AR No. 3 - Refrigeration Discharge Pressure

Recommendation

Lower the minimum ammonia condensing (discharge) pressure on the refrigeration compressors to 128 psig (75.8°F) and install a variable speed drive on the condenser fans to decrease associated energy costs by 7%.

Assessment Recommendation Savings Summary

Source	*Quantity*	*Units*	*Cost Savings*
Electrical Consumption	69,909	kWh (site)	$3,021
Total	**238.6**	**MMBtu**	**$3,021**

Assessment Recommendation Cost Summary

Description	*Cost*	*Payback*
Implementation Cost	$10,000	3.3

Facility Background

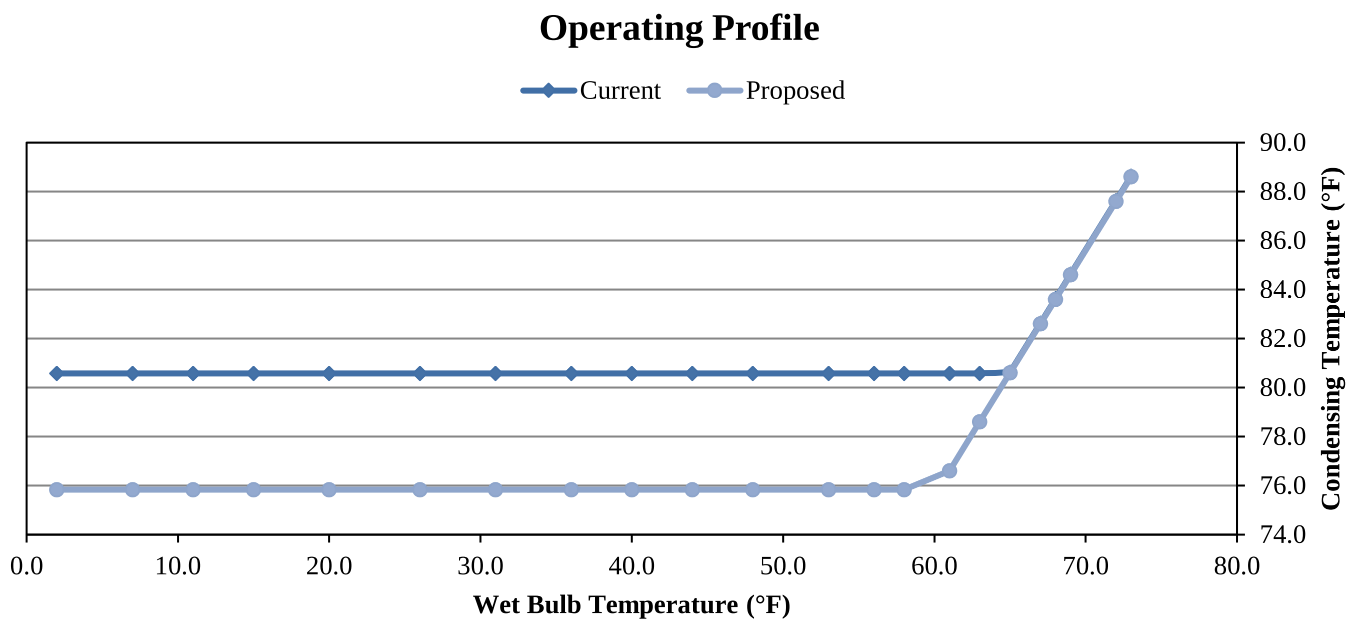
The facility currently uses an ammonia refrigeration system to serve its cooling requirements; mostly for the blow mold process in plastics. Both of the two Mycom refrigerant compressors are used at full capacity all of the time, except when one is down for maintenance. Each Mycom compressor is powered by a 100 hp electric motor coupled via belt drive. For information collected on-site, see Site Reports in the Site Data section.

Technology Background

Refrigeration discharge temperature is determined by the condenser's capacity to reject heat. When the condensing pressure goes below a minimum pressure setting, selected by operators, condenser fans turn off. This reduces condenser capacity and prevents the temperature and associated pressure from going below the set point. Compressors require less energy to operate against low discharge pressures, but to reduce this discharge pressure, the condenser fans must operate more frequently. As condenser fans typically use significantly less energy than the compressor, reducing compressor use can lead to significant energy savings. Reducing compressor discharge pressure saves approximately 1% of compressor energy consumption for each degree Fahrenheit reduction of condensing temperature.

