



SPORLAN

Subcool Control

Installation and Operation Instructions



Controller v. B



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Bulletin 100-50-5.2, November 2012 supersedes SD-358M, June 2012 and all prior publications.

Introduction

The **Sporlan Subcool Control** is a simple means of controlling the Electronic Expansion Valve (EEV) on most liquid subcooling systems. The Subcool Control provides liquid temperature and superheat (pressure-temperature) control for most common refrigerants. It displays actual leaving liquid temperature, superheat, suction pressure, valve position, controller status, and alarms. It also allows manual control of the valve position.



Features

- One dial for setting superheat and liquid temperature
- One EEV control (bipolar step motor)
- 4-digit LED display
- Optional controller networking (MODBUS)
- One pressure input (Sporlan transducer)
- One digital input (for external switch or relay)
- Three temperature inputs (Sporlan surface or air sensors)

1. Installation

Refer to *Appendix I - Wiring Diagram* and *Appendix J - Sensor Installation*

TOOLS REQUIRED:

- Small flat screwdriver for terminal connections
 - Cordless screwdriver
 - Phillips and flat screwdrivers
 - Needle-nose pliers
 - Wire cutters
 - Scotch-Brite™ pad
 - Two #8 x 1/2" self-tapping screws to mount DIN rail
1. Mount the controller in a rain-tight, protected location using the supplied DIN Rail. To leave enough working space, the suggested mounting area is 10 inches high and 5 inches wide. The minimum depth is 3 inches. See Figures 1 and 2.
 2. Connect the subcool liquid temperature sensor wires to terminals 29 and 30. The sensor is not polarized. **Maximum torque on screw terminals is 3.5 in-lbs.**
 3. Connect the suction temperature sensor wires to terminals 31 and 32. The sensor is not polarized.
 4. Connect the pressure transducer wires to terminals 33, 34, and 35. Sporlan has used transducer cables with two wire color combinations; see Table 1 on page 4. If the cable is spliced in the field to extend its length, ensure the new wire is properly connected.
 5. Connect terminals 25 and 26 to a digital input. A short

or a closed contact from an external relay will close the valve for pump down. See *Section 4 - System Operation*, on page 4.

6. Connect the Sporlan EEV wires to terminals 5, 6, 7, and 8.
7. Connect power to terminals 1 and 2. Transformer requirements are 24 volts AC at 40 VA, Class II.
8. Remove the protective clear film from the front of the Subcool Control.



WARNING: Use caution when working around high voltage components. Safety covers should be used for personal safety on high voltage panels.

NOTE: The Sporlan Subcool Control should be installed only by a qualified professional. All other system components (valves and sensors) should be supplied by Sporlan to ensure compatibility and proper operation. For optimal performance, a counterflow heat exchanger is recommended. There are no user-serviceable components inside the Sporlan Subcool Control. Opening the case will void the warranty.

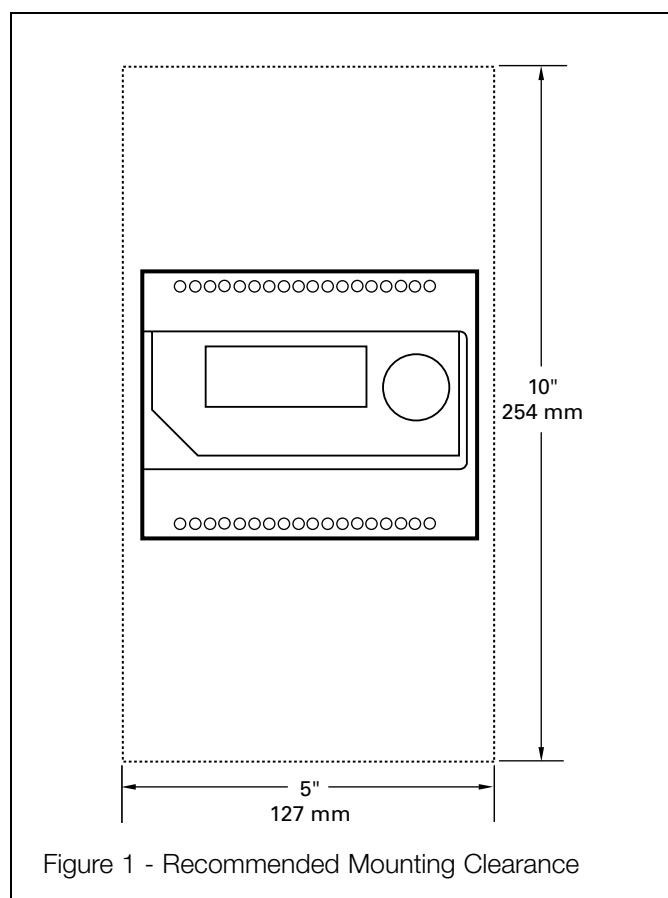


Figure 1 - Recommended Mounting Clearance

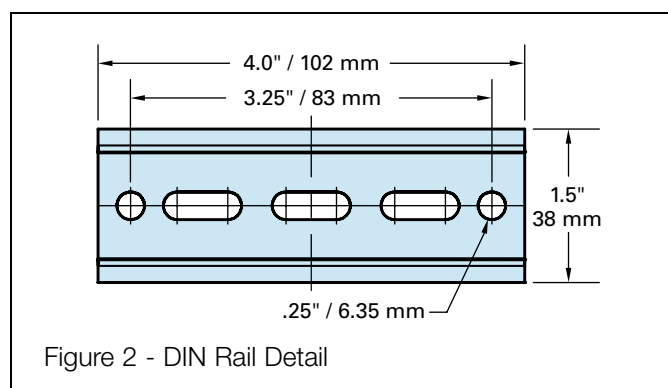


Figure 2 - DIN Rail Detail

Table 1 - Pressure Transducer Wire Colors

	CONTROLLER TERMINAL	OLD PIGTAIL LEADS	NEW HERMETIC CABLE
+	35	Red	Black
S	33	Green	White
-	34	Black	Green

Table 2 - Sporlan Electric Expansion Valves

SPORLAN MODEL NUMBERS	STEPS
SEI-5, SEI-1, SER-1.5, SEI-2, SEI-3.5, SEI-6, SER-6, SEI-11, SER-11, SER-20	1596
SER-AA, SER-A, SER-B, SER-C, SER-D, SER-G, SER-J, SER-K, SER-L	2500
SEI-30	3193
SEI-50, SEH-100, SEH-175	6386

2. Setup

Enter values for four basic system variables; refer to *Appendix A - Setup Menu*, page 9. The EEV is closed upon startup and the system will not operate until completing setup.

Once powered up, the controller will display the firmware versions for the display and the controller. It will then display the first variable to set.

1. Set **StEP**, Step Motor Stroke. Press and then turn the SELECT knob to select the correct number of steps for the EEV being used. See Table 2 for a list of Sporlan EEVs. Default is 2500. Press the SELECT button again to enter the value. The next variable is displayed.
2. Set **rEFr**, Refrigerant. Select the actual refrigerant used in the system (the refrigerant feeding the EEV), following the steps above. Default is R-404A.



CAUTION: Select the actual refrigerant used in the system.

3. Set **PltP**, Pressure Sensor Type. Select Absolute or Gauge, following the steps above. Default is Gauge (sealed).
4. Set **PrnR**, Pressure Sensor Range. Select 150, 300, or 500, following the steps above. Default is 300.
5. Once setup is complete, the display will alternate between **Lout** and the actual Liquid Outlet Temperature. After the system is in operation, verify that the Liquid Outlet Temperature Setpoint, **LoSP**, is met. Default is 75 degrees.

NOTE: If using a 3K temperature probe (or if unsure which probe you are using) refer to Appendix E, page 10, and follow the instructions to set the controller to the correct probe profile. Images of 2K and 3K probes are shown in Figure 8, page 15.

3. Setpoint Menu Operation

Make final setpoint changes; refer to *Appendix E - Setpoint Parameters*, page 10. The noted values are for verification; change them if necessary. All other values are for informational purposes.

NOTE: The Parameter Menu times out after 60 seconds of inactivity and you will lose all changes entered.

1. Enter the Parameter Menu: Press and hold the SELECT knob for 5 seconds. Rotate the knob to enter the password “111” and press the SELECT knob again.
2. To change a parameter, rotate the SELECT knob to the desired parameter and press the SELECT knob. The default value will display.
3. Turn the SELECT knob to change the value and then press the SELECT knob to enter the value and return to the Parameter Menu.
4. After all parameters are set, turn the SELECT knob to “ESC” and press the SELECT knob to save all changes. Observe the system for subcool operation. See *Appendix O - System Flowchart*, page 21.

The system is now operational. See *Appendix B - Process Values*, page 9, for the variables that the Subcool Control monitors.

4. System Operation

The Sporlan Subcool Control uses an interactive control scheme for Subcooling and Superheat operation. The controller optimizes the use of the heat exchanger based on the demand of subcooling loads.

If a third party or master controller is connected to the liquid line solenoid or suction stop valve, a digital input must be connected to terminals 25 and 26. This input allows the controller to respond to major flow variations upstream or downstream of the subcool control EEV (e.g.). Closing or shorting these terminals (when the liquid line solenoid or suction stop valve closes) places the controller into pumpdown mode and closes the subcool EEV. During this time, the controller will shut down the control scheme and prepare for restart. This ensures maximum control efficiency and system stability.

Two features of the controller allow enhanced operation as compared to previous subcooling methods.

The first feature is **SboF** (Subcooler Off Temperature Differential). The **SboF** is set as the minimum differential temperature above the **LoSP** (Liquid Outlet Temperature Control Setpoint). When ambient conditions provide a reduced condensing temperature and the need for subcooling has diminished, the Subcool Control can be turned off. The optional liquid inlet temperature sensor measures the liquid drop leg temperature. At temperatures below **SboF + LoSP**, the controller will go into pumpdown mode and close the subcool EEV. The control status will read **OFF**. The controller will switch back to the subcooling mode when the liquid temperature rises 5°F above the differential temperature (**Lout + SboF + 5°F**).

The second feature, **r9hL** (Return Gas High Limit), limits the temperature of the superheated refrigerant returning to the suction header to a maximum target value. By default, this setpoint is high in order to provide full functional subcool control from the factory. If the **r9hL** is set low, the controller

will override traditional subcool control in order to satisfy the return gas temperature. In this state, the *Lout* temperature may fall below the setpoint. To access these parameters see *Section 3 - Setpoint Menu Operation*, page 4.

