Application Engineering BULLETIN

AE4-1287 R7 December 2013

Copeland Discus™ Demand Cooling™

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Safety Instructions

Copeland Scroll™ compressors are manufactured according to the latest U.S. and European Safety Standards. Particular emphasis has been placed on the user's safety. Safey icons are explained below and safety instructions applicable to the products in this bulletin are grouped on page 3. These instructions should be retained throughout the lifetime of the compressor. **You are strongly advised to follow these safety instructions.**

Safety Icon Explanation

⚠ DANGER	DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury.
⚠ WARNING	WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.
⚠ CAUTION	CAUTION, used with the safety alert symbol, indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
NOTICE	NOTICE is used to address practices not related to personal injury.
CAUTION	CAUTION, without the safety alert symbol, is used to address practices not related to personal injury.

Instructions Pertaining to Risk of Electrical Shock, Fire, or Injury to Persons

⚠WARNING	**ELECTRICAL SHOCK HAZARD** • Disconnect and lock out power before servicing. • Discharge all capacitors before servicing. • Use compressor with grounded system only. • Molded electrical plug must be used when required. • Refer to original equipment wiring diagrams. • Electrical connections must be made by qualified electrical personnel. • Failure to follow these warnings could result in serious personal injury.
⚠WARNING	**PRESSURIZED SYSTEM HAZARD** • System contains refrigerant and oil under pressure. • Remove refrigerant from both the high and low compressor side before removing compressor. • Use appropriate back up wrenches on rotalock fittings when servicing. • Never install a system and leave it unattended when it has no charge, a holding charge, or with the service valves closed without electrically locking out the system. • Use only approved refrigerants and refrigeration oils. • Personal safety equipment must be used. • Failure to follow these warnings could result in serious personal injury.
⚠WARNING	**BURN HAZARD** • Do not touch the compressor until it has cooled down. • Ensure that materials and wiring do not touch high temperature areas of the compressor. • Use caution when brazing system components. • Personal safety equipment must be used. • Failure to follow these warnings could result in serious personal injury or property damage.
⚠CAUTION	**COMPRESSOR HANDLING** • Use the appropriate lifting devices to move compressors. • Personal safety equipment must be used. • Failure to follow these warnings could result in personal injury or property damage.

Safety Statements

- Refrigerant compressors must be employed only for their intended use.
- Only qualified and authorized HVAC or refrigeration personnel are permitted to install, commission and maintain this equipment.
- Electrical connections must be made by qualified electrical personnel.
- All valid standards and codes for installing, servicing, and maintaining electrical and refrigeration equipment must be observed.

Introduction

HCFC-22, when used in a properly designed and controlled refrigeration system, is a realistic low temperature refrigerant alternative to CFC-502, which has been phased out due to its high ozone depletion potential. However, experience has shown that HCFC-22 can present problems as a low temperature refrigerant because under some conditions the internal compressor discharge temperature exceeds the safe temperature limit for long term stability of refrigeration oil. Other refrigerants such as HFC-407A, HFC-407C and HFC-407F also have these characteristics.

⚠ CAUTION

POE must be handled carefully and the proper protective equipment (gloves, eye protection, etc.) must be used when handling POE lubricant. POE must not come into contact with any surface or material that might be harmed by POE, including without limitation, certain polymers (e.g. PVC/CPVC and polycarbonate).

The Demand Cooling™ system (see **Figure 1** at the end of this bulletin) uses modern electronics to provide a reliable cost effective solution to this problem. It is required for all single stage HCFC-22, HFC-407A, HFC-407C and HFC-407F applications with saturated suction temperatures below -10°F.

Demand Cooling is compatible with single (conventional) units as well as parallel racks.

The Demand Cooling module uses the signal of a discharge head temperature sensor to monitor discharge gas temperature. If a critical temperature is reached, the module energizes a long life injection valve which meters a controlled amount of saturated refrigerant into the compressor suction cavity to cool the suction gas. This process controls the discharge temperature to a safe level. If, for some reason, the discharge temperature rises above a preset maximum level, the Demand Cooling module will turn the compressor off (requiring a manual reset) and actuate its alarm contact. To minimize the amount of refrigerant which must be injected, the suction gas cooling process is performed after the gas has passed around and through the motor.

Injection valve orifices have been carefully chosen for each body style to be large enough to provide the necessary cooling when required but not so large that dangerous amounts of liquid are injected, or that excessive system pressure fluctuation occurs during injection valve cycling. Normally, pressure fluctuations are no greater than 1 to 2 psi. It is important to use the correct valve for each compressor body style.

Performance data for Demand Cooling compressors includes the effects of injection when it is required. The approximate conditions where injection occurs are shown in **Figures 2** and **3**. At the conditions where Demand Cooling is operating, the performance values are time averages of the instantaneous values, since small fluctuations in suction and discharge conditions occur as the Demand Cooling injection valve cycles.

While the refrigerant injection concept has been widely recognized for some time, its application has not been widely used since the early 1960's because of the widespread availability of CFC-502, reduction of capacity and efficiency, and poor reliability of injection systems.

The Demand Cooling system addresses the capacity and efficiency issues by limiting injection to those times when it is required to control discharge temperatures to safe levels. For most applications this will only be during periods of high condensing temperatures, high return gas temperatures, or abnormally low suction pressure. The Demand Cooling system has been designed to meet the same high reliability standards as Discus compressors.

In most cases, with floating head systems where condensing temperatures are low during most of the year, Demand Cooling will operate primarily as a compressor protection control much as the oil failure control protects the compressor during periods of low oil pressure. Demand Cooling will be called to operate only during those periods when condensing temperatures and return gas temperatures are high or in periods where a system failure (such as an iced evaporator, an expansion valve which does not control superheat, blocked condenser, or a failed condenser fan) raises condensing temperatures or return gas temperatures to abnormally high levels or lowers suction pressure to abnormally low levels.

Operating Range

Demand Cooling is designed to protect the compressor from high discharge temperatures over the evaporating and condensing temperature ranges shown in **Figures 2** and **3**. For information on head fan requirements or other return gas conditions, contact your Application Engineer.

Demand Cooling System Design

When Demand Cooling operates, it "diverts" refrigeration capacity in the form of injected saturated refrigerant from the evaporator to the compressor (See **Figure 4** for a typical single system schematic). The effect of this diversion on evaporator capