

TECH₂TECH

REFRIGERANT RELATED DIAGNOSTIC SUPPORT

1.866.433.8324 tech2tech@icorinternational.com

Useful Information

<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">Types of Compressor Failures</th> </tr> <tr> <td>Flood back</td> <td>High Compression</td> </tr> <tr> <td>Flooded Start</td> <td>Loss of Oil</td> </tr> <tr> <td>Slugging</td> <td>Single Phase</td> </tr> <tr> <td>High Discharge Temp</td> <td>High/Low Voltage</td> </tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">Horse Power Vs Tonnage</th> </tr> <tr> <td>+35 evap 1hp = 1ton</td> <td></td> </tr> <tr> <td>+20 evap 1.5hp = 1ton</td> <td></td> </tr> <tr> <td>-10 evap 2hp = 1ton</td> <td></td> </tr> <tr> <td>-20 evap 3hp = 1ton</td> <td></td> </tr> <tr> <td>-30 evap 5hp = 1ton</td> <td></td> </tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">Calculate Compression Ratio</th> </tr> <tr> <td>Compression Ratio=</td> <td style="text-align: center;">$\frac{\text{Discharge (psia)}}{\text{Suction (psia)}}$</td> </tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">Coefficient of Performance Formula</th> </tr> <tr> <td>Useful refrigerating effect</td> <td></td> </tr> <tr> <td>Net energy supplied from external source</td> <td></td> </tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">1ph Hermetic & Semi Hermetic motors</th> </tr> <tr> <td>Split Phase or Resistance Start Induction Run (RSIR)</td> <td></td> </tr> <tr> <td>Capacitor Start Induction Run (CSIR)</td> <td></td> </tr> <tr> <td>Capacitor Start Capacitor Run (CSCR)</td> <td></td> </tr> <tr> <td>Permanent Split Capacitor (PSC)</td> <td></td> </tr> </table>	Types of Compressor Failures		Flood back	High Compression	Flooded Start	Loss of Oil	Slugging	Single Phase	High Discharge Temp	High/Low Voltage	Horse Power Vs Tonnage		+35 evap 1hp = 1ton		+20 evap 1.5hp = 1ton		-10 evap 2hp = 1ton		-20 evap 3hp = 1ton		-30 evap 5hp = 1ton		Calculate Compression Ratio		Compression Ratio=	$\frac{\text{Discharge (psia)}}{\text{Suction (psia)}}$	Coefficient of Performance Formula		Useful refrigerating effect		Net energy supplied from external source		1ph Hermetic & Semi Hermetic motors		Split Phase or Resistance Start Induction Run (RSIR)		Capacitor Start Induction Run (CSIR)		Capacitor Start Capacitor Run (CSCR)		Permanent Split Capacitor (PSC)		<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="4" style="text-align: center;">Compressor Capacity Loss</th> </tr> <tr> <td rowspan="4" style="text-align: center;">Evaporator Temp °F</td> <td style="text-align: center;">R-22</td> <td style="text-align: center;">R-404A</td> <td style="text-align: center;">R-404A</td> </tr> <tr> <td colspan="3" style="text-align: center;">Suction Line Pressure Loss</td> </tr> <tr> <td style="text-align: center;">2 psi</td> <td style="text-align: center;">2 psi</td> <td style="text-align: center;">1 psi</td> </tr> <tr> <td colspan="3" style="text-align: center;">% Compressor Capacity Loss</td> </tr> <tr> <td style="text-align: center;">40</td> <td style="text-align: center;">3.1</td> <td style="text-align: center;">na</td> <td style="text-align: center;">na</td> </tr> <tr> <td style="text-align: center;">15</td> <td style="text-align: center;">5.1</td> <td style="text-align: center;">3.6</td> <td style="text-align: center;">1.8</td> </tr> <tr> <td style="text-align: center;">-25</td> <td style="text-align: center;">17.6</td> <td style="text-align: center;">8.8</td> <td style="text-align: center;">4.4</td> </tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">Compression Ratio</th> </tr> <tr> <td>Semi Hermetic Recip 14:1 SP 12:1 LP</td> <td></td> </tr> <tr> <td>Hermetic Recip 7.5:1</td> <td></td> </tr> <tr> <td>Scroll high-temp 7:1 to 10:1</td> <td></td> </tr> <tr> <td>Scroll Refrigeration 10:1</td> <td></td> </tr> <tr> <td>Open 14:1</td> <td></td> </tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">Compressor low oil pressure</th> </tr> <tr> <td>Liquid refrigerant entrained in the oil</td> <td></td> </tr> <tr> <td>High compressor wear</td> <td></td> </tr> <tr> <td>Bad oil pump</td> <td></td> </tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">Compressor Superheat W/fixed Meter</th> </tr> <tr> <td>A/C 10° to 35°</td> <td></td> </tr> <tr> <td>Refrigeration > 20°</td> <td></td> </tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">Recip Compressor min Discharge</th> </tr> <tr> <td>R-12,134a,414B</td> <td style="text-align: center;">100 psig</td> </tr> <tr> <td>R-22,407C,422B</td> <td style="text-align: center;">180 psig</td> </tr> <tr> <td>R-502,404A,507A,422C</td> <td style="text-align: center;">180 psig</td> </tr> <tr> <td>R-410A</td> <td style="text-align: center;">300 psig</td> </tr> </table>	Compressor Capacity Loss				Evaporator Temp °F	R-22	R-404A	R-404A	Suction Line Pressure Loss			2 psi	2 psi	1 psi	% Compressor Capacity Loss			40	3.1	na	na	15	5.1	3.6	1.8	-25	17.6	8.8	4.4	Compression Ratio		Semi Hermetic Recip 14:1 SP 12:1 LP		Hermetic Recip 7.5:1		Scroll high-temp 7:1 to 10:1		Scroll Refrigeration 10:1		Open 14:1		Compressor low oil pressure		Liquid refrigerant entrained in the oil		High compressor wear		Bad oil pump		Compressor Superheat W/fixed Meter		A/C 10° to 35°		Refrigeration > 20°		Recip Compressor min Discharge		R-12,134a,414B	100 psig	R-22,407C,422B	180 psig	R-502,404A,507A,422C	180 psig	R-410A	300 psig	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">Flooded Condensers Refrigerant Charge</th> </tr> <tr> <td style="text-align: center;">1 - $\frac{15}{(90 - 0)}$ X 100</td> <td></td> </tr> <tr> <td>Condenser TD at design conditions 15 °F</td> <td></td> </tr> <tr> <td>Head psi control setting 90 °F</td> <td></td> </tr> <tr> <td>Minimum ambient temperature 0 °F</td> <td></td> </tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">Air Cooled Condensers</th> </tr> <tr> <td>Refrigeration 750 to 1000 CFM Per Ton</td> <td></td> </tr> <tr> <td>Air Condition 1000 CFM Per HP</td> <td></td> </tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">Condenser Sizing</th> </tr> <tr> <td>A/C Evap BTU + .33</td> <td></td> </tr> <tr> <td>Med Temp BTU + .50</td> <td></td> </tr> <tr> <td>Low Temp BTU + 2.0</td> <td></td> </tr> <tr> <td>< -20 BTU + 3.0</td> <td></td> </tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">Residential A/C Condenser Fan Motor</th> </tr> <tr> <td>Tonnage</td> <td style="text-align: center;">HP</td> </tr> <tr> <td style="text-align: center;">2.0</td> <td style="text-align: center;">1/5</td> </tr> <tr> <td style="text-align: center;">2.5</td> <td style="text-align: center;">1/4</td> </tr> <tr> <td style="text-align: center;">3.0</td> <td style="text-align: center;">1/3</td> </tr> <tr> <td style="text-align: center;">3.5</td> <td style="text-align: center;">1/2</td> </tr> <tr> <td style="text-align: center;">4 to 5</td> <td style="text-align: center;">3/4</td> </tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">Air Cooled Condenser Subcooling</th> </tr> <tr> <td>Residential < 10 SEER 10° to 15° W/TEV</td> <td></td> </tr> <tr> <td>Residential > 12 SEER 6° to 12° W/TEV</td> <td></td> </tr> <tr> <td>Commercial A/C 8° to 15° W/TEV</td> <td></td> </tr> <tr> <td>Refrigeration 10° W/TEV</td> <td></td> </tr> </table>	Flooded Condensers Refrigerant Charge		1 - $\frac{15}{(90 - 0)}$ X 100		Condenser TD at design conditions 15 °F		Head psi control setting 90 °F		Minimum ambient temperature 0 °F		Air Cooled Condensers		Refrigeration 750 to 1000 CFM Per Ton		Air Condition 1000 CFM Per HP		Condenser Sizing		A/C Evap BTU + .33		Med Temp BTU + .50		Low Temp BTU + 2.0		< -20 BTU + 3.0		Residential A/C Condenser Fan Motor		Tonnage	HP	2.0	1/5	2.5	1/4	3.0	1/3	3.5	1/2	4 to 5	3/4	Air Cooled Condenser Subcooling		Residential < 10 SEER 10° to 15° W/TEV		Residential > 12 SEER 6° to 12° W/TEV		Commercial A/C 8° to 15° W/TEV		Refrigeration 10° W/TEV		<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">Subcooling Methods</th> </tr> <tr> <td>Ambient Sub-Cooling</td> <td></td> </tr> <tr> <td>Mechanical Sub-Cooling</td> <td></td> </tr> <tr> <td>Sub-Cooling Circuits and Heat Exchangers</td> <td></td> </tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">Water Requirements for Condensers</th> </tr> <tr> <td>City Water 1.5 GPM Per Ton</td> <td></td> </tr> <tr> <td>Cooling Tower 3.0 GPM Per Ton</td> <td></td> </tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">Air Cooled Condenser TD</th> </tr> <tr> <td>A/C 10° to 30°</td> <td></td> </tr> <tr> <td>Refrigeration 15° to 25°</td> <td></td> </tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">Residential Condenser TD</th> </tr> <tr> <td>Condenser SEER</td> <td style="text-align: center;">TD</td> </tr> <tr> <td style="text-align: center;">6 to 7</td> <td style="text-align: center;">30</td> </tr> <tr> <td style="text-align: center;">8 to 9</td> <td style="text-align: center;">25</td> </tr> <tr> <td style="text-align: center;">10 to 11</td> <td style="text-align: center;">20</td> </tr> <tr> <td style="text-align: center;">12 to 13</td> <td style="text-align: center;">15</td> </tr> <tr> <td style="text-align: center;">14 to 16</td> <td style="text-align: center;">10</td> </tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="4" style="text-align: center;">Approximate Orifice/Piston Size</th> </tr> <tr> <td>Tonnage</td> <td style="text-align: center;">10 seer 22</td> <td style="text-align: center;">>10 seer 22</td> <td style="text-align: center;">410A</td> </tr> <tr> <td style="text-align: center;">2.0</td> <td style="text-align: center;">0.059</td> <td style="text-align: center;">0.063</td> <td style="text-align: center;">0.055</td> </tr> <tr> <td style="text-align: center;">2.5</td> <td style="text-align: center;">0.063</td> <td style="text-align: center;">0.067</td> <td style="text-align: center;">0.059</td> </tr> <tr> <td style="text-align: center;">3.0</td> <td style="text-align: center;">0.072</td> <td style="text-align: center;">0.074</td> <td style="text-align: center;">0.067</td> </tr> <tr> <td style="text-align: center;">4.0</td> <td style="text-align: center;">0.082</td> <td style="text-align: center;">0.084</td> <td style="text-align: center;">0.078</td> </tr> <tr> <td style="text-align: center;">5.0</td> <td style="text-align: center;">0.090</td> <td style="text-align: center;">0.094</td> <td style="text-align: center;">0.084</td> </tr> </table>	Subcooling Methods		Ambient Sub-Cooling		Mechanical Sub-Cooling		Sub-Cooling Circuits and Heat Exchangers		Water Requirements for Condensers		City Water 1.5 GPM Per Ton		Cooling Tower 3.0 GPM Per Ton		Air Cooled Condenser TD		A/C 10° to 30°		Refrigeration 15° to 25°		Residential Condenser TD		Condenser SEER	TD	6 to 7	30	8 to 9	25	10 to 11	20	12 to 13	15	14 to 16	10	Approximate Orifice/Piston Size				Tonnage	10 seer 22	>10 seer 22	410A	2.0	0.059	0.063	0.055	2.5	0.063	0.067	0.059	3.0	0.072	0.074	0.067	4.0	0.082	0.084	0.078	5.0	0.090	0.094	0.084
Types of Compressor Failures																																																																																																																																																																																																																														
Flood back	High Compression																																																																																																																																																																																																																													
Flooded Start	Loss of Oil																																																																																																																																																																																																																													
Slugging	Single Phase																																																																																																																																																																																																																													
High Discharge Temp	High/Low Voltage																																																																																																																																																																																																																													
Horse Power Vs Tonnage																																																																																																																																																																																																																														
+35 evap 1hp = 1ton																																																																																																																																																																																																																														
+20 evap 1.5hp = 1ton																																																																																																																																																																																																																														
-10 evap 2hp = 1ton																																																																																																																																																																																																																														
-20 evap 3hp = 1ton																																																																																																																																																																																																																														
-30 evap 5hp = 1ton																																																																																																																																																																																																																														
Calculate Compression Ratio																																																																																																																																																																																																																														
Compression Ratio=	$\frac{\text{Discharge (psia)}}{\text{Suction (psia)}}$																																																																																																																																																																																																																													
Coefficient of Performance Formula																																																																																																																																																																																																																														
Useful refrigerating effect																																																																																																																																																																																																																														
Net energy supplied from external source																																																																																																																																																																																																																														
1ph Hermetic & Semi Hermetic motors																																																																																																																																																																																																																														
Split Phase or Resistance Start Induction Run (RSIR)																																																																																																																																																																																																																														
Capacitor Start Induction Run (CSIR)																																																																																																																																																																																																																														
Capacitor Start Capacitor Run (CSCR)																																																																																																																																																																																																																														
Permanent Split Capacitor (PSC)																																																																																																																																																																																																																														
Compressor Capacity Loss																																																																																																																																																																																																																														
Evaporator Temp °F	R-22	R-404A	R-404A																																																																																																																																																																																																																											
	Suction Line Pressure Loss																																																																																																																																																																																																																													
	2 psi	2 psi	1 psi																																																																																																																																																																																																																											
	% Compressor Capacity Loss																																																																																																																																																																																																																													
40	3.1	na	na																																																																																																																																																																																																																											
15	5.1	3.6	1.8																																																																																																																																																																																																																											
-25	17.6	8.8	4.4																																																																																																																																																																																																																											
Compression Ratio																																																																																																																																																																																																																														
Semi Hermetic Recip 14:1 SP 12:1 LP																																																																																																																																																																																																																														
Hermetic Recip 7.5:1																																																																																																																																																																																																																														
Scroll high-temp 7:1 to 10:1																																																																																																																																																																																																																														
Scroll Refrigeration 10:1																																																																																																																																																																																																																														
Open 14:1																																																																																																																																																																																																																														
Compressor low oil pressure																																																																																																																																																																																																																														
Liquid refrigerant entrained in the oil																																																																																																																																																																																																																														
High compressor wear																																																																																																																																																																																																																														
Bad oil pump																																																																																																																																																																																																																														