Manual Valve Position Feature

The Sporlan Subcool Control offers the ability to control the subcooler expansion valve manually. This feature can be used in troubleshooting to determine if the expansion valve responds to an open or closed position signal directly from the controller. In normal operation, the manual mode should never be used.



WARNING : Be sure to avoid floodback while using this feature. Start with the valve in the low position.

Prior to entering manual mode, attach a Sporlan Kelvin II remote display to the RJ-45 port on the side of the Subcool Control to monitor superheat. This will allow the user to maintain a minimum superheat while in manual mode by adjusting the valve position. If the valve is positioned too far open while in manual mode, superheat will drop and liquid may enter the suction line. It is always better to start with the valve position low and work up to a higher position gradually while observing the superheat value on the remote display. Superheat should never be allowed to drop below 2°F. If this situation occurs, reduce valve position and allow system to respond (superheat should increase).

An alternate way to monitor superheat is to use a gauge set and a calibrated temperature sensor on the suction line; however the pressure and temperature will need to be converted to superheat.

To enter manual mode, press and hold the Select knob, select *!!!*, scroll to *SPoS* and push the knob. See *Section 3 - Setpoint Menu Operation*. The valve will start at the current “original” position. The controller will show percent valve opening. To verify if the valve is functioning, lower the valve position by rotating the knob counter-clockwise and note the change in superheat (increase). From this, increase valve position slowly and note the change in superheat (decrease). It may be necessary to allow appropriate time for system to respond to changes. Ensure superheat does not drop below that described above. To exit manual operation mode, press encoder knob, scroll to *ESC*, and press the knob again. After exiting manual mode, observe the system for proper operation.



WARNING: The controller should never be left unattended in manual mode.

5. Controller Networking

The Sporlan Subcool Control can communicate with a MODBUS communication master via RS485 to transfer process values and setpoints.

The Subcool Control supports only the RTU transmission mode. The serial settings are:

- 9600 baud (default), 19200 baud, 38400 baud
- 8 data bits
- 1 stop bit
- Even parity (default), odd parity, no parity

The Subcool Control supports the ‘Read Input Registers’, ‘Read Holding Register’, ‘Write Single Register’, ‘Read Multiple Coils’ and ‘Write Single Coil’ function codes. Other requests will cause an exception response. The Subcool Control will allow a full and partial block read of the Input and Holding registers and coils.

Scaling for Celsius / Bar

For better precision, scaling is used for Bar or Celsius units. PSI and Fahrenheit values are whole numbers and have no scaling. See *Appendix K - MODBUS Memory Map*.

Celsius values transferred via MODBUS are 10X. A value of 45 will be transferred for the Superheat when the actual Superheat temperature is 4.5°C. Remember this when changing a setpoint.

Bar values transferred via MODBUS are 100X. A value of 1034 will be transferred for the Maximum Operating Pressure when the actual pressure is 10.34 bar. Remember this when changing a setpoint.

Setup

The Sporlan Subcool Control can be networked to communicate process variables back to a master controller. This information can be used for verifying system performance or updating individual setpoints via RS-485 and PC interface. Data can be accessed remotely thru the master controller. For further information on remote monitoring of subcooling, see corresponding manuals for the master controller.

Prior to establishing the network, each controller must be assigned a separate address. Refer to *Section 3 – Setpoint Menu Operation* to enter setpoint menu. Once in the Setpoint menu, scroll to *Addr* and set each controller on the network with individual addresses. Note: No two controllers can have the same address. Default address for each controller is ‘1’.

MODBUS Communication Requirements

See *Figure 4 - MODBUS Wiring*.

Wire Type: 22-24 AWG Universal Twisted Pair

Maximum Number of Network Nodes: 100

Maximum Run Length: 4000 ft

Recommended Network Configuration: Daisy Chain, a single continuous transmission line from one end to the other. Other configurations involving triple-lug connections, such as star, are not recommended. See Figure 3.

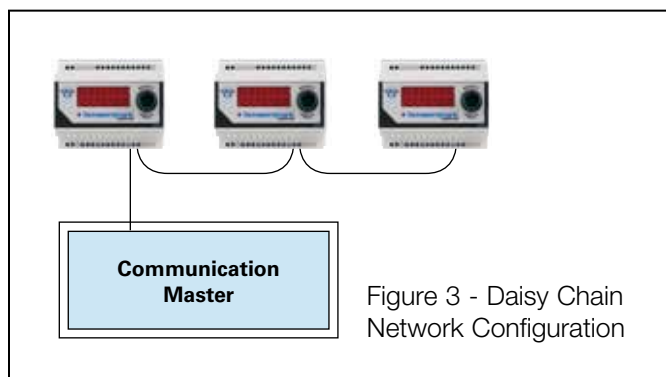
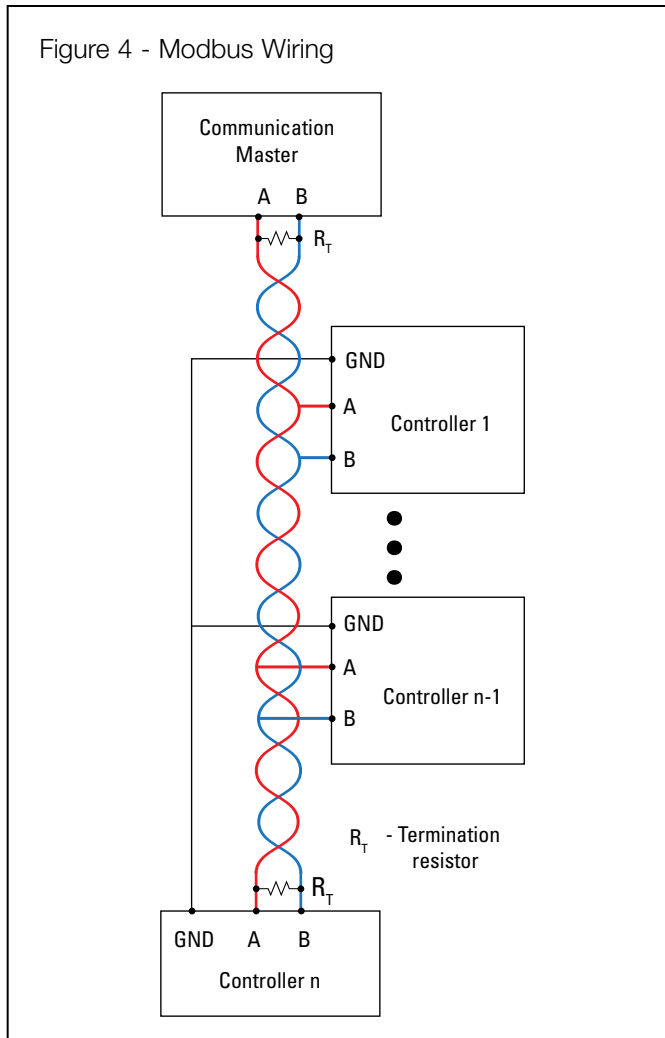


Figure 4 - Modbus Wiring



Addr - The address of the controller on the MODBUS network. See *Section 3 - Setpoint Menu Operation* to change it.

Noise Reduction: Termination resistance (R_T in Figure 4) is recommended to reduce reflections and noise on the data transmission lines. Place the resistance at the extreme ends of the cable with the resistance value matching the characteristic impedance of the transmission line (typically 120 ohms for twisted pair cables).

Shielding prevents noise from EMI sources. If the cable is shielded, connect the shield to earth ground at one end only. Do not connect shield to RS485 GND.

Keep RS485 wiring away from high voltage AC lines to reduce noise and data errors on communication lines. RS485 communication cable should be perpendicular to AC lines at any intersection.

Grounding: Connect a third conductor to RS485 GND (pin 13) to prevent ground potentials from node to node. This conductor should be included in the shield of the twisted pair cable to prevent noise. Do not connect RS485 GND to earth ground.

Third Party Controllers: To avoid nuisance “network errors”, the use of third party controllers on the same RS485 network

with Sporlan controllers and master is not recommended. If necessary, use a separate communication board on the master to connect separate third-party controllers.

See *Appendix K - MODBUS Memory Map*, page 16. Also, refer to the documentation supplied with the communication master for additional RS485 network requirements.

6. PID Tuning

The Sporlan Subcool Control is factory programmed with default Proportional-Integral-Derivative (PID) settings that will provide efficient control. It may be necessary, however, to fine tune the PID settings in applications where systems experience rapid transient conditions (such as frequent “impulse” changes in loading or mass flow rates).

The controller offers PID adjustments for both Subcooled liquid temperature and Superheat control. In most instances, adjustments to the PI set-points are adequate. If tuning is needed, see *Section 3 - Setpoint Menu Operation* to enter the PID setpoint menu. The following guidelines should be followed:

L_P (Liquid Proportional Coefficient) – Increase value to increase valve response to Subcooled liquid out temperature.

L_I (Liquid Integral Coefficient) – Increase value to decrease valve response to Subcooled liquid out temperature over a given time period.

L_D (Liquid Derivative Coefficient) – Increase value to increase valve response to rate of change in Subcooled liquid out temperature.

S_P (Superheat Proportional Coefficient) – Increase value to increase valve response to Superheat.

S_I (Superheat Integral Coefficient) – Increase value to decrease valve response to Superheat over a given time period.

S_D (Superheat Derivative Coefficient) – Increase value to increase valve response to rate of change in Superheat.

L_{SHI} (Low Superheat Integral Coefficient) – Increase value to decrease valve response to superheat over a given time period (Only in low Superheat conditions).

If PID adjustments are made, allow adequate time for the system to respond to the changes.

Large oscillations in Subcooled liquid or Superheat may require adjustments to the respective PID values. If Subcooled liquid and Superheat are equally unstable, adjust the Superheat PID values first, followed by the liquid PID values.

- When the Superheat is oscillating to extremes, the Proportional value may be too high and/or the Integral value may be too low.
- If the Superheat is not oscillating to extremes, but the Liquid control is very inconsistent around setpoint, then the Proportional value may need to be reduced or the Integral value increased.

These actions are inversely proportional in nature. If the sub-cooled liquid temperature or Superheat are slow to react to a transient system change, then the Proportional may be too low and or the Integral value may be too high in value.