Proposal

Adjust your minimum discharge pressure set points to 128 psig (75.8°F) and install a variable speed drive (VSD) on the condenser fans. If implemented, the recommended actions will save 69,909 kWh annually and result in annual cost savings of $3,021 for a 3.3 year payback after a $10,000 implementation cost.



Notes

Often there are specific applications that drive the need for high pressure set points. Below is a list of four common reasons for having such set points and how they can be fixed.

1. Liquid Injection Cooling typically consumes 5-15% of the compressor power to recompress injected refrigerant and is used to cool the compressor. Install thermo syphon oil cooling to avoid power and energy costs associated with liquid injection oil cooling. Thermosyphon cooling does not consume compressor power.
2. Expansion Device Design can lead to higher required discharge pressures. By looking into different designs, having your system evaluated and selecting components that operate well with lower discharge pressure, the efficiency of your refrigeration system can be improved.
3. Moving Refrigerant to Distant Endpoints can lead to a need for higher discharge pressures to ensure refrigerant can reach its destination. By installing liquid pumps in the system, discharge pressure can be reduced while still serving the entire refrigeration system.
4. Hot Gas Defrost is sometimes used to defrost evaporators as needed and requires a high discharge pressure. We suggest only raising the discharge pressure when needed for hot gas defrost and letting the discharge pressure drop lower otherwise, or using another defrost strategy such as applying warm process water.

Check to make sure your facility does not require high pressure set points for special applications before making alterations to your process or equipment.

Typically, ammonia refrigeration systems can run at a discharge pressure of 95-100 psig for the highest efficiency. In this case the most savings results from a pressure of 128 psig. This could be due to a dirty or fouled condensing unit. We recommend performing regular maintenance checks on the condensing unit to avoid energy losses.

AR No. 3 - Data Preparation

Implementation Cost

Overall Material Costs

Number of Fans	(n_F)	*3*		
Fan Power	(P_F)	*15*	hp	
Incremental Implementation Cost	(IC_{hp})	*$200*	/hp	**(Rf. 1)**
Total Material Cost	(C_M)	***$9,000***		**(Eq. 1)**

Individual Material Costs

Condenser Fan VSD	(C_{VSD})	***$1,980***	**(Rf. 2)**
Bypass	(C_B)	***$1,630***	**(Rf. 2)**
Drive and Bypass Cost	(C_{DB})	***$3,610***	**(Eq. 2)**
VSD Controller Cost	(C_C)	***$5,390***	**(N. 1)**

Labor Costs

Total Labor Cost	(C_L)	***$1,000***	**(Rf. 2, N. 2)**

Total Cost

Total Implementation Cost	(C_I)	***$10,000***	**(Eq. 4)**

References

N. 1) VSD controller cost (C_C) is assumed to be the remaining amount of the total implementation cost (C_M) after subtracting the costs for the VSD drive and bypass (C_{DB}).

N. 2) This includes labor costs, installation costs, and any miscellaneous costs.

Equations

Eq. 1) Total Material Cost (C_M)

$$n_F \times P_F \times IC_{hp}$$

Eq. 2) Drive and Bypass Cost (C_{DB})

$$C_{VSD} + C_B$$

Eq. 3) VSD Controller Cost (C_C)

$$C_M - C_{DB}$$

Eq. 4) Total Implementation Cost (C_I)

$$C_M + C_L$$

References

Rf. 1) An estimate for implementation cost of condenser fan VSDs is $200/fan hp. Source: Peterson, Allen, Joe Junker, and Greg Wheeler. "Recommendation #4: Install ASD on Condenser Fans." Assessing Industrial Refrigeration Efficiency. 37-38. Print.

Rf. 2) From VSD cost estimate tool. Confirmed with grainger website.

