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010417
 Barometric Pressure (in HG):  29.85       Nozzle Temp (F):  62.44   0.46
   Air Chamber Nozzle Pressure Drop (in Water):  1.331    0.019
  Evaporator Coil Air Pressure Drop (in Water):  0.312    0.009
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  273.51    0.792       Ref-side Cap (Btu/h) : 35974.64   595.49
        Upstream Temp (F):  105.60    0.455         Ref-side Cap (tons):     3.00     0.05
                                              Refrigerant Mdot (lbm/h):   568.32     9.62
                                            Coriolis Density (lbm/ft3):    82.41     0.16
   Upstream R22 Tsat (F):  119.69    0.225
  Average Subcooling (F):   14.09    0.620

Evap Exit Pressure (psia):   91.83    0.425
     Evap Exit Avg Temp  :   57.65    1.747
       Exit Superheat (F):   11.96    1.747
       Evap Exit Tsat (F):   45.69    0.271
```

```
             DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
        DATA FILENAME: a040607a.dat   SUMMARY FILENAME: a040607a.sum
                                                                    Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 27090.45   778.33
    Indoor Dry-Bulb : 80.205   0.17    Sensible Cap (Btu/h): 24679.42   794.58
Indoor Inlet Dew (F): 60.519   0.06      Latent Cap (Btu/h):  2411.02   212.56
Indoor Exit Dry-Bulb: 66.346   0.11     EvapAir Delta T (F):  16.11     0.43
 Indoor Exit Dew (F): 59.617   0.05  Air/Ref Cap Prcnt Diff:  -1.12     3.30
                                        Sensible Heat Ratio:   0.911    0.0085
 Indoor Airflow (CFM): 1395.31  13.71          SCFM per Ton:  615.80
Indoor Airflow (SCFM): 1390.19  13.33      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011294
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010931
 Barometric Pressure (in HG):  29.81       Nozzle Temp (F):  65.33   0.57
   Air Chamber Nozzle Pressure Drop (in Water):  1.331    0.026
  Evaporator Coil Air Pressure Drop (in Water):  0.307    0.013
--------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  273.06    0.487      Ref-side Cap (Btu/h) : 26784.91   450.70
        Upstream Temp (F):  105.68    0.315        Ref-side Cap (tons):     2.23     0.04
                                              Refrigerant Mdot (lbm/h):   423.29     6.96
                                            Coriolis Density (lbm/ft3):    82.46     0.14
    Upstream R22 Tsat (F):  119.56    0.139
   Average Subcooling (F):   13.89    0.315

Evap Exit Pressure (psia):   99.96    0.243
     Evap Exit Avg Temp  :   64.36    1.181
       Exit Superheat (F):   13.65    1.181
       Evap Exit Tsat (F):   50.71    0.146
```

Coil 9
R410A, A01154, Fan

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040716a.dat   SUMMARY FILENAME: a040716a.sum
                                                                      Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 19952.67   354.03
    Indoor Dry-Bulb : 79.986   0.14    Sensible Cap (Btu/h): 12845.02   284.44
Indoor Inlet Dew (F): 60.436   0.06      Latent Cap (Btu/h):  7107.65   136.91
Indoor Exit Dry-Bulb: 58.954   0.16     EvapAir Delta T (F):  23.24     0.32
 Indoor Exit Dew (F): 52.186   0.10  Air/Ref Cap Prcnt Diff:   0.48     2.14
                                        Sensible Heat Ratio:   0.644    0.0049
 Indoor Airflow (CFM):  501.58   5.80          SCFM per Ton:  302.28
Indoor Airflow (SCFM):  502.60   6.20      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011330
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.008365
 Barometric Pressure (in HG):  29.63       Nozzle Temp (F):  60.37   0.82
   Air Chamber Nozzle Pressure Drop (in Water):  0.905    0.021
  Evaporator Coil Air Pressure Drop (in Water):  1.940    0.000
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  425.06    2.071       Ref-side Cap (Btu/h) : 20047.22   377.05
        Upstream Temp (F):  104.08    0.289         Ref-side Cap (tons):     1.67     0.03
                                               Refrigerant Mdot (lbm/h):   313.67     5.95