Note: Not all refrigeration systems are designed alike. Use caution when tuning PID setpoints.

7. Troubleshooting

Recommendations

As with any refrigeration component troubleshooting, actual system conditions should be verified with a gauge set and calibrated temperature sensor (i.e verify actual superheat, subcooling and refrigerant condition). This system information is valuable in determining whether it is component related or system related.

For systems or applications that experience light loads on the Subcool control circuit, it is important that the Heat exchanger and refrigerant lines are sized correctly. This will ensure proper oil return and will minimize the effects of oil logging in the Heat exchanger. Many Heat exchanger manufacturers recommend a hot gas bypass for loads below 50%. Refer to the heat exchanger manufacturer’s installation instructions.

Sensors

Failed sensors will trigger an alarm. An alarm code will show which sensor is mis-wired, disconnected, or faulty. (See Appendix G - Alarms and Failsafes, page 13) The alarm will persist until the problem is corrected.

Failed temperature sensors will generally read extremely low or infinite resistance when tested with an ohmmeter. Readings should be taken with the sensor disconnected from the Subcool Control. A missing or disconnected temperature sensor will read **-50** on the controller.

Temperature sensor output can be checked by measuring the DC voltage across the sensor wire using the tables in Appendix L, page 18 and Appendix M, page 19.

Since the liquid and suction temperature sensors are identical, no alarm will be triggered if the sensors are switched (i.e. liquid sensor on the suction line). **Severe system damage may occur if these two sensor locations are interchanged.**

Pressure transducers must be installed tight enough to depress the valve stem in the fitting. Failure to do so will result in erroneous pressure readings and possibly leaks.

Pressure transducers should be tested while connected to the controller and powered. Test at the controller terminals. Voltage between terminals 34 and 35 should be 4.8 - 5.2 volts DC. Voltage between 33 and 34 should be between 0.5 and 4.5 volts DC. See Table 1 - Pressure Transducer Wire Colors, page 4.

To test the accuracy of the transducer, use a gauge set to obtain the actual system pressure. For volts-to-pressure conversion, measure the voltage between terminals 33 and 34. Identify the pressure transducer used and find the correct range **Prng** in Table 3.

Substitute the measured voltage (**V**) in the formula in the PSI column. The result should be within 3 psi of the actual system pressure shown on the gauge set. If not, check transducer for proper installation, correct schrader valve, and verify the pressure range identified on the transducer.

To test the transducer cable, disconnect the cable from the transducer and check for 4.8 - 5.2 volts between terminals **+** and **-**. See Figure 5 - Pressure Sensor Cable.

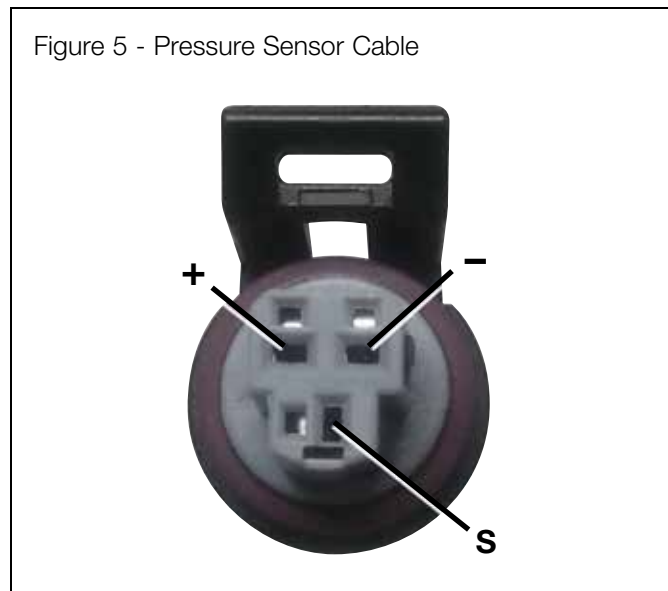


Table 3 - Pressure Transducer Specifications

LABEL COLOR	Prng	PSI
Green	150	(v-.5) x 37.5
None / Silver	300	(v-.5) x 75
Yellow	500	(v-.5) x 125

Table 4 - Troubleshooting

SYMPTOM	CHECK
Will not power up	Wiring terminals (power) at transformer and controller
	Supply voltage (see Technical Specification section)
Subcooling below setpoint	EPR valve setting (too low)
	Pressure Transducer Range (correct transducer set up in controller; 0-300, etc.)
	Pressure Transducer Type (correct transducer set up in controller; gauge/sealed versus absolute)
	Temperature Sensor Type (correct sensor set up in controller; 2K or 3K (see Appendix J - Sensor Installation, page 15)
	Temperature Sensor wiring (ensure sensor locations are not mis-matched)
	Proper foam insulation on piping and sensors
	Return Gas High Limit (<i>r_{9hL}</i>) set too low
Subcooling above setpoint	EPR valve setting (too high)
	Liquid condition entering expansion valve
	Pressure Transducer Range (correct transducer set up in controller; 0-300, etc.)
	Temperature Sensor Type (correct sensor set up in controller; 2K or 3K, see Appendix J - Sensor Installation, page 15)
	Subcool Control expansion valve (correct valve set up in controller; 1596, 2500 steps, etc.)
	Subcool Control expansion valve sizing (if valve position in controller is at 100% when symptom exists, valve may be undersized)
	Heat exchanger sizing
	Proper system refrigerant charge
	Oil return (oil logging in heat exchanger)
	Liquid line filter (clogging or excessive pressure drop)
No Subcooling	Subcool Control power
	Pump down signal (ensure Subcool Control expansion valve is not closed)
	Proper system refrigerant charge
	Liquid line filter (clogging or excessive pressure drop)
	Proper Subcooler Off Temperature Differential (<i>5boF</i>) (see Section 4 - System Operation, page 4)
	Subcool Control Expansion Valve operation
Subcooling Unstable	Wiring terminals (power) at transformer and controller
	Wiring terminals (sensors) at controller
	Sensor locations
	Sensor operation (See additional information under Section 7 - Troubleshooting, page 7)
	Proper heat exchanger flow direction
	Stability of head pressure control valves (upstream of Subcool Control expansion valve)
	Stability of suction pressure control valves (downstream of Subcool Control expansion valve)
	Stability of rack controller (verify compressors are not short cycling)
Controller PID setting (See Section 6 - PID Tuning, page 6)	
No Communication	Wiring at controller and master communication board
	Addresses of controllers (see Section 5 - Controller Networking, page 5)
Communication errors	Wiring terminals at controller and master communication board
	Network wiring from controller to master communication board (see Section 5 - Controller Networking, page 5)
	Proper network wire grounding (see Section 5 - Controller Networking, page 5)
	Termination resistors (see Section 5 - Controller Networking, page 5)
	Network parameters in controller and master communication board (baud rate, parity, etc; see Section 5, page 5)
Third party controllers on Subcool Control network	
Setpoints not saved	ESC must be set within 60 seconds of changes being made

APPENDIX A - Setup Menu

SETUP MENU																																						
<i>StEP</i>	Valve Type Default is 2500	↑ Counterclockwise	<table border="1"> <thead> <tr> <th>Display Readout</th> <th>Description</th> </tr> </thead> <tbody> <tr><td>1596</td><td>1596 Step Bipolar Valve</td></tr> <tr><td>3193</td><td>3193 Step Bipolar Valve</td></tr> <tr><td>2500</td><td>2500 Step Bipolar Valve</td></tr> <tr><td>6386</td><td>6386 Step Bipolar Valve</td></tr> <tr><td>400</td><td>400 Step Unipolar Valve</td></tr> </tbody> </table>	Display Readout	Description	1596	1596 Step Bipolar Valve	3193	3193 Step Bipolar Valve	2500	2500 Step Bipolar Valve	6386	6386 Step Bipolar Valve	400	400 Step Unipolar Valve	↓ Clockwise																						
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<i>rEFr</i>	Refrigerant Type Default is 404A NOTE: Select the actual refrigerant used in the system.	↑ Counterclockwise	<table border="1"> <thead> <tr> <th>Display Readout</th> <th>Description</th> </tr> </thead> <tbody> <tr><td>r22</td><td>R-22</td></tr> <tr><td>134A</td><td>R-134a</td></tr> <tr><td>402A</td><td>R-402A</td></tr> <tr><td>404A</td><td>R-404A</td></tr> <tr><td>407A</td><td>R-407A</td></tr> <tr><td>407C</td><td>R-407C</td></tr> <tr><td>410A</td><td>R-410A</td></tr> <tr><td>417A</td><td>R-417A</td></tr> <tr><td>422A</td><td>R-422A</td></tr> <tr><td>422d</td><td>R-422D</td></tr> <tr><td>r507</td><td>R-507A</td></tr> <tr><td>r744</td><td>R-744</td></tr> <tr><td>245F</td><td>R-245FA</td></tr> <tr><td>r-E5</td><td>R-E5</td></tr> <tr><td>438A</td><td>R-438A</td></tr> <tr><td>401b</td><td>R-401B</td></tr> </tbody> </table>	Display Readout	Description	r22	R-22	134A	R-134a	402A	R-402A	404A	R-404A	407A	R-407A	407C	R-407C	410A	R-410A	417A	R-417A	422A	R-422A	422d	R-422D	r507	R-507A	r744	R-744	245F	R-245FA	r-E5	R-E5	438A	R-438A	401b	R-401B	↓ Clockwise
Display Readout	Description																																					
r22	R-22																																					
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r-E5	R-E5																																					
438A	R-438A																																					
401b	R-401B																																					
<i>PtYP</i>	Pressure Sensor Type Default is Gauge	↑ Counterclockwise	<table border="1"> <thead> <tr> <th>Display Readout</th> <th>Description</th> </tr> </thead> <tbody> <tr><td>AbSL</td><td>Absolute Pressure Type</td></tr> <tr><td>9AUG</td><td>Gauge (Sealed) Pressure Type</td></tr> </tbody> </table>	Display Readout	Description	AbSL	Absolute Pressure Type	9AUG	Gauge (Sealed) Pressure Type	↓ Clockwise																												
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<i>Prrg</i>	Pressure Sensor Range Default is 300	↑ Counterclockwise	<table border="1"> <thead> <tr> <th>Display Readout</th> <th>Description</th> </tr> </thead> <tbody> <tr><td>150</td><td>0-150 PSI</td></tr> <tr><td>300</td><td>0-300 PSI</td></tr> <tr><td>500</td><td>0-500 PSI</td></tr> </tbody> </table>	Display Readout	Description	150	0-150 PSI	300	0-300 PSI	500	0-500 PSI	↓ Clockwise																										
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500	0-500 PSI																																					

Default values are highlighted.