AR No. 3 - Analysis

General Data

Overall Material Costs

Number of Fans		*Ammonia*		(N. 1)
Fan Power		*Evaporative*		(N. 1)
Condenser Fan Control Type		*On-Off*		(N. 1)
Operating Hours	(t_h)	*7,200*	hrs./yr.	(N. 1)

Individual Material Costs

Condenser Fan VSD	(p_{DC})	*140.0*	psig	(N. 1)
Minimum Discharge Temperature	(T_{DC})	*80.6*	°F	(N. 2)

Drive and Bypass Cost

VSD Controller Cost	(IC_E)	*$0.04322*	/kWh	(Rf. 1)

Assumptions

Proposed Set Points

Minimum Discharge Pressure	(p_{DP})	*128.0*	psig	(N. 3)
Minimum Discharge Temperature	(T_{DP})	*75.8*	°F	(N. 2)

Proposed Condenser System Data

Condenser Fan Control Type		*VSD*		
Proposed Approach Temperature	(T_{AP})	*15.6*	°F	(N. 4)
VSD Efficiency	(η_{VSD})	*97.0%*		(Rf. 2)

Compressor Savings

Compressor Energy Savings Factor	($F_{\%S}$)	*1.0%*	/°F	(Rf. 3)

Condenser Approach Analysis

Discharge Temperature

Minimum Discharge Pressure	(p_{DM})	*135.0*	psig	(N. 5)
Measured Discharge Temperature	(T_{DM})	*78.6*	°F	(N. 2)

Weather Readings

Dry Bulb Temperature	(T_{DB})	*77.0*	°F	(N. 6)
Wet Bulb Temperature	(T_{WB})	*63.0*	°F	(N. 6)

Approach Temperature

Minimum Approach Temperature	(T_{AC})	*15.6*	°F	(Eq. 1)

References

Rf. 1) Incremental energy costs developed in the Utility Analysis located in the Site Data section.

Rf. 2) VSD efficiencies are assumed by analysts based on *Motor Tip Sheet #11,* June 2008, USDOE, Industrial Technologies Program, Energy Efficiency and Renewable Energy.

Rf. 3) Compressor energy savings factor from *Industrial Refrigeration Best Practices Guide* , Cascade Energy Engineering, December 2004

Equations

Eq. 1) Current Approach Temperature (T_{AC})

If evaporative condenser

$$T_{DM} - T_{WB}$$

If air cooled condenser

$$T_{DM} - T_{DB}$$

Notes

N. 1) Refrigeration system information collected on-site during the assessment, for more details see Site Reports in the Site Data section.

N. 2) Corresponding temperature for the specified pressure and refrigerant type from thermodynamic tables.

N. 3) As discharge pressure decreases, fan energy use increases. There is a tradeoff between compressor energy use and fan energy use. Proposed minimum discharge pressure (T_{AC}) was calculated at the pressure that would result in the most savings. Typically discharge pressure could be reduced by a larger amount. Compromised condensers may be the reason that a lower discharge pressure is not an optimal solution. This might indicate that the condensers are dirty or undersized, or they may have fouled heat exchangers or non-condensable gases.

N. 4) Proposed approach temperature is assumed the same as current approach temperature.

N. 5) Minimum discharge temperature difference determined by observing the system under typical loading conditions with all heat exchanger fans running at full-power.

N. 6) Dry bulb temperature was measured on-site using a thermal couple. Weather data (see Reference 6) for the day of the visit was used to determine the wet bulb temperature.

AR No. 3 - Analysis

Energy Use Summary

Current Conditions

Compressor Energy Consumption	(E_{CC})	*868,676*	kWh	**(Rf. 4)**
Fan Energy Consumption	(E_{FC})	*119,534*	kWh	**(Rf. 4)**
Total Energy Consumption	(E_{TC})	*988,210*	kWh	**(Eq. 2)**

Proposed Conditions

Compressor Energy Consumption	(E_{CP})	*829,520*	kWh	**(Rf. 4)**
Fan Energy Consumption	(E_{FP})	*88,780*	kWh	**(Rf. 4)**
Total Energy Consumption	(E_{TP})	*918,301*	kWh	**(Eq. 2)**

Savings

Total Energy Savings	(E_{TS})	*69,909*	kWh	**(Eq. 3)**

Economic Results

Cost Savings	(C_S)	*$3,021*	/yr.	**(Eq. 4)**
Implementation Cost	(C_I)	*$10,000*		**(Rf. 7)**
Payback	(t_{PB})	*3.3*	years	

Notes

N. 7) There is no implementation cost associated with plant personnel adjusting the refrigeration system discharge pressure.