                                             Coriolis Density (lbm/ft3):    72.80     0.16
   Upstream R22 Tsat (F):  118.59    0.377
  Average Subcooling (F):   14.52    0.458

Evap Exit Pressure (psia):  148.69    0.728
     Evap Exit Avg Temp  :   61.26    0.676
       Exit Superheat (F):   14.55    0.697
       Evap Exit Tsat (F):   46.71    0.295
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040728a.dat   SUMMARY FILENAME: a040728a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 13018.25   438.26
    Indoor Dry-Bulb : 80.075   0.20    Sensible Cap (Btu/h):  9855.61   293.12
Indoor Inlet Dew (F): 60.371   0.05      Latent Cap (Btu/h):  3162.64   233.87
Indoor Exit Dry-Bulb: 64.382   0.22     EvapAir Delta T (F):  17.85     0.43
 Indoor Exit Dew (F): 56.937   0.26  Air/Ref Cap Prcnt Diff:   3.39     6.66
                                        Sensible Heat Ratio:   0.757    0.0126
 Indoor Airflow (CFM):  502.39   5.71          SCFM per Ton:  462.20
Indoor Airflow (SCFM):  501.42   5.74      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011241
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009919
 Barometric Pressure (in HG):  29.79       Nozzle Temp (F):  64.77   0.64
   Air Chamber Nozzle Pressure Drop (in Water):  0.904    0.020
  Evaporator Coil Air Pressure Drop (in Water):  2.000    0.000
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  425.00    1.279       Ref-side Cap (Btu/h) : 13458.06   676.75
        Upstream Temp (F):  104.53    0.350         Ref-side Cap (tons):     1.12     0.06
                                               Refrigerant Mdot (lbm/h):   211.23    10.62
                                             Coriolis Density (lbm/ft3):    72.85     0.36
    Upstream R22 Tsat (F):  118.58    0.233
   Average Subcooling (F):   14.05    0.483

Evap Exit Pressure (psia):  160.83    0.485
     Evap Exit Avg Temp  :   64.99    1.716
       Exit Superheat (F):   13.50    1.902
       Evap Exit Tsat (F):   51.49    0.186
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040729a.dat   SUMMARY FILENAME: a040729a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 20056.82   491.41
    Indoor Dry-Bulb : 79.633   0.40    Sensible Cap (Btu/h): 12753.21   283.59
Indoor Inlet Dew (F): 60.733   0.10      Latent Cap (Btu/h):  7303.61   246.33
Indoor Exit Dry-Bulb: 58.829   0.13     EvapAir Delta T (F):  22.94     0.32
 Indoor Exit Dew (F): 52.283   0.34  Air/Ref Cap Prcnt Diff:   2.06     7.48
                                        Sensible Heat Ratio:   0.636    0.0039
 Indoor Airflow (CFM):  499.63   5.05          SCFM per Ton:  302.43
Indoor Airflow (SCFM):  505.48   4.62      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011351
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.008322
 Barometric Pressure (in HG):  29.89       Nozzle Temp (F):  59.92   0.55
   Air Chamber Nozzle Pressure Drop (in Water):  0.906    0.017
  Evaporator Coil Air Pressure Drop (in Water):  2.000    0.000
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  420.74    5.177       Ref-side Cap (Btu/h) : 20469.27  1264.18
        Upstream Temp (F):  105.86    2.763         Ref-side Cap (tons):     1.71     0.11
                                               Refrigerant Mdot (lbm/h):   324.24    14.01
                                             Coriolis Density (lbm/ft3):    73.10     0.81
    Upstream R22 Tsat (F):  117.80    0.947
   Average Subcooling (F):   11.95    3.591

Evap Exit Pressure (psia):  145.54    2.669
     Evap Exit Avg Temp  :   59.76   10.064
       Exit Superheat (F):   14.34   11.159
       Evap Exit Tsat (F):   45.42    1.095
```

```
             DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: b040729b.dat   SUMMARY FILENAME: b040729b.sum
                                                                    Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 20078.83   368.42
    Indoor Dry-Bulb : 80.044   0.28    Sensible Cap (Btu/h): 12900.77   277.15
Indoor Inlet Dew (F): 60.663   0.10      Latent Cap (Btu/h):  7178.06   142.28