APPENDIX B - Process Values

PROCESS	DESCRIPTION
<i>End</i>	Controller display address <i>EAdr</i> must be reset*
<i>Lout</i>	Liquid Outlet Temperature
<i>SupH</i>	Superheat (<i>tout-tsat</i>)
<i>SucP</i>	Suction Pressure
<i>tSAT</i>	Conversion of suction pressure to its saturated temperature
<i>tout</i>	Sensible heat out of the evaporator
<i>Posn</i>	Position of the EEV step motor
<i>L in</i>	Liquid Inlet Temperature (Optional)
<i>S-4</i>	Status of the Auxiliary Temperature Input
<i>StAt</i>	Controller Status
<i>ALS</i>	Controller Alarms

APPENDIX C - Controller Status

DISPLAY	DESCRIPTION
<i>Cool</i>	Subcool On (Valve modulating)
<i>Pdn</i>	Pumpdown (Valve closed)
<i>StPo</i>	Stepper Override (Manual valve control) Shown when manually controlling valve through remote display or Modbus
<i>OFF</i>	Subcool Off (Valve closed) When <i>SboF</i> and optional Liquid In temperature sensor is used, see Section 4 - System Operation

*If the controller display is alternating between *Ctrl*, and either a number 1-99 or *LoCL*, then scroll to *LoCL* and press the Select knob to view the local controller attached to this display. Then press and hold the Select knob for approximately 5 seconds and enter password *!!!* when prompted. Scroll to *EAdr* (Controller address) and set it to 0. Exit the setpoint menu.

APPENDIX D - Miscellaneous Displays

DISPLAY	DESCRIPTION
End	Press SELECT knob to exit menu
bAd	The wrong password has been entered
LoCL	Shows that readings refer to current controller
Ctrl	Shows which controller is displayed

APPENDIX E - Setpoint Parameters

PARAMETERS																																					
Counter-clockwise	ESC	Escape and Save Settings	—																																		
	LoSP	Liquid Outlet Temperature Setpoint Change to desired Liquid Out Temperature	10 to 100°F (-12.3 to 37.7°C) Default is 75°F (23.8°C)																																		
	rghL	Return Gas High Limit	40 to 120°F (4.4 to 48.8°C) Default is 120°F (48.8°C)																																		
	SboF	Subcooler Off Temperature Differential	0 to 30°F (0 to 16.7°C) Default is 10°F (5.5°C)																																		
	SHSP	Superheat Setpoint Change to desired Superheat Setpoint	5 to 45°F (2.8 to 25°C) Default is 10°F (5.5°C)																																		
	rEFr	Refrigerant Type Chosen at Setup Change to desired Refrigerant Type	<table border="1"> <thead> <tr> <th>Readout</th> <th>Description</th> </tr> </thead> <tbody> <tr><td>r22</td><td>R-22</td></tr> <tr><td>134A</td><td>R-134A</td></tr> <tr><td>402A</td><td>R-402A</td></tr> <tr><td>404A</td><td>R-404A</td></tr> <tr><td>407A</td><td>R-407A</td></tr> <tr><td>407C</td><td>R-407C</td></tr> <tr><td>410A</td><td>R-410A</td></tr> <tr><td>417A</td><td>R-417A</td></tr> <tr><td>422A</td><td>R-422A</td></tr> <tr><td>422d</td><td>R-422D</td></tr> <tr><td>r507</td><td>R-507A</td></tr> <tr><td>r744</td><td>R-744</td></tr> <tr><td>245F</td><td>R-245FA</td></tr> <tr><td>r-E5</td><td>R-E5</td></tr> <tr><td>438A</td><td>R-438A</td></tr> <tr><td>401b</td><td>R-401B</td></tr> </tbody> </table>	Readout	Description	r22	R-22	134A	R-134A	402A	R-402A	404A	R-404A	407A	R-407A	407C	R-407C	410A	R-410A	417A	R-417A	422A	R-422A	422d	R-422D	r507	R-507A	r744	R-744	245F	R-245FA	r-E5	R-E5	438A	R-438A	401b	R-401B
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	407A	R-407A																																			
	407C	R-407C																																			
	410A	R-410A																																			
417A	R-417A																																				
422A	R-422A																																				
422d	R-422D																																				
r507	R-507A																																				
r744	R-744																																				
245F	R-245FA																																				
r-E5	R-E5																																				
438A	R-438A																																				
401b	R-401B																																				
H.VP	Maximum Valve Capacity	0 to 100% Default is 100																																			
-LP-	Liquid Proportional Coefficient	0 to 25.5 Default is 1.0 Increase value to increase valve response to liquid out temperature																																			
-LI-	Liquid Integral Coefficient	0 to 255 Default is 60 Increase value to decrease valve response to liquid out temperature over time																																			
-LD-	Liquid Derivative Coefficient	0 to 255 Default is 0 Increase value to increase valve response to change in liquid out temperature																																			
-SP-	Superheat Proportional Coefficient	0 to 25.5 Default is 1.0 Increase value to increase valve response to superheat																																			
-SI-	Superheat Integral Coefficient	0 to 255 Default is 120 Increase value to decrease valve response to superheat over time																																			
-SD-	Superheat Derivative Coefficient	0 to 255 Default is 0 Increase value to increase valve response to change in superheat																																			
Clockwise																																					

Default values are highlighted.

APPENDIX E - Setpoint Parameters (continued)

PARAMETERS														
<i>LSH</i>	Low Superheat Integral Coefficient	1 to 255 Default is 10 <i>Increase value to decrease valve response to superheat over time, low Superheat condition</i>												
<i>CT</i>	CycleTime	1 to 10 seconds Default is 1												
<i>STEP</i> Chosen at Setup	Valve Type	<table border="1"> <thead> <tr> <th>Readout</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td><i>1596</i></td> <td>1596 Step Bipolar Valve</td> </tr> <tr> <td><i>3193</i></td> <td>3193 Step Bipolar Valve</td> </tr> <tr> <td>2500</td> <td>2500 Step Bipolar Valve</td> </tr> <tr> <td><i>6386</i></td> <td>6386 Step Bipolar Valve</td> </tr> <tr> <td><i>400</i></td> <td>400 Step Unipolar Valve</td> </tr> </tbody> </table>	Readout	Description	<i>1596</i>	1596 Step Bipolar Valve	<i>3193</i>	3193 Step Bipolar Valve	2500	2500 Step Bipolar Valve	<i>6386</i>	6386 Step Bipolar Valve	<i>400</i>	400 Step Unipolar Valve
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<i>3193</i>	3193 Step Bipolar Valve													
2500	2500 Step Bipolar Valve													
<i>6386</i>	6386 Step Bipolar Valve													
<i>400</i>	400 Step Unipolar Valve													
<i>SPoS</i>	Manual Valve Position	0 to 100% Open Default is 0												
<i>Addr</i>	MODBUS Network Address	1 to 255 Default is 1												
<i>baud</i>	MODBUS Baud Rate	<table border="1"> <thead> <tr> <th>Readout</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>96</td> <td>9600</td> </tr> <tr> <td><i>192</i></td> <td>19200</td> </tr> <tr> <td><i>384</i></td> <td>38400</td> </tr> </tbody> </table>	Readout	Description	96	9600	<i>192</i>	19200	<i>384</i>	38400				
Readout	Description													
96	9600													
<i>192</i>	19200													
<i>384</i>	38400													
<i>nPAR</i>	MODBUS Network Parity	<table border="1"> <thead> <tr> <th>Readout</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td><i>nonE</i></td> <td>No Parity</td> </tr> <tr> <td>EuEn</td> <td>Even Parity</td> </tr> <tr> <td><i>Odd</i></td> <td>Odd Parity</td> </tr> </tbody> </table>	Readout	Description	<i>nonE</i>	No Parity	EuEn	Even Parity	<i>Odd</i>	Odd Parity				
Readout	Description													
<i>nonE</i>	No Parity													
EuEn	Even Parity													
<i>Odd</i>	Odd Parity													
<i>Un_P</i>	Pressure Units	<table border="1"> <thead> <tr> <th>Readout</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>PS</td> <td>Pounds Force Per Square Inch</td> </tr> <tr> <td><i>bar</i></td> <td>Bars</td> </tr> </tbody> </table>	Readout	Description	PS	Pounds Force Per Square Inch	<i>bar</i>	Bars						
Readout	Description													
PS	Pounds Force Per Square Inch													
<i>bar</i>	Bars													
<i>Un_t</i>	Temperature Units	<table border="1"> <thead> <tr> <th>Readout</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>FAH</td> <td>Fahrenheit</td> </tr> <tr> <td><i>CELS</i></td> <td>Celsius</td> </tr> </tbody> </table>	Readout	Description	FAH	Fahrenheit	<i>CELS</i>	Celsius						
Readout	Description													
FAH	Fahrenheit													
<i>CELS</i>	Celsius													
<i>TEMP</i>	Temperature Sensor Type	<table border="1"> <thead> <tr> <th>Readout</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td><i>TEMP3</i></td> <td>3k</td> </tr> <tr> <td>TEMP2</td> <td>2k</td> </tr> </tbody> </table>	Readout	Description	<i>TEMP3</i>	3k	TEMP2	2k						
Readout	Description													
<i>TEMP3</i>	3k													
TEMP2	2k													
<i>PTYP</i> Chosen at Setup	Pressure Sensor Type	<table border="1"> <thead> <tr> <th>Readout</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td><i>ABS</i></td> <td>Absolute Pressure Type</td> </tr> <tr> <td>GAS</td> <td>Gauge (Sealed) Pressure Type</td> </tr> </tbody> </table>	Readout	Description	<i>ABS</i>	Absolute Pressure Type	GAS	Gauge (Sealed) Pressure Type						
Readout	Description													
<i>ABS</i>	Absolute Pressure Type													
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<i>PRNG</i> Chosen at Setup	Pressure Sensor Range	<table border="1"> <thead> <tr> <th>Readout</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td><i>150</i></td> <td>0-150 PSI</td> </tr> <tr> <td>300</td> <td>0-300 PSI</td> </tr> <tr> <td><i>500</i></td> <td>0-500 PSI</td> </tr> </tbody> </table>	Readout	Description	<i>150</i>	0-150 PSI	300	0-300 PSI	<i>500</i>	0-500 PSI				
Readout	Description													
<i>150</i>	0-150 PSI													
300	0-300 PSI													
<i>500</i>	0-500 PSI													
<i>CALP</i>	Pressure Sensor Calibration Offset	-5 to 5 PSI (-0.34 to 0.34 Bar) Default is 0												
<i>LT1</i>	Suction Temperature Calibration Offset	-5 to 5°F (-2.7 to 2.7°C) Default is 0												
<i>LT2</i>	Liquid Outlet Temperature Calibration Offset	-5 to 5°F (-2.7 to 2.7°C) Default is 0												
<i>LT3</i>	Liquid Inlet Temperature Calibration Offset	-5 to 5°F (-2.7 to 2.7°C) Default is 0												
<i>LT4</i>	Auxiliary Temperature Calibration Offset	-5 to 5°F (-2.7 to 2.7°C) Default is 0												
<i>ADR</i>	Controller Display Address	0 to 99 Default is 0, Do not change												

Default values are highlighted.