Compressor Superheat W/fixed Meter																																																																																																																																																																																																																														
A/C 10° to 35°																																																																																																																																																																																																																														
Refrigeration > 20°																																																																																																																																																																																																																														
Recip Compressor min Discharge																																																																																																																																																																																																																														
R-12,134a,414B	100 psig																																																																																																																																																																																																																													
R-22,407C,422B	180 psig																																																																																																																																																																																																																													
R-502,404A,507A,422C	180 psig																																																																																																																																																																																																																													
R-410A	300 psig																																																																																																																																																																																																																													
Flooded Condensers Refrigerant Charge																																																																																																																																																																																																																														
1 - $\frac{15}{(90 - 0)}$ X 100																																																																																																																																																																																																																														
Condenser TD at design conditions 15 °F																																																																																																																																																																																																																														
Head psi control setting 90 °F																																																																																																																																																																																																																														
Minimum ambient temperature 0 °F																																																																																																																																																																																																																														
Air Cooled Condensers																																																																																																																																																																																																																														
Refrigeration 750 to 1000 CFM Per Ton																																																																																																																																																																																																																														
Air Condition 1000 CFM Per HP																																																																																																																																																																																																																														
Condenser Sizing																																																																																																																																																																																																																														
A/C Evap BTU + .33																																																																																																																																																																																																																														
Med Temp BTU + .50																																																																																																																																																																																																																														
Low Temp BTU + 2.0																																																																																																																																																																																																																														
< -20 BTU + 3.0																																																																																																																																																																																																																														
Residential A/C Condenser Fan Motor																																																																																																																																																																																																																														
Tonnage	HP																																																																																																																																																																																																																													
2.0	1/5																																																																																																																																																																																																																													
2.5	1/4																																																																																																																																																																																																																													
3.0	1/3																																																																																																																																																																																																																													
3.5	1/2																																																																																																																																																																																																																													
4 to 5	3/4																																																																																																																																																																																																																													
Air Cooled Condenser Subcooling																																																																																																																																																																																																																														