References

Rf. 4) Current and proposed energy consumption values developed analysis table on following pages.

Rf. 5) Motor load factor developed in the previous Motor Analysis Tool (MAT) pages.

Rf. 6) Weather bin data is processed using the DOE2 tool and TMY3 data from the National Solar Radiation Data Base.

Rf. 7) Taken from previous Data Preparation page

Equations

Eq. 2) Total Energy Consumption ($E_{TC,TP}$)

$$E_{CC,CP} + E_{FC,FP}$$

Eq. 3) Total Energy Savings (E_{TS})

$$E_{TC} - E_{TP}$$

Eq. 4) Cost Savings (C_S)

$$E_{TS} \times IC_E$$

Eq. 5) Power Draw ($P_{CC,FC}$)

$$\frac{W_R \times LF}{\eta_M} \times \frac{0.7457\ kW}{1\ hp}$$

Eq. 6) Energy Consumption (E_{CC})

$$P_{CC} \times t_h \times UF$$

Eq. 7) Discharge Temperature ($T_{DC,DP}$)

$$If\ \ evaporative\ condenser$$

$$\max\left(T_{WB} + T_{AC,AP}, T_{DC,DP}\right)$$

$$If\ \ air\ cooled\ condenser$$

$$\max\left(T_{DB} + T_{AC,AP}, T_{DC,DP}\right)$$

Eq. 8) Degree Hour Savings (H_S)

$$\left(T_{DC} - T_{DP}\right) \times t_{BIN}$$

Eq. 9) Percent Savings ($E_{\%S}$)

$$H_S \times F_{\%S} \times \frac{1\ year}{8,760\ hrs}$$

Eq. 10) Compressor Energy Savings (E_{CS})

$$E_{CC} \times E_{\%S}$$

Eq. 11) Energy Consumption (E_{FC})

$$P_{FC} \times t_h$$

Eq. 12) Fan Use Factor ($U_{FC,FP}$)

$$If\ \ evaporative\ condenser$$

$$T_{AC,AP} / (T_{DC,DP} - T_{WB})$$

$$If\ \ air\ cooled\ condenser$$

$$T_{AC,AP} / (T_{DC,DP} - T_{DB})$$

Eq. 13) Fan Energy Consumption ($E_{FC,FP}$)

$$If\ \ on-off\ \ \ fan\ control$$

$$E_{FT} \times U_{FC,FP} \times t_{BIN} / 8,760\ hrs$$

$$If\ \ VSD\ \ fan\ control$$

$$E_{FT} \times U^3_{FC,FP} / \eta_{VSD} \times t_{BIN} / 8,760\ hrs$$

Eq. 14) Fan Energy Savings (E_{FS})

$$E_{FC} - E_{FP}$$

AR No. 3 - Analysis

Compressor Energy Analysis

Compressor Description	Rated Power (W_R) (N. 1)	Efficiency (η_M) (N. 1)	Load Factor (LF) (Rf. 5)	Usage (UF) (N. 1)	Power Draw (P_{CC}) (Eq. 5)	Energy Usage (E_{CC}) (Eq. 6)
	(hp)				(kW)	(kWh)
Compressor No. 1	*100*	*93.0%*	*78.7%*	*100.0%*	*63.1*	*454,348*
Compressor No. 2	*100*	*95.4%*	*81.8%*	*90.0%*	*63.9*	*414,328*
					-	*-*
					-	*-*
					-	*-*
Totals	**200**				**127.0**	**868,676**