APPENDIX F - Parameter Definitions

DISPLAY	MEANING	DESCRIPTION
<i>ESC</i>	Escape	Escape from the Settings Menu and Return to Process Variables Menu
<i>LoSP</i>	Liquid Outlet Temperature Control Setpoint	The target control temperature of the liquid leaving the heat exchanger
<i>rghL</i>	Return Gas High Limit	Limits the temperature of the superheated refrigerant to a maximum target value (Limits superheat PID target)
<i>SboF</i>	Subcooler Off Temperature Differential	Temperature differential above the liquid outlet temperature setpoint that the liquid inlet temperature must fall below in order to switch to OFF mode. Will switch back to cooling after the liquid inlet temperature rises above the liquid outlet temperature + subcooler off temperature differential + 5 degrees F
<i>SHSP</i>	Superheat Setpoint	The minimum target superheat setpoint that the superheat PID can try to maintain
<i>rEFR</i>	Refrigerant	The currently selected refrigerant used to calculate the saturation temperature based on suction pressure
<i>HICP</i>	Maximum Stepper % Open	The maximum % open of the valve referenced to full stroke
<i>-LP-</i>	Liquid Proportional Gain Coefficient	Liquid Proportional Gain Coefficient
<i>-LI-</i>	Liquid Integral Gain Coefficient	Liquid Integral Gain Coefficient
<i>-LD-</i>	Liquid Derivative Gain Coefficient	Liquid Derivative Gain Coefficient
<i>-SP-</i>	Superheat Proportional Gain Coefficient	Superheat Proportional Gain Coefficient
<i>-SI-</i>	Superheat Integral Gain Coefficient	Superheat Integral Gain Coefficient
<i>-SD-</i>	Superheat Derivative Gain Coefficient	Superheat Derivative Gain Coefficient
<i>LSH_I</i>	Low Superheat Integral Gain Coefficient	The integral gain coefficient to use for the superheat PID loop if the superheat is below 3 degrees F
<i>CYCL</i>	Cycle Time	The PID update time
<i>STEP</i>	Stepper Type	The number of steps of resolution for the stepper valve at full stroke
<i>SPoS</i>	Manual Stepper Position	Overrides the stepper valve position and moves to the desired percent open relative to full stroke of the valve
<i>Addr</i>	Network Address	The address of the controller on the MODBUS network
<i>baud</i>	Network Baud Rate	The baud rate in hundreds of bits per second of the MODBUS network
<i>nPAR</i>	Network Parity Mode	The network parity mode of the MODBUS network
<i>Un_P</i>	Units of Pressure	The units of pressure the controller uses to display (PSI or Bar)
<i>Un_t</i>	Units of Temperature	The units of temperature the controller uses to display (Fahrenheit or Celsius)
<i>tT4P</i>	Temperature Sensor Type	The type of thermistor connected to the controller (2K type or 3K type)
<i>Pt4P</i>	Pressure Sensor Type	The type of pressure sensor connected to the controller (absolute or gauge type)
<i>Prrg</i>	Pressure Sensor Range	The range of the pressure sensor connected to the controller (0-150 PSI, 0-300 PSI, or 0-500 PSI)
<i>CRLP</i>	Pressure Calibration Offset	Adds a constant offset to the pressure reading
<i>CLt1</i>	T1 Temperature Calibration Offset	Adds a constant offset to the T1 temperature reading
<i>CLt2</i>	T2 Temperature Calibration Offset	Adds a constant offset to the T2 temperature reading
<i>CLt3</i>	T3 Temperature Calibration Offset	Adds a constant offset to the T3 temperature reading
<i>CLt4</i>	T4 Temperature Calibration Offset	Adds a constant offset to the T4 temperature reading
<i>CAdr</i>	Controller Address on Display Network	Controller must be set to 0 (Standalone) No display networking option

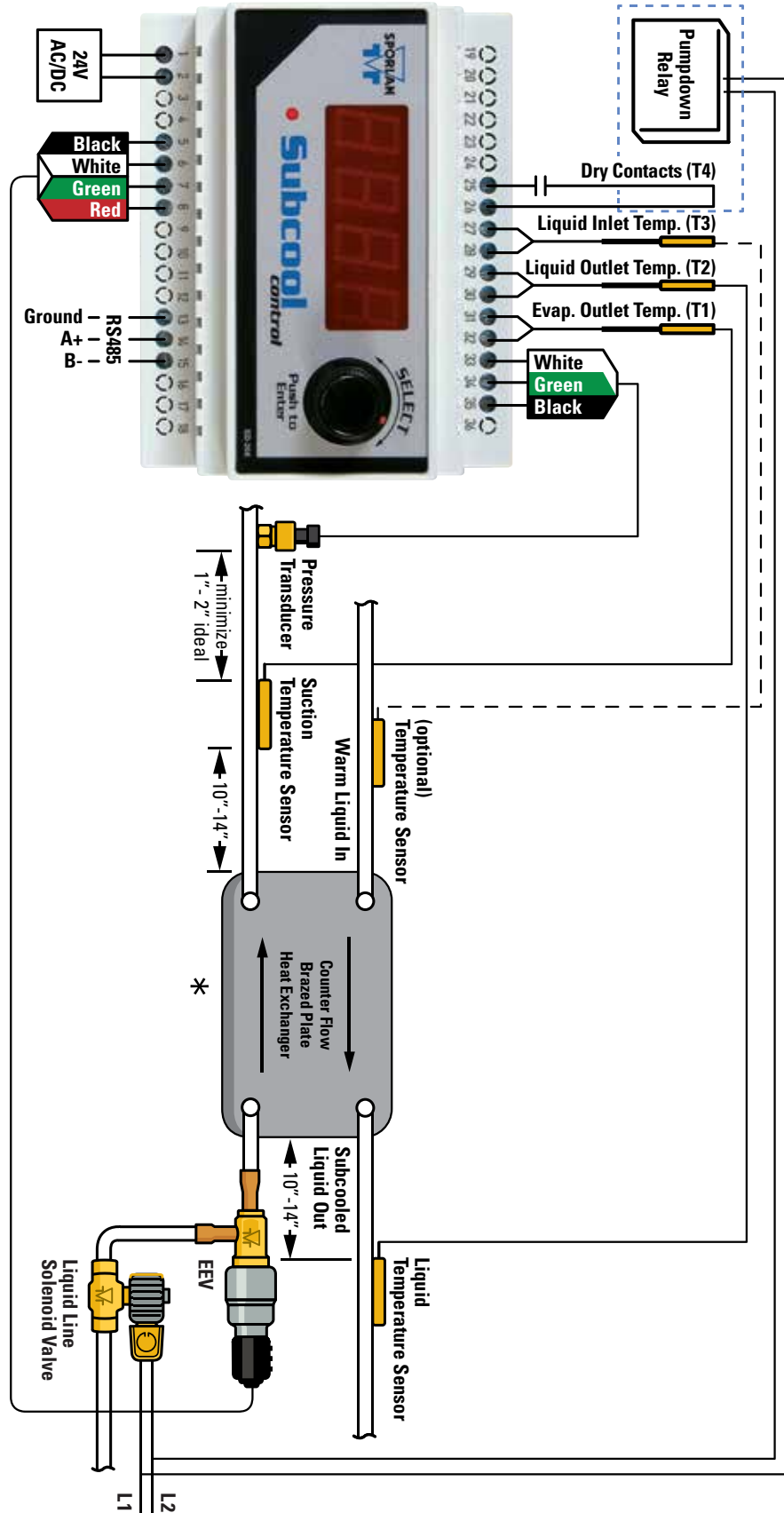
APPENDIX G - Alarms and Failsafes

READOUT	DESCRIPTION	CAUSE and FAILSAFE
<i>nonE</i>	No Active Alarms	Normal Operation
<i>PSAL</i>	Pressure Sensor Alarm	When the pressure is outside the operating range. Will force a pump-down.
<i>TSAL</i>	Suction Temperature Sensor Alarm	When the suction temperature is outside the operating range. (under -60 degrees, over 150 degrees) Will force a pump-down.
<i>LSAL</i>	Liquid Outlet Temperature Sensor Alarm	When the liquid outlet temperature is outside the operating range. Will force a pump-down.
<i>LSHA</i>	Low Superheat Alarm	When superheat is below 3 degrees for 30 cumulative seconds or more.