Indoor Exit Dry-Bulb: 59.059   0.12     EvapAir Delta T (F):  23.24     0.32
 Indoor Exit Dew (F): 52.348   0.08  Air/Ref Cap Prcnt Diff:   2.43     3.30
                                        Sensible Heat Ratio:   0.643    0.0043
 Indoor Airflow (CFM):  499.25   5.00          SCFM per Ton:  301.73
Indoor Airflow (SCFM):  504.86   4.90      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011322
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.008341
 Barometric Pressure (in HG):  29.89       Nozzle Temp (F):  60.17   0.83
   Air Chamber Nozzle Pressure Drop (in Water):  0.904    0.018
  Evaporator Coil Air Pressure Drop (in Water):  2.000    0.000
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  422.34    0.853      Ref-side Cap (Btu/h) : 20565.08   359.86
        Upstream Temp (F):  105.76    0.454        Ref-side Cap (tons):     1.71     0.03
                                               Refrigerant Mdot (lbm/h):   325.54     6.05
                                             Coriolis Density (lbm/ft3):    73.13     0.23
    Upstream R22 Tsat (F):  118.10    0.156
   Average Subcooling (F):   12.34    0.365

Evap Exit Pressure (psia):  146.06    0.303
     Evap Exit Avg Temp  :   58.79    1.633
       Exit Superheat (F):   13.15    1.633
       Evap Exit Tsat (F):   45.64    0.125
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040730a.dat   SUMMARY FILENAME: a040730a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 23873.45   528.34
    Indoor Dry-Bulb : 79.875   0.22    Sensible Cap (Btu/h): 14650.46   408.94
Indoor Inlet Dew (F): 60.410   0.10      Latent Cap (Btu/h):  9222.99   136.03
Indoor Exit Dry-Bulb: 55.759   0.09     EvapAir Delta T (F):  26.22     0.43
 Indoor Exit Dew (F): 49.191   0.05  Air/Ref Cap Prcnt Diff:   2.59     2.58
                                        Sensible Heat Ratio:   0.614    0.0054
 Indoor Airflow (CFM):  498.81   5.64          SCFM per Ton:  255.62
Indoor Airflow (SCFM):  508.54   5.84      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011196
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.007394
 Barometric Pressure (in HG):  29.95       Nozzle Temp (F):  57.28   0.79
   Air Chamber Nozzle Pressure Drop (in Water):  0.910    0.021
  Evaporator Coil Air Pressure Drop (in Water):  2.000    0.000
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  420.09    0.975       Ref-side Cap (Btu/h) : 24489.87   230.39
        Upstream Temp (F):  104.60    0.341         Ref-side Cap (tons):     2.04     0.02
                                               Refrigerant Mdot (lbm/h):   384.57     3.21
                                             Coriolis Density (lbm/ft3):    72.80     0.27
    Upstream R22 Tsat (F):  117.68    0.179
   Average Subcooling (F):   13.08    0.374

Evap Exit Pressure (psia):  138.64    0.425
     Evap Exit Avg Temp  :   56.11    0.591
       Exit Superheat (F):   13.59    0.581
       Evap Exit Tsat (F):   42.53    0.181
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040803a.dat   SUMMARY FILENAME: a040803a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 15230.41   604.05
    Indoor Dry-Bulb : 80.216   0.47    Sensible Cap (Btu/h): 11003.77   360.44
Indoor Inlet Dew (F): 60.383   0.44      Latent Cap (Btu/h):  4226.64   435.63
Indoor Exit Dry-Bulb: 62.392   0.27     EvapAir Delta T (F):  19.91     0.43
 Indoor Exit Dew (F): 55.700   0.25  Air/Ref Cap Prcnt Diff:   3.44     7.17
                                        Sensible Heat Ratio:   0.722    0.0211
 Indoor Airflow (CFM):  500.37   5.94          SCFM per Ton:  395.56
Indoor Airflow (SCFM):  502.05   5.68      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011227
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009462
 Barometric Pressure (in HG):  29.84       Nozzle Temp (F):  63.02   0.70
   Air Chamber Nozzle Pressure Drop (in Water):  0.901    0.021
  Evaporator Coil Air Pressure Drop (in Water):  2.000    0.000
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  426.42    4.507      Ref-side Cap (Btu/h) : 15753.76   782.81