Compressor Summary

Weather Bin Data			Current Discharge (T_{DC}) (Eq. 7)	Proposed Discharge (T_{DP}) (Eq. 7)	Degree Hour Savings (H_S) (Eq. 8)	Percent Savings ($E_{\%S}$) (Eq. 9)	Compressor Savings (E_{CS}) (Eq. 10)
Dry Bulb (T_{DB}) (Rf. 6)	Wet Bulb (T_{WB}) (Rf. 6)	Hours (t_{BIN}) (Rf. 6)					
(°F)	(°F)	(hrs./yr.)	(°F)	(°F)	(°F-hrs.)		(kWh)
107.0	*73.0*	*0*	*88.6*	*88.6*	*0*	*0.00%*	*0*
102.0	*72.0*	*2*	*87.6*	*87.6*	*0*	*0.00%*	*0*
97.0	*69.0*	*6*	*84.6*	*84.6*	*0*	*0.00%*	*0*
92.0	*68.0*	*24*	*83.6*	*83.6*	*1*	*0.00%*	*1*
87.0	*67.0*	*65*	*82.6*	*82.6*	*2*	*0.00%*	*2*
82.0	*65.0*	*136*	*80.6*	*80.6*	*4*	*0.00%*	*4*
77.0	*63.0*	*231*	*80.6*	*78.6*	*457*	*0.05%*	*453*
72.0	*61.0*	*402*	*80.6*	*76.6*	*1,599*	*0.18%*	*1,585*
67.0	*58.0*	*594*	*80.6*	*75.8*	*2,816*	*0.32%*	*2,792*
62.0	*56.0*	*1,007*	*80.6*	*75.8*	*4,773*	*0.54%*	*4,733*
57.0	*53.0*	*1,266*	*80.6*	*75.8*	*6,001*	*0.69%*	*5,951*
52.0	*48.0*	*1,269*	*80.6*	*75.8*	*6,015*	*0.69%*	*5,965*
47.0	*44.0*	*1,357*	*80.6*	*75.8*	*6,432*	*0.73%*	*6,379*
42.0	*40.0*	*1,215*	*80.6*	*75.8*	*5,759*	*0.66%*	*5,711*
37.0	*36.0*	*681*	*80.6*	*75.8*	*3,228*	*0.37%*	*3,201*
32.0	*31.0*	*323*	*80.6*	*75.8*	*1,531*	*0.17%*	*1,518*
27.0	*26.0*	*108*	*80.6*	*75.8*	*512*	*0.06%*	*508*
22.0	*20.0*	*45*	*80.6*	*75.8*	*213*	*0.02%*	*212*
17.0	*15.0*	*22*	*80.6*	*75.8*	*104*	*0.01%*	*103*
12.0	*11.0*	*7*	*80.6*	*75.8*	*33*	*0.00%*	*33*
7.0	*7.0*	*1*	*80.6*	*75.8*	*5*	*0.00%*	*5*
2.0	*2.0*	*0*	*80.6*	*75.8*	*0*	*0.00%*	*0*
			80.6	*75.8*	*0*	*0.00%*	*0*
			80.6	*75.8*	*0*	*0.00%*	*0*
			80.6	*75.8*	*0*	*0.00%*	*0*
Totals		**8,761**			**39,486**	**4.51%**	**39,155**

AR No. 3 - Analysis

Condenser Fan Energy Analysis

Condenser Description	Quantity (Q_{FM}) (N. 1)	Rated Power (W_R) (N. 1)	Efficiency (η_M) (N. 1)	Load Factor (LF) (Rf. 5)	Power Draw (P_{FC}) (Eq. 5)	Energy Usage (E_{FT}) (Eq. 11)
		(hp)			(kW)	(kWh)
Condenser No. 1	*3*	*15*	*95.0%*	*90.0%*	*31.8*	*228,891*
					-	-
					-	-
					-	-
					-	-
Totals					**31.8**	**228,891**