APPENDIX H - Technical Specifications

<p>ELECTRICAL</p> <p>Supply Voltage 20-26VAC 50/60Hz or 22-26.6VDC; Class II input</p> <p>Digital Inputs 0-5VDC Maximum Range Interface to dry contact or open collector</p> <p>Analog Inputs 4 Temperature Sensors - 2 Kohm (3 Kohm optional)</p> <p>1 Pressure Transducer .5 - 4.5VR (150 psig, 300 psig, or 500 psig)</p> <p>Digital Display LED - Red, 7 segment, 4 digit</p> <p>Indicators LED - Red, Power</p> <p>User Interface Optical Encoder (SELECT knob)</p> <p>Data Interface RS485, Modbus</p>	<p>MECHANICAL</p> <p>Operating Temperature -40°F to 158°F (-40°C to 70°C)</p> <p>Humidity 0-95%RH (Non-Condensing)</p> <p>Enclosure PC - Light Gray</p> <p>Wiring Screw terminal</p> <p>Mounting DIN Rail - EN 50 022</p> <p>COMPLIANCE</p> <p>Environmental RoHS WEEE</p> <p>Electrical CE UL/CUL (Recognized per 873) FCC (Class A, part 15) C-tick</p>
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APPENDIX I - Wiring Diagram



Note: Use caution when working around high voltage components. Safety covers should be used for personal safety on high voltage panels.



* Refer to the heat exchanger manufacturer's installation/orientation instructions.

APPENDIX J - Sensor Installation

Refer to *Appendix I - Wiring Diagram* for sensor locations.

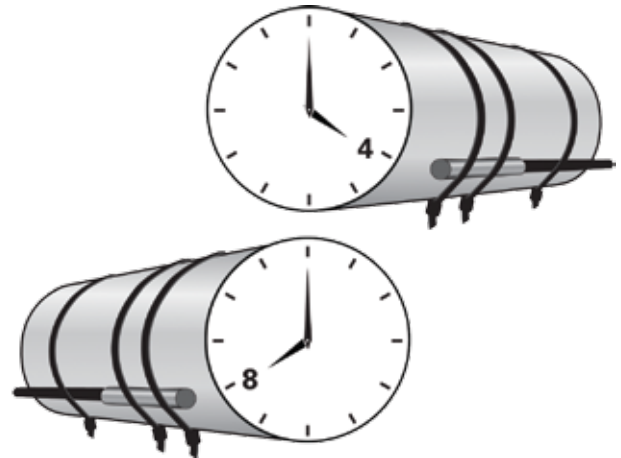
Mount the Pressure Transducer

1. Position the suction return gas pressure access port near the outlet of the heat exchanger.
2. Verify that the pressure range matches the expected system operating pressure (i.e 0-150 psig, 0-300 psig, etc).
3. Install transducer on access port at 12 o'clock, minimizing distance from temperature sensor. Check for leaks.
4. For safety, ensure Schrader core is installed in access fitting (only if 1/4" SAE is used). **Use caution when removing Schrader cap to avoid contacting expanding refrigerant.**
5. Connect pressure transducer cable to transducer.
6. Route and secure transducer cable away from hot surfaces and high power A/C voltage lines.
7. Attach wires to the Subcool Control.
8. Ensure pressure range and type (i.e gauge or absolute) are configured properly in the Subcool Controller, See *Section 2 - SETUP*, page 4.
9. After startup, use a gauge set to verify proper pressure reading through the Subcool Control. An improperly installed Schrader core can cause erroneous pressure readings.
10. Check for leaks after system is in operation.

Mount the Temperature Sensors – Suction and Liquid

1. Per *Appendix I - Wiring Diagram*, page 14, measure and mark locations on copper pipe. Position sensors 10-14 inches from the heat exchanger on a free-draining horizontal line.
2. Remove all insulation and adhesives at the marked location. Using Scotch-Brite™, clean the copper line to remove oxides and dirt. This will increase sensor accuracy.
3. Fasten the temperature sensors in orientation shown in *Figure 6*. Carefully note the locations of temperature sensors for Suction Gas and Liquid.
 - Mount the suction temperature sensor on the suction line after the heat exchanger, near the pressure transducer.
 - Mount the subcool liquid temperature sensor on the subcooled liquid outlet.
4. Attach and secure temperature sensor cables, routing them away from hot surfaces and high power A/C voltage lines.
5. Ensure that the Subcool Control is configured properly (i.e 2K or 3K sensor selection), See *Section 2 - SETUP*, page 4. **NOTE: 2K and 3K sensors have approximately 1.9kΩ and 2.8kΩ, respectively, at 80°F measured across the sensor wires.**
6. Wrap temperature sensors and copper tube with foam insulation to minimize ambient temperature effects, See *Figure 7*.

Figure 6 - Temperature Sensor Positioning



Temperature sensor should be mounted at either 4 or 8 o'clock, on a free-draining horizontal line.

Figure 7 - Cutaway of Pipe Insulation



2K sensor shown

Figure 8 - Temperature Sensors



2K sensor

3K sensor



WARNING: Ensure that “Suction” and “Liquid” temperature sensor locations are not reversed. Severe system damage may occur if these two sensor locations are interchanged.

APPENDIX K - MODBUS Memory Map

	REGISTER ADDRESS/DESCRIPTION	RANGE
Read Coils (0x01)	0. Manual Valve Enabled Flag	0 = Disabled 1 = Enabled
	1. Manual Valve Duration Enabled Flag	0 = Disabled 1 = Enabled
Read Holding Register (0x03)	0. Liquid Outlet Temperature Setpoint	10 to 100°F (-12.2 to 37.8°C)
	1. Return Gas Temperature Limit	10 to 120°F (-12.2 to 48.9°C)
	2. Subcooler Off Temperature Differential	0 to 30°F (0 to -16.7°C)
	3. Superheat Setpoint	5 to 45°F (2.8 to 25°C)
	6. Refrigerant Type	0 = R-22 1 = R-134A 2 = R-402A 3 = R-404A 4 = R-407A 5 = R-407C 6 = R-410A 7 = R-417A 8 = R-422A 9 = R-422D 10 = R-507A 11 = R-744 12 = R-245FA 13 = R-E5 14 = R-438A 15 = R-401B
	7. Valve Maximum	0 to 100%
	8. Liquid Proportional Coefficient	0 to 255
	9. Liquid Integral Coefficient	0 to 255
	10. Liquid Derivative Coefficient	0 to 255
	11. Superheat Proportional Coefficient	0 to 255
	12. Superheat Integral Coefficient	0 to 255
	13. Superheat Derivative Coefficient	0 to 255
	14. Cycle Time	1 to 10 seconds
	15. Valve Type	0 = 1596 1 = 3193 2 = 2500 3 = 6386 4 = 400
	16. Manual Valve Position	0 to 1000 (0 to 100.0%) Open
	17. MODBUS Network Address	1 to 255
	18. Pressure Units	0 = PSI 1 = BAR
	19. Temperature Units	0 = FAHR 1 = CELS
	20. Pressure Sensor Type	0 = ABSL 1 = GauG
	21. Pressure Range	1 = 150 PSI 2 = 300 PSI 3 = 500 PSI
	22. Pressure Calibration Offset	-5 to 5 PSI (-0.34 to 0.34 Bar)
	23. Suction Temperature Calibration Offset	-5 to 5°F (-2.8 to 2.8°C)
	24. Liquid Outlet Temperature Calibration Offset	-5 to 5°F (-2.8 to 2.8°C)
	25. Liquid Inlet Temperature Calibration Offset	-5 to 5°F (-2.8 to 2.8°C)
	26. Auxiliary Temperature Calibration Offset	-5 to 5°F (-2.8 to 2.8°C)
	27. Temperature Sensor Type	0 = 3K 1 = 2K
	28. Low Superheat Integral	1-255, Default is 10

APPENDIX K - MODBUS Memory Map (continued)

	REGISTER ADDRESS/DESCRIPTION	RANGE
Read Input Registers (0x04)	0. Controller FW Rev Level	0 to 65,535
	1. Liquid Outlet Temperature	-60 to 150°F (-51.1 to 65.6°C)
	2. Superheat	0 to 165°F (0 to 91.6°C)
	3. Suction Pressure	Depends on Pressure Sensor Range and Type (-15 to 500 PSI, -1.01 to 34.47 Bar) Maximum Range
	4. Saturation Temperature	-60 to 150°F (-51.1 to 65.6°C)
	5. Suction Temperature	-60 to 125°F (-51.1 to 65.6°C)
	6. Valve Position (% of Max. Stroke)	0 to 1000 (0 to 100.0%) Open
	7. Liquid Inlet Temperature	-60 to 125°F (-51.1 to 65.6°C)
	8. Auxiliary Temperature	-60 to 125°F (-51.1 to 65.6°C)
	9. System State	If Bit set then mode is active: Bit 0 = Setup Mode Bit 1 = Off Cycle Bit 2 = Cooling Cycle Bit 3 = Pump-down Cycle Bit 4 = Manual Valve Override Mode
10. Alarm Status	If Bit set then alarm is active: Bit 0 = Pressure Sensor Failure Alarm Bit 1 = Suction Temperature Sensor Failure Alarm Bit 2 = Liquid Outlet Temperature Sensor Failure Alarm Bit 3 = Low Superheat Alarm	
Write Single Coil (0x05)	0. Manual Valve Enabled Flag	0 = Disabled, 1 = Enabled The other coils are read-only.
Write Single Register (0x06)	Same as above.	The max number of registers written at a time is 1. The limits are listed under 'Read Holding Register.'