Residential < 10 SEER 10° to 15° W/TEV																																																																																																																																																																																																																														
Residential > 12 SEER 6° to 12° W/TEV																																																																																																																																																																																																																														
Commercial A/C 8° to 15° W/TEV																																																																																																																																																																																																																														
Refrigeration 10° W/TEV																																																																																																																																																																																																																														
Subcooling Methods																																																																																																																																																																																																																														
Ambient Sub-Cooling																																																																																																																																																																																																																														
Mechanical Sub-Cooling																																																																																																																																																																																																																														
Sub-Cooling Circuits and Heat Exchangers																																																																																																																																																																																																																														
Water Requirements for Condensers																																																																																																																																																																																																																														
City Water 1.5 GPM Per Ton																																																																																																																																																																																																																														
Cooling Tower 3.0 GPM Per Ton																																																																																																																																																																																																																														
Air Cooled Condenser TD																																																																																																																																																																																																																														
A/C 10° to 30°																																																																																																																																																																																																																														
Refrigeration 15° to 25°																																																																																																																																																																																																																														
Residential Condenser TD																																																																																																																																																																																																																														
Condenser SEER	TD																																																																																																																																																																																																																													
6 to 7	30																																																																																																																																																																																																																													
8 to 9	25																																																																																																																																																																																																																													
10 to 11	20																																																																																																																																																																																																																													
12 to 13	15																																																																																																																																																																																																																													
14 to 16	10																																																																																																																																																																																																																													
Approximate Orifice/Piston Size																																																																																																																																																																																																																														
Tonnage	10 seer 22	>10 seer 22	410A																																																																																																																																																																																																																											
2.0	0.059	0.063	0.055																																																																																																																																																																																																																											
2.5	0.063	0.067	0.059																																																																																																																																																																																																																											
3.0	0.072	0.074	0.067																																																																																																																																																																																																																											
4.0	0.082	0.084	0.078																																																																																																																																																																																																																											
5.0	0.090	0.094	0.084																																																																																																																																																																																																																											