Condenser Fan Summary

Weather Bin Data			Current Fan Use	Proposed Fan Use	Current Fan Energy	Proposed Fan (VSD) Energy	Fan Savings
Dry Bulb (T_{DB}) (Rf. 6)	Wet Bulb (T_{WB}) (Rf. 6)	Hours (t_{BIN}) (Rf. 6)	(U_{FC}) (Eq. 12)	(U_{FP}) (Eq. 12)	(E_{FC}) (Eq. 13)	(E_{FP}) (Eq. 13)	(E_{FS}) (Eq. 14)
(°F)	(°F)	(hrs./yr.)			(kWh)	(kWh)	(kWh)
107.0	*73.0*	*0*	*100.0%*	*100.0%*	*0*	*0*	*0*
102.0	*72.0*	*2*	*100.0%*	*100.0%*	*52*	*66*	*-13*
97.0	*69.0*	*6*	*100.0%*	*100.0%*	*157*	*197*	*-40*
92.0	*68.0*	*24*	*100.0%*	*100.0%*	*627*	*787*	*-159*
87.0	*67.0*	*65*	*100.0%*	*100.0%*	*1,698*	*2,130*	*-432*
82.0	*65.0*	*136*	*100.0%*	*100.0%*	*3,554*	*4,457*	*-904*
77.0	*63.0*	*231*	*88.9%*	*100.0%*	*5,366*	*7,571*	*-2,204*
72.0	*61.0*	*402*	*79.8%*	*100.0%*	*8,385*	*13,175*	*-4,790*
67.0	*58.0*	*594*	*69.2%*	*87.6%*	*10,743*	*13,093*	*-2,349*
62.0	*56.0*	*1,007*	*63.6%*	*78.8%*	*16,731*	*16,136*	*594*
57.0	*53.0*	*1,266*	*56.7%*	*68.4%*	*18,746*	*13,296*	*5,450*
52.0	*48.0*	*1,269*	*48.0%*	*56.1%*	*15,906*	*7,359*	*8,548*
47.0	*44.0*	*1,357*	*42.7%*	*49.1%*	*15,149*	*5,260*	*9,889*
42.0	*40.0*	*1,215*	*38.5%*	*43.6%*	*12,227*	*3,302*	*8,925*
37.0	*36.0*	*681*	*35.1%*	*39.2%*	*6,238*	*1,347*	*4,891*
32.0	*31.0*	*323*	*31.5%*	*34.9%*	*2,660*	*448*	*2,212*
27.0	*26.0*	*108*	*28.6%*	*31.4%*	*808*	*109*	*699*
22.0	*20.0*	*45*	*25.8%*	*28.0%*	*303*	*32*	*271*
17.0	*15.0*	*22*	*23.8%*	*25.7%*	*137*	*12*	*125*
12.0	*11.0*	*7*	*22.5%*	*24.1%*	*41*	*3*	*38*
7.0	*7.0*	*1*	*21.2%*	*22.7%*	*6*	*0*	*5*
2.0	*2.0*	*0*	*19.9%*	*21.2%*	*0*	*0*	*0*
0.0	*0.0*	*0*	*19.4%*	*20.6%*	*0*	*0*	*0*
0.0	*0.0*	*0*	*19.4%*	*20.6%*	*0*	*0*	*0*
0.0	*0.0*	*0*	*19.4%*	*20.6%*	*0*	*0*	*0*
Totals		**8,761**			**119,534**	**88,780**	**30,754**