APPENDIX L - 2k Temperature Sensor Specifications

°C	°F	RANGE VDC
-51.1	-60	4.375 - 4.555
-50.6	-59	4.361 - 4.539
-50.0	-58	4.345 - 4.524
-49.4	-57	4.330 - 4.508
-48.9	-56	4.314 - 4.492
-48.3	-55	4.299 - 4.475
-47.8	-54	4.282 - 4.458
-47.2	-53	4.266 - 4.441
-46.7	-52	4.249 - 4.423
-46.1	-51	4.232 - 4.406
-45.6	-50	4.214 - 4.387
-45.0	-49	4.196 - 4.369
-44.4	-48	4.178 - 4.350
-43.9	-47	4.160 - 4.331
-43.3	-46	4.141 - 4.311
-42.8	-45	4.122 - 4.291
-42.2	-44	4.102 - 4.271
-41.7	-43	4.083 - 4.251
-41.1	-42	4.063 - 4.230
-40.6	-41	4.042 - 4.209
-40.0	-40	4.022 - 4.187
-39.4	-39	4.001 - 4.165
-38.9	-38	3.979 - 4.143
-38.3	-37	3.958 - 4.121
-37.8	-36	3.936 - 4.098
-37.2	-35	3.914 - 4.075
-36.7	-34	3.891 - 4.052
-36.1	-33	3.868 - 4.028
-35.6	-32	3.845 - 4.004
-35.0	-31	3.822 - 3.980
-34.4	-30	3.798 - 3.955
-33.9	-29	3.774 - 3.930
-33.3	-28	3.750 - 3.905
-32.8	-27	3.726 - 3.880
-32.2	-26	3.701 - 3.854
-31.7	-25	3.676 - 3.828
-31.1	-24	3.651 - 3.802
-30.6	-23	3.625 - 3.775
-30.0	-22	3.600 - 3.749
-29.4	-21	3.574 - 3.722
-28.9	-20	3.548 - 3.694
-28.3	-19	3.521 - 3.667
-27.8	-18	3.495 - 3.639
-27.2	-17	3.468 - 3.611
-26.7	-16	3.441 - 3.583
-26.1	-15	3.414 - 3.555
-25.6	-14	3.386 - 3.527
-25.0	-13	3.359 - 3.498
-24.4	-12	3.331 - 3.469
-23.9	-11	3.303 - 3.440
-23.3	-10	3.275 - 3.411
-22.8	-9	3.247 - 3.381
-22.2	-8	3.218 - 3.352
-21.7	-7	3.190 - 3.322
-21.1	-6	3.161 - 3.293
-20.6	-5	3.133 - 3.263
-20.0	-4	3.104 - 3.233
-19.4	-3	3.075 - 3.203
-18.9	-2	3.046 - 3.173

°C	°F	RANGE VDC
-18.3	-1	3.017 - 3.142
-17.8	0	2.988 - 3.112
-17.2	1	2.958 - 3.082
-16.7	2	2.929 - 3.051
-16.1	3	2.900 - 3.021
-15.6	4	2.871 - 2.990
-15.0	5	2.841 - 2.960
-14.4	6	2.812 - 2.929
-13.9	7	2.782 - 2.899
-13.3	8	2.753 - 2.868
-12.8	9	2.724 - 2.837
-12.2	10	2.694 - 2.807
-11.7	11	2.665 - 2.776
-11.1	12	2.636 - 2.746
-10.6	13	2.607 - 2.716
-10.0	14	2.577 - 2.685
-9.4	15	2.548 - 2.655
-8.9	16	2.519 - 2.625
-8.3	17	2.490 - 2.595
-7.8	18	2.462 - 2.565
-7.2	19	2.433 - 2.535
-6.7	20	2.404 - 2.505
-6.1	21	2.376 - 2.475
-5.6	22	2.347 - 2.446
-5.0	23	2.319 - 2.416
-4.4	24	2.291 - 2.387
-3.9	25	2.263 - 2.358
-3.3	26	2.235 - 2.329
-2.8	27	2.207 - 2.300
-2.2	28	2.179 - 2.271
-1.7	29	2.152 - 2.242
-1.1	30	2.125 - 2.214
-0.6	31	2.098 - 2.186
0.0	32	2.071 - 2.158
0.6	33	2.044 - 2.130
1.1	34	2.017 - 2.102
1.7	35	1.991 - 2.075
2.2	36	1.965 - 2.048
2.8	37	1.939 - 2.021
3.3	38	1.913 - 1.994
3.9	39	1.888 - 1.967
4.4	40	1.862 - 1.941
5.0	41	1.837 - 1.915
5.6	42	1.812 - 1.889
6.1	43	1.788 - 1.863
6.7	44	1.763 - 1.837
7.2	45	1.739 - 1.812
7.8	46	1.715 - 1.787
8.3	47	1.691 - 1.763
8.9	48	1.668 - 1.738
9.4	49	1.644 - 1.714
10.0	50	1.621 - 1.690
10.6	51	1.598 - 1.666
11.1	52	1.576 - 1.642
11.7	53	1.554 - 1.619
12.2	54	1.531 - 1.596
12.8	55	1.510 - 1.573
13.3	56	1.488 - 1.551
13.9	57	1.467 - 1.529

°C	°F	RANGE VDC
14.4	58	1.446 - 1.507
15.0	59	1.425 - 1.485
15.6	60	1.404 - 1.463
16.1	61	1.384 - 1.442
16.7	62	1.363 - 1.421
17.2	63	1.344 - 1.400
17.8	64	1.324 - 1.380
18.3	65	1.305 - 1.360
18.9	66	1.285 - 1.340
19.4	67	1.266 - 1.320
20.0	68	1.248 - 1.301
20.6	69	1.229 - 1.281
21.1	70	1.211 - 1.262
21.7	71	1.193 - 1.244
22.2	72	1.175 - 1.225
22.8	73	1.158 - 1.207
23.3	74	1.141 - 1.189
23.9	75	1.124 - 1.171
24.4	76	1.107 - 1.154
25.0	77	1.090 - 1.137
25.6	78	1.074 - 1.120
26.1	79	1.058 - 1.103
26.7	80	1.042 - 1.086
27.2	81	1.026 - 1.070
27.8	82	1.011 - 1.054
28.3	83	0.996 - 1.038
28.9	84	0.981 - 1.022
29.4	85	0.966 - 1.007
30.0	86	0.951 - 0.992
30.6	87	0.937 - 0.977
31.1	88	0.923 - 0.962
31.7	89	0.909 - 0.948
32.2	90	0.895 - 0.933
32.8	91	0.882 - 0.919
33.3	92	0.868 - 0.905
33.9	93	0.855 - 0.892
34.4	94	0.842 - 0.878
35.0	95	0.830 - 0.865
35.6	96	0.817 - 0.852
36.1	97	0.805 - 0.839
36.7	98	0.792 - 0.826
37.2	99	0.780 - 0.814
37.8	100	0.769 - 0.801
38.3	101	0.757 - 0.789
38.9	102	0.746 - 0.777
39.4	103	0.734 - 0.766
40.0	104	0.723 - 0.754
40.6	105	0.712 - 0.743
41.1	106	0.702 - 0.731
41.7	107	0.691 - 0.720
42.2	108	0.681 - 0.710
42.8	109	0.670 - 0.699
43.3	110	0.660 - 0.688
43.9	111	0.650 - 0.678
44.4	112	0.641 - 0.668
45.0	113	0.631 - 0.658
45.6	114	0.621 - 0.648
46.1	115	0.612 - 0.638
46.7	116	0.603 - 0.629

°C	°F	RANGE VDC
47.2	117	0.594 - 0.619
47.8	118	0.585 - 0.610
48.3	119	0.576 - 0.601
48.9	120	0.568 - 0.592
49.4	121	0.559 - 0.583
50.0	122	0.551 - 0.574
50.6	123	0.543 - 0.566
51.1	124	0.535 - 0.557
51.7	125	0.527 - 0.549
52.2	126	0.519 - 0.541
52.8	127	0.511 - 0.533
53.3	128	0.504 - 0.525
53.9	129	0.496 - 0.517
54.4	130	0.489 - 0.510
55.0	131	0.482 - 0.502
55.6	132	0.475 - 0.495
56.1	133	0.468 - 0.488
56.7	134	0.461 - 0.480
57.2	135	0.454 - 0.473
57.8	136	0.447 - 0.466
58.3	137	0.441 - 0.460
58.9	138	0.434 - 0.453
59.4	139	0.428 - 0.446
60.0	140	0.422 - 0.440
60.6	141	0.416 - 0.433
61.1	142	0.410 - 0.427
61.7	143	0.404 - 0.421
62.2	144	0.398 - 0.415
62.8	145	0.392 - 0.409
63.3	146	0.386 - 0.403
63.9	147	0.381 - 0.397
64.4	148	0.375 - 0.391
65.0	149	0.370 - 0.386
65.6	150	0.365 - 0.380

APPENDIX M - 3k Temperature Sensor Specifications

°C	°F	RANGE VDC
-51.1	-60	4.747 - 4.941
-50.6	-59	4.741 - 4.935
-50.0	-58	4.735 - 4.928
-49.4	-57	4.728 - 4.921
-48.9	-56	4.722 - 4.915
-48.3	-55	4.715 - 4.907
-47.8	-54	4.708 - 4.900
-47.2	-53	4.700 - 4.893
-46.7	-52	4.693 - 4.885
-46.1	-51	4.685 - 4.877
-45.6	-50	4.677 - 4.868
-45.0	-49	4.669 - 4.860
-44.4	-48	4.660 - 4.851
-43.9	-47	4.651 - 4.842
-43.3	-46	4.642 - 4.832
-42.8	-45	4.633 - 4.823
-42.2	-44	4.623 - 4.813
-41.7	-43	4.613 - 4.802
-41.1	-42	4.603 - 4.792
-40.6	-41	4.593 - 4.781
-40.0	-40	4.582 - 4.769
-39.4	-39	4.571 - 4.758
-38.9	-38	4.559 - 4.746
-38.3	-37	4.547 - 4.734
-37.8	-36	4.535 - 4.721
-37.2	-35	4.523 - 4.708
-36.7	-34	4.510 - 4.695
-36.1	-33	4.497 - 4.681
-35.6	-32	4.484 - 4.667
-35.0	-31	4.470 - 4.653
-34.4	-30	4.456 - 4.638
-33.9	-29	4.441 - 4.623
-33.3	-28	4.426 - 4.608
-32.8	-27	4.411 - 4.592
-32.2	-26	4.395 - 4.576
-31.7	-25	4.379 - 4.559
-31.1	-24	4.363 - 4.542
-30.6	-23	4.346 - 4.525
-30.0	-22	4.329 - 4.507
-29.4	-21	4.312 - 4.489
-28.9	-20	4.294 - 4.470
-28.3	-19	4.275 - 4.451
-27.8	-18	4.256 - 4.431
-27.2	-17	4.237 - 4.411
-26.7	-16	4.218 - 4.391
-26.1	-15	4.198 - 4.370
-25.6	-14	4.177 - 4.349
-25.0	-13	4.157 - 4.327
-24.4	-12	4.135 - 4.305
-23.9	-11	4.114 - 4.283
-23.3	-10	4.092 - 4.260
-22.8	-9	4.069 - 4.237
-22.2	-8	4.046 - 4.213
-21.7	-7	4.023 - 4.189
-21.1	-6	3.999 - 4.164
-20.6	-5	3.975 - 4.139
-20.0	-4	3.951 - 4.114
-19.4	-3	3.926 - 4.088
-18.9	-2	3.901 - 4.062