Temp difference & relative humidity	
RH%	TD °F
Over 90	8
80 to 90	10
70 to 80	15
50 to 60	20

A/C Superheat Calculation (non TEV)
SH = (3 x wb) (-80) (-ambient) (/2)

Evaporator Superheat W/TEV
R-22 A/C 6° to 12°
R-22 High Efficiency 6° to 8°
R-410A 6° to 8°
Low Temp Refrigeration 4° to 6°
Med Temp Refrigeration 6° to 8°

TEV Sensing Bulb Location
3 or 9 O'clock < 7/8" Suction Line
4 or 8 O'Clock >7/8" Suction Line

Normal Conditions Pipe Insulation °F			
35	5	0	-20
3/8 to 1/2	1/2 to 3/4	3/4 to 1	1 to 1-1/4

Refrigerant Pipe Support
< 3/8 every 4'
3/8 to 7/8 every 5'
1-1/8 to 1-3/8 every 7'
1-5/8 to 2-1/8 every 9'

Refrigerant Density Formula
lbs original ref x density of new ref density of original refrigerant

Refrigerant Critical Temp °F			
R-22	R-134a	R-404A	R-407C
205	214	162	187
R-410A	R-414B	R-422B	R-422C
160	231	186	168

Approximate T.D. Calculation
TD = $\frac{\text{Condensing Unit BTU at SST}}{\text{Evaporator BTU at 1° TD}}$

Evaporator TD
A/C 30° to 35°
Refrigeration 10° to 15°

TEV Element Charges
Liquid cross-charge
Liquid charge
Gas charge
Gas cross-charged
Absorption

Refrigerant Pipe Support
< 3/8 every 4'
3/8 to 7/8 every 5'
1-1/8 to 1-3/8 every 7'
1-5/8 to 2-1/8 every 9'

Welding Temperatures
Brazing >840 °F
Solder <840 °F

Determining Fitting Equivalent Length			
90° short	30	1/8 / .125	
90° long	20	1/4 / .250	
90° street	50	3/8 / .375	
45°	16	1/2 / .500	
45° street	26	5/8 / .625	
Tee flow straight	20	3/4 / .750	
Tee flow branch	60	7/8 / .875	
Example 50 x .375 / 12 = 1.56 ft			

Refrigerant Liquid Density@70 °F.lbm/ft³			
R-22	R-134a	R-404A	R-407C
75.27	76.24	66.31	72.05
R-410A	R-414B	R-422B	R-422C
67.28	76.64	73.05	72.66

Refrigerant Normal Boiling Points °F			
R-22	R-134a	R-404A	R-407C
-41.46	-14.93	-51.20	-46.53
R-410A	R-414B	R-422B	R-422C
-60.60	-27.16	-42.36	-50.67

Refrigerant in Cylinder			
R-22	R-134a	R-404A	R-407C
30 lbs	30 lbs	24 lbs	25 lbs
R-410A	R-414B	R-422B	R-422C
25 lbs	25 lbs	25 lbs	24 lbs

Stages of The Refrigeration Cycle
Compression of the Vapor
Desuperheating of the Vapor
Condensing
Subcooling of the Liquid
Expansion and Pressure Reduction
Evaporation
Superheating of the Vapor

Common Fraction & Decimal			
1/8	0.12500	9/16	0.56250
3/16	0.18750	5/8	0.62500
1/4	0.25000	11/16	0.68750
5/16	0.32812	3/4	0.75000
3/8	0.37500	13/16	0.81250
7/16	0.43750	7/8	0.87500
1/2	0.50000	15/16	0.93750

Function of a Liquid Line Drier
Moisture removal
Dirt removal
Acid removal
Sludge and varnish removal

Heating Air Formulas
BTU = CFM X 1.08 X TD
Sensible Heat Ratio = SH/TH

Electric Formulas
Watts = Volts X AMPs [P = I x E]
1 Watt = 3.414 BTU

Residential T-Stat Wire Color
Red (Rh-24V Heating) (Rc-24V Cooling)
Yellow (Y1-1st Stage Cooling)
Blue (Y2-2nd Stage Cooling)
Green or Gray (Indoor Fan)
White (1st Stage Heat)
Black (2nd Stage Heat)

Above sea level gauge correction	
2000 ft.	+ 1.0
4000 ft.	+ 2.0
5000 ft.	+ 2.5
6000 ft.	+ 3.0

Maximum Suction Filter Drier PSI Drop			
Permanent	HT/AC	MT	LT
22 / 404A	3 psi	2 psi	1 psi
12 / 134a	2 psi	1.5 psi	0.5 psi
Temporary	HT/AC	MT	LT
22 / 404A	8 psi	4 psi	2 psi
12 / 134a	6 psi	3 psi	1 psi