Refrigerant - Pressure/Temperature Table

Temp	R-11	R-12	R-22	R-123	R-134a	R-500	Ammonia
-20.0	-	0.6	10.2	-	-	3.2	3.6
-18.0	-	1.3	11.4	-	-	4.1	4.6
-16.0	-	2.0	12.6	-	-	5.0	5.6
-14.0	-	2.8	13.9	-	0.4	5.9	6.7
-12.0	-	3.6	15.2	-	1.1	6.8	7.8
-10.0	-	4.5	16.5	-	1.9	7.8	9.0
-8.0	-	5.4	17.9	-	2.8	8.8	10.3
-6.0	-	6.3	19.4	-	3.7	9.9	11.5
-4.0	-	7.2	20.9	-	4.6	11.0	12.9
-2.0	-	8.1	22.4	-	5.5	12.1	14.3
0.0	-	9.1	24.0	-	6.5	13.3	15.7
2.0	-	10.2	25.7	-	7.5	14.5	17.2
4.0	-	11.2	27.4	-	8.6	15.7	18.8
6.0	-	12.3	29.2	-	9.6	17.0	20.4
8.0	-	13.5	31.0	-	10.8	18.3	22.1
10.0	-	14.6	32.9	-	12.0	19.7	23.8
12.0	-	15.8	34.8	-	13.2	21.1	25.6
14.0	-	17.1	36.8	-	14.4	22.6	27.5
16.0	-	18.3	38.8	-	15.7	24.1	29.4
18.0	-	19.7	40.9	-	17.1	25.6	31.4
20.0	-	21.0	43.1	-	18.5	27.2	33.5
22.0	-	22.4	45.4	-	19.9	28.9	35.7
24.0	-	23.9	47.7	-	21.4	30.6	37.9
26.0	-	25.3	50.0	-	22.9	32.3	40.2
28.0	-	26.9	52.5	-	24.5	34.1	42.6
30.0	-	28.4	55.0	-	26.1	36.0	45.1
32.0	-	30.0	57.6	-	27.8	37.9	47.6
34.0	-	31.7	60.2	-	29.5	39.8	50.2
36.0	-	33.4	62.9	-	31.3	41.8	53.0
38.0	-	35.1	65.7	-	33.2	43.9	55.8
40.0	-	36.9	68.6	-	35.1	46.0	58.7
42.0	-	38.8	71.5	-	37.0	48.2	61.6
44.0	-	40.7	74.6	-	39.1	50.4	64.7
46.0	-	42.6	77.7	-	41.1	52.7	67.9
48.0	-	44.6	80.8	-	43.3	55.1	71.2
50.0	-	46.7	84.1	-	45.5	57.5	74.5
52.0	-	48.8	87.4	-	47.7	60.0	78.0
54.0	-	50.9	90.9	-	50.1	62.6	81.6
56.0	-	53.1	94.4	-	52.5	65.2	85.3
58.0	-	55.4	98.0	-	54.9	67.8	89.1
60.0	-	57.7	101.7	-	57.5	70.6	93.0
62.0	-	60.1	105.5	-	60.1	73.4	97.0
64.0	-	62.5	109.3	-	62.7	76.3	101.1
66.0	-	65.0	113.3	-	65.5	79.2	105.3
68.0	-	67.5	117.3	-	68.3	82.3	109.7
70.0	-	70.2	121.5	-	71.2	85.3	114.2
72.0	-	72.8	125.7	-	74.1	88.5	118.8
74.0	-	75.6	130.1	-	77.2	91.7	123.5