°C	°F	RANGE VDC
-18.3	-1	3.875 - 4.035
-17.8	0	3.849 - 4.008
-17.2	1	3.823 - 3.981
-16.7	2	3.796 - 3.953
-16.1	3	3.769 - 3.924
-15.6	4	3.741 - 3.896
-15.0	5	3.713 - 3.867
-14.4	6	3.685 - 3.837
-13.9	7	3.657 - 3.808
-13.3	8	3.628 - 3.778
-12.8	9	3.598 - 3.747
-12.2	10	3.569 - 3.717
-11.7	11	3.539 - 3.686
-11.1	12	3.509 - 3.654
-10.6	13	3.478 - 3.623
-10.0	14	3.448 - 3.591
-9.4	15	3.417 - 3.558
-8.9	16	3.385 - 3.526
-8.3	17	3.354 - 3.493
-7.8	18	3.322 - 3.460
-7.2	19	3.290 - 3.427
-6.7	20	3.258 - 3.393
-6.1	21	3.226 - 3.360
-5.6	22	3.193 - 3.326
-5.0	23	3.160 - 3.292
-4.4	24	3.127 - 3.257
-3.9	25	3.094 - 3.223
-3.3	26	3.061 - 3.189
-2.8	27	3.028 - 3.154
-2.2	28	2.994 - 3.119
-1.7	29	2.961 - 3.084
-1.1	30	2.927 - 3.049
-0.6	31	2.894 - 3.014
0.0	32	2.860 - 2.979
0.6	33	2.826 - 2.944
1.1	34	2.792 - 2.909
1.7	35	2.758 - 2.874
2.2	36	2.725 - 2.838
2.8	37	2.691 - 2.803
3.3	38	2.657 - 2.768
3.9	39	2.623 - 2.733
4.4	40	2.590 - 2.698
5.0	41	2.556 - 2.663
5.6	42	2.522 - 2.628
6.1	43	2.489 - 2.593
6.7	44	2.455 - 2.558
7.2	45	2.422 - 2.524
7.8	46	2.389 - 2.489
8.3	47	2.356 - 2.455
8.9	48	2.323 - 2.421
9.4	49	2.290 - 2.386
10.0	50	2.258 - 2.353
10.6	51	2.226 - 2.319
11.1	52	2.193 - 2.285
11.7	53	2.161 - 2.252
12.2	54	2.130 - 2.219
12.8	55	2.098 - 2.186
13.3	56	2.067 - 2.154
13.9	57	2.036 - 2.121

°C	°F	RANGE VDC
14.4	58	2.005 - 2.089
15.0	59	1.974 - 2.057
15.6	60	1.944 - 2.026
16.1	61	1.914 - 1.994
16.7	62	1.884 - 1.963
17.2	63	1.854 - 1.932
17.8	64	1.825 - 1.902
18.3	65	1.796 - 1.872
18.9	66	1.767 - 1.842
19.4	67	1.739 - 1.812
20.0	68	1.711 - 1.783
20.6	69	1.683 - 1.754
21.1	70	1.656 - 1.725
21.7	71	1.628 - 1.697
22.2	72	1.602 - 1.669
22.8	73	1.575 - 1.641
23.3	74	1.549 - 1.614
23.9	75	1.523 - 1.587
24.4	76	1.497 - 1.561
25.0	77	1.472 - 1.534
25.6	78	1.447 - 1.508
26.1	79	1.422 - 1.483
26.7	80	1.398 - 1.457
27.2	81	1.374 - 1.432
27.8	82	1.351 - 1.408
28.3	83	1.327 - 1.383
28.9	84	1.304 - 1.360
29.4	85	1.282 - 1.336
30.0	86	1.259 - 1.313
30.6	87	1.237 - 1.290
31.1	88	1.216 - 1.267
31.7	89	1.194 - 1.245
32.2	90	1.173 - 1.223
32.8	91	1.153 - 1.202
33.3	92	1.132 - 1.180
33.9	93	1.112 - 1.159
34.4	94	1.093 - 1.139
35.0	95	1.073 - 1.119
35.6	96	1.054 - 1.099
36.1	97	1.035 - 1.079
36.7	98	1.017 - 1.060
37.2	99	0.998 - 1.041
37.8	100	0.981 - 1.022
38.3	101	0.963 - 1.004
38.9	102	0.946 - 0.986
39.4	103	0.929 - 0.968
40.0	104	0.912 - 0.951
40.6	105	0.895 - 0.934
41.1	106	0.879 - 0.917
41.7	107	0.863 - 0.900
42.2	108	0.848 - 0.884
42.8	109	0.832 - 0.868
43.3	110	0.817 - 0.852
43.9	111	0.803 - 0.837
44.4	112	0.788 - 0.822
45.0	113	0.774 - 0.807
45.6	114	0.760 - 0.792
46.1	115	0.746 - 0.778
46.7	116	0.732 - 0.764

°C	°F	RANGE VDC
47.2	117	0.719 - 0.750
47.8	118	0.706 - 0.736
48.3	119	0.693 - 0.723
48.9	120	0.681 - 0.710
49.4	121	0.668 - 0.697
50.0	122	0.656 - 0.684
50.6	123	0.644 - 0.672
51.1	124	0.633 - 0.660
51.7	125	0.621 - 0.648
52.2	126	0.610 - 0.636
52.8	127	0.599 - 0.624
53.3	128	0.588 - 0.613
53.9	129	0.577 - 0.602
54.4	130	0.567 - 0.591
55.0	131	0.557 - 0.580
55.6	132	0.547 - 0.570
56.1	133	0.537 - 0.560
56.7	134	0.527 - 0.550
57.2	135	0.518 - 0.540
57.8	136	0.508 - 0.530
58.3	137	0.499 - 0.520
58.9	138	0.490 - 0.511
59.4	139	0.481 - 0.502
60.0	140	0.473 - 0.493
60.6	141	0.464 - 0.484
61.1	142	0.456 - 0.475
61.7	143	0.448 - 0.467
62.2	144	0.440 - 0.459
62.8	145	0.432 - 0.450
63.3	146	0.424 - 0.442
63.9	147	0.417 - 0.435
64.4	148	0.409 - 0.427
65.0	149	0.402 - 0.419
65.6	150	0.395 - 0.412

APPENDIX N - Accessories

DESCRIPTION	ITEM	NOTES
Sporlan Controllers Subcool Controller Kelvin II d	952570 952568	Remote display unit
Parker Sporlan Temperature Probes 2K Well Sensor Kit 2K Sensor 3K Well Sensor Kit 3K Surface Sensor Brass Well	952795 952662 953156 952551 952969	Brass well with nickel plated brass housing Nickel plated brass housing, used with well. Can be used without well. Brass well with stainless steel housing Brass, not used with well Brass well only, no sensor
Parker Sporlan Pressure Transducers PSPT0500SVSP-S PSPT0300SVSP-S PSPT0150SVSP-S	952576 952574 952572	0-500 psis transducer (R-744 subcritical) 0-300 psis transducer (R-410A) 0-150 psis transducer (all other refrigerants)
Transducer Cables PSPT000000CP50 PSPT000000CP20	953100 953192	5 meter cable 2 meter cable
Troubleshooting Accessories SMA-12	953276	Handheld digital instrument for testing electric valve performance

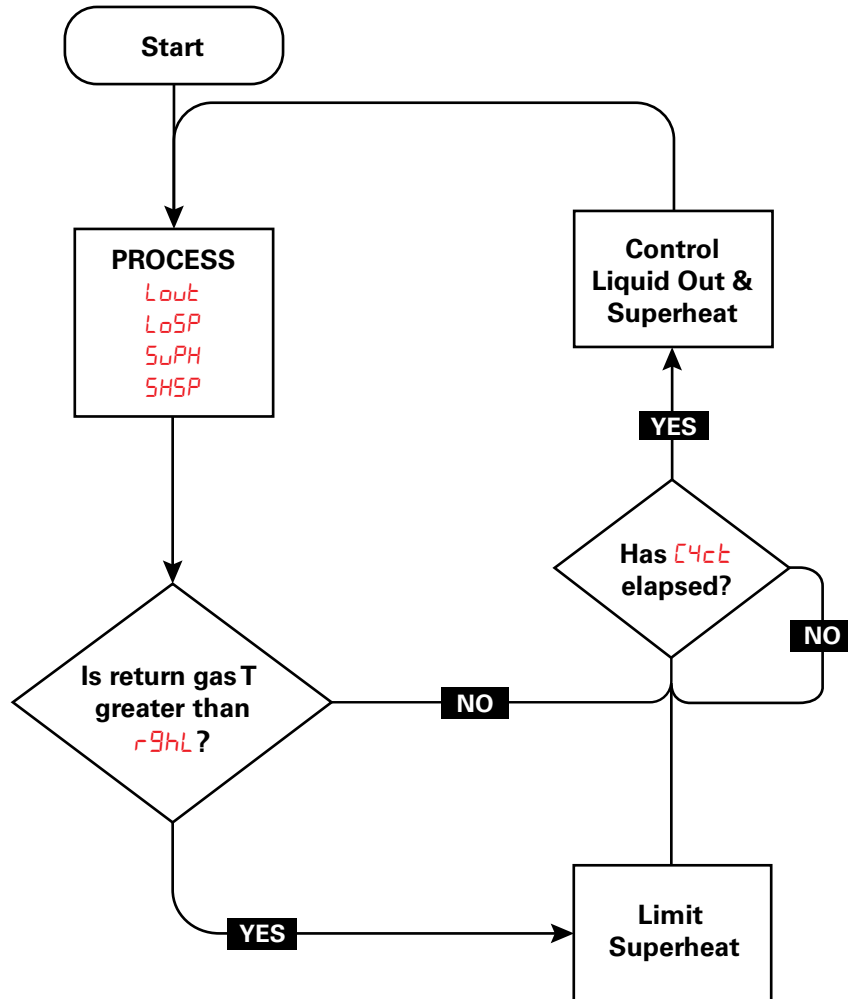
* Transducer selection is based on the refrigerant being used.

R-744 requires 500 psi

R-410A requires 300 psi or higher

All others require 150 psi or higher

APPENDIX 0 - System Flow Chart



DOCUMENT REVISION HISTORY

Revision	Date Code	Description of Revision	Author	Approved
000	122011	Added Revision History	—	—
001	062012	Updated Appendices E, I, K, N Updated Table 2	JH	ER
002	112012	Revised as Bulletin	JH	ER



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