Cooling Air Formulas	
BTU = CFM X 4.5 X Difference in Enthalpy	
400 CFM per ton	

Temperatures °F
Water Boils 212
Standard Conditions 68
Water Freezes 32
Fresh Food Storage 45 to 32
Frozen Food Storage 0 to -20
Absolute 0 -460

Electrical Safety
1.0 ampere=1000 milliamps (ma)
0.5 ampere = 500 milliamps (ma)
0.1 ampere = 100 milliamps (ma)
0.05 ampere = 50 milliamps (ma)
0.001 ampere = 1 milliamps (ma)

Electrical Safety
0.5 ma No sensation
2-10 ma Muscular contraction
5-25 ma Painful shock
25-50 ma Violent muscular contraction
50-100 ma Heart convulsion, death
Over 100 ma Paralysis of breathing

400 & 500 Series Refrigerants
Must be charged as a Liquid
400 series are zeotropic
500 series are azeotropic

Refrigerant Safety
Always use with adequate ventilation
Flush exposed skin with warm water
Never expose to flames
Never trap liquid between valves
Never use oxygen or compressed air to pressurize a system
Read the MSDS

Vacuum			
Microns	"Hg	Microns	"Hg
100,000	25.98	4,000	29.76
50,000	27.95	2,000	29.84
20,000	29.13	1,000	29.88
15,000	29.33	500	29.90
10,000	29.53	200	29.91
8,000	29.62	150	29.92

Vacuum
2000 microns (29.84 "Hg) >50 ppm H ₂ O
1000 microns (29.88 "Hg) <10 ppm H ₂ O
500 (29.90 "Hg) microns Industry Standard

Refrigerant Migration Protection
Crank Case Heater
Pump Down
Pump Out
Solenoid Drop

30lb Recovery Cylinder Fill Level				
R-22	R-134a	R-404A	R-407C	
25.0 lbs	25.4 lbs	22.0 lbs	23.7 lbs	
R-410A	R-414B	R-422B	R-422C	
22.3 lbs	25.3 lbs	24.3 lbs	23.8 lbs	

Size of Vacuum Pump	
CFM	Maximum System Tonnage
1.5	2.25
3	9
5	25
7	49
10	100

Refrigerant GWP				
R-22	R-134a	R-404A	R-407C	
1750	1300	3900	1800	
R-410A	R-414B	R-422B	R-422C	
2100	1400	2500	3100	

Orange (Reversing Valve Cool)
Brown (Reversing Valve Heat) (24V Comm)

Types of Refrigeration Oil
Mineral (MO)
Alkybenzene (AB)
Polyolester (POE)
Polyalkylene Glycol (PAG)
Polyvinyl Ether (PVE)

Electrical Safety
1.0 ampere=1000 milliamps (ma)
0.5 ampere = 500 milliamps (ma)
0.1 ampere = 100 milliamps (ma)
0.05 ampere = 50 milliamps (ma)
0.001 ampere = 1 milliamps (ma)

Electrical Safety
0.5 ma No sensation
2-10 ma Muscular contraction
5-25 ma Painful shock
25-50 ma Violent muscular contraction
50-100 ma Heart convulsion, death
Over 100 ma Paralysis of breathing

Refrigerant Oil Type	
CFC	MO
HCFC	MO, AB, POE, PVE
HFC	POE, PAG, PVE
HFC/HC	MO, AB, POE, PVE
HFO	POE, PAG, PVE

Refrigerant Oil Type	
CFC	MO
HCFC	MO, AB, POE, PVE
HFC	POE, PAG, PVE
HFC/HC	MO, AB, POE, PVE
HFO	POE, PAG, PVE

Air Cooled Head Pressure			
Evap Temp	Condenser DB Entering Temp		
	70	80	95
-25 / 0	90	100	115
-20/5/25	93	103	118
-15/10/30	96	106	121
-10/15/35	99	109	124
-5/20/40	102	112	127
45	105	115	130