76.0	0.3	78.3	134.5	-	80.3	95.1	128.4
78.0	0.9	81.2	139.0	-	83.5	98.5	133.4
80.0	1.5	84.1	143.7	-	86.7	101.9	138.5
82.0	2.2	87.1	148.4	-	90.1	105.5	143.7
84.0	2.8	90.2	153.3	0.6	93.5	109.1	149.1
86.0	3.5	93.3	158.2	1.2	97.1	112.8	154.6
88.0	4.2	96.5	163.3	1.9	100.7	116.6	160.3
90.0	4.9	99.7	168.5	2.5	104.4	120.5	166.1
92.0	5.6	103.1	173.7	3.2	108.2	124.4	172.0
94.0	6.4	106.5	179.1	3.9	112.0	128.5	178.1
96.0	7.1	109.9	184.6	4.6	116.0	132.6	184.4
98.0	7.9	113.5	190.3	5.4	120.1	136.8	190.8
100.0	8.8	117.1	196.0	6.1	124.2	141.1	197.3
102.0	9.6	120.8	201.8	6.9	128.5	145.5	204.0
104.0	10.5	124.6	207.8	7.7	132.8	150.0	210.9
106.0	11.4	128.4	213.9	8.6	137.3	154.5	217.9
108.0	12.3	132.3	220.1	9.4	141.8	159.2	225.1
110.0	13.2	136.3	226.4	10.3	146.5	164.0	232.5
112.0	14.2	140.4	232.9	11.2	151.2	168.8	240.0
114.0	15.1	144.6	239.5	12.2	156.1	173.8	247.7
116.0	16.1	148.8	246.2	13.1	161.0	178.8	255.5
118.0	17.2	153.2	253.1	14.1	166.1	183.9	263.6
120.0	18.2	157.6	260.0	15.1	171.3	189.2	271.8
122.0	19.3	162.1	267.2	16.2	176.5	194.5	280.2
124.0	20.5	166.7	274.4	17.2	181.9	200.0	288.8
126.0	21.6	171.3	281.8	18.3	187.5	205.5	297.6
128.0	22.8	176.1	289.3	19.4	193.1	211.2	306.6
130.0	24.0	180.9	297.0	20.6	198.8	217.0	315.7
132.0	25.2	185.9	304.8	21.8	204.7	222.8	325.1
134.0	26.5	190.9	312.7	23.0	210.7	228.8	334.6
136.0	27.8	196.0	320.8	24.2	216.8	234.9	344.4
138.0	29.1	201.2	329.1	25.5	223.0	241.1	354.3
140.0	30.4	206.5	337.5	26.8	229.4	247.4	364.5
142.0	31.8	211.9	346.0	28.2	235.8	253.8	374.9
144.0	33.2	217.4	354.7	29.5	242.5	260.4	385.4
146.0	34.7	223.0	363.6	30.9	249.2	267.0	396.2
148.0	36.2	228.7	372.6	32.4	256.1	273.8	407.3
150.0	37.7	234.5	381.7	33.8	263.1	280.7	418.5
152.0	39.2	240.4	391.1	35.4	270.2	287.7	429.9
154.0	40.8	246.4	400.6	36.9	277.5	294.9	441.6
156.0	42.4	252.5	410.2	38.5	285.0	302.1	453.5
158.0	44.1	258.7	420.1	40.1	292.5	309.5	465.7
160.0	45.8	265.0	430.1	41.7	300.2	317.1	478.0
162.0	47.5	271.4	440.3	43.4	308.1	324.7	490.6
164.0	49.2	278.0	450.6	45.2	316.1	332.5	503.5
166.0	51.0	284.6	461.1	46.9	324.3	340.4	516.6
168.0	52.9	291.3	471.9	48.7	332.6	348.5	529.9
170.0	54.8	298.2	482.8	50.6	341.1	356.7	543.5
172.0	56.7	305.2	493.9	52.5	349.7	365.0	557.4
174.0	58.6	312.2	505.1	54.4	358.5	373.5	571.5

176.0	*60.6*	*319.4*	*516.6*	*56.3*	*367.5*	*382.1*	*585.8*
178.0	*62.6*	*326.8*	*528.3*	*58.4*	*376.6*	*390.8*	*600.5*
180.0	*64.7*	*334.2*	*540.2*	*60.4*	*386.0*	*399.7*	*615.4*
182.0	*66.8*	*341.7*	*552.3*	*62.5*	*395.4*	*408.8*	*630.5*
184.0	*69.0*	*349.4*	*564.6*	*64.6*	*405.1*	*418.0*	*646.0*
186.0	*71.2*	*357.2*	*577.1*	*66.8*	*414.9*	*427.4*	*661.7*
188.0	*73.4*	*365.1*	*589.8*	*69.0*	*425.0*	*436.9*	*677.7*
190.0	*75.7*	*373.2*	*602.8*	*71.3*	*435.2*	*446.6*	*693.9*
192.0	*78.1*	*381.3*	*616.0*	*73.6*	*445.6*	*456.5*	*710.5*
194.0	*80.4*	*389.6*	*629.5*	*76.0*	*456.2*	*466.5*	*727.4*
196.0	*82.8*	*398.0*	*643.2*	*78.4*	*467.0*	*476.7*	*744.5*
198.0	*85.3*	*406.6*	*657.2*	*80.8*	*478.1*	*487.1*	*762.0*
200.0	*87.8*	*415.3*	*671.4*	*83.4*	*489.3*	*497.7*	*779.7*

Pressure to Temperature Interpolation

	Current	*Proposed*	*Measured*
Pressure (psig)	***140.0***	***128.0***	***135.0***
Refrigerant	***Temp (°F)***	***Temp (°F)***	***Temp (°F)***
R-11	-	-	***340.3***
R-12	***111.8***	***105.8***	***109.4***
R-22	***78.4***	***73.0***	***76.2***
R-123	-	-	***357.4***
R-134a	***107.2***	***101.8***	***105.0***
R-500	***99.5***	***93.8***	***97.1***
Ammonia	***80.6***	***75.8***	***78.6***