        Upstream Temp (F):  105.37    1.638        Ref-side Cap (tons):     1.31     0.07
                                              Refrigerant Mdot (lbm/h):   248.70    14.29
                                            Coriolis Density (lbm/ft3):    73.10     0.60
    Upstream R22 Tsat (F):  118.84    0.819
   Average Subcooling (F):   13.48    1.173

Evap Exit Pressure (psia):  159.78    1.213
     Evap Exit Avg Temp  :   65.49    3.001
       Exit Superheat (F):   14.40    3.292
       Evap Exit Tsat (F):   51.09    0.466
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: b040803b.dat   SUMMARY FILENAME: b040803b.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 15328.62   177.88
    Indoor Dry-Bulb : 80.106   0.21    Sensible Cap (Btu/h): 10983.96   159.46
Indoor Inlet Dew (F): 60.463   0.05      Latent Cap (Btu/h):  4344.66    70.27
Indoor Exit Dry-Bulb: 62.313   0.11     EvapAir Delta T (F):  19.86     0.22
 Indoor Exit Dew (F): 55.656   0.03  Air/Ref Cap Prcnt Diff:   2.61     3.99
                                        Sensible Heat Ratio:   0.717    0.0044
 Indoor Airflow (CFM):  500.68   5.04          SCFM per Ton:  393.29
Indoor Airflow (SCFM):  502.38   4.71      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011259
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.009447
 Barometric Pressure (in HG):  29.84       Nozzle Temp (F):  63.00   0.62
   Air Chamber Nozzle Pressure Drop (in Water):  0.903    0.017
  Evaporator Coil Air Pressure Drop (in Water):  2.000    0.000
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  427.81    1.766       Ref-side Cap (Btu/h) : 15728.51   604.89
        Upstream Temp (F):  105.94    0.429         Ref-side Cap (tons):     1.31     0.05
                                               Refrigerant Mdot (lbm/h):   249.30     9.07
                                             Coriolis Density (lbm/ft3):    73.21     0.21
    Upstream R22 Tsat (F):  119.09    0.320
   Average Subcooling (F):   13.15    0.518

Evap Exit Pressure (psia):  159.82    0.243
     Evap Exit Avg Temp  :   65.51    1.029
       Exit Superheat (F):   14.41    1.122
       Evap Exit Tsat (F):   51.10    0.093
```

```
                   DOE/ARI MIX-MATCH EVAPORATOR TEST SUMMARY SHEET
         DATA FILENAME: a040817a.dat   SUMMARY FILENAME: a040817a.sum
                                                                        Range
  Air-Side Conditions        Range  Total Air-Side Capacity: 11007.81   265.30
    Indoor Dry-Bulb : 79.944   0.34    Sensible Cap (Btu/h):  9076.99   221.25
Indoor Inlet Dew (F): 60.380   0.15      Latent Cap (Btu/h):  1930.83   110.83
Indoor Exit Dry-Bulb: 65.709   0.17     EvapAir Delta T (F):  16.35     0.22
 Indoor Exit Dew (F): 58.334   0.18  Air/Ref Cap Prcnt Diff:   5.15     3.35
                                        Sensible Heat Ratio:   0.825    0.0077
 Indoor Airflow (CFM):  504.95   6.74          SCFM per Ton:  549.33
Indoor Airflow (SCFM):  503.91   7.26      (0.075 lb/ft3 standard air)
Evap Inlet Humidity Ratio (lbH2O/lbAir):   0.011211
 Evap Exit Humidity Ratio (lbH2O/lbAir):   0.010407
 Barometric Pressure (in HG):  29.88       Nozzle Temp (F):  66.27   0.55
   Air Chamber Nozzle Pressure Drop (in Water):  0.913    0.025
  Evaporator Coil Air Pressure Drop (in Water):  2.000    0.000
-------------------------------------------------------------------------------
Refrigerant Side Conditions
 Expansion Valve
 Upstream Pressure (psia):  432.75    1.157       Ref-side Cap (Btu/h) : 11574.22   244.37
        Upstream Temp (F):  104.11    0.487         Ref-side Cap (tons):     0.96     0.02
                                               Refrigerant Mdot (lbm/h):   181.14     3.66
                                             Coriolis Density (lbm/ft3):    72.91     0.21
    Upstream R22 Tsat (F):  119.98    0.208
   Average Subcooling (F):   15.87    0.596

Evap Exit Pressure (psia):  167.22    0.728
     Evap Exit Avg Temp  :   67.73    0.893
       Exit Superheat (F):   13.83    0.983
       Evap Exit Tsat (F):   53.90    0.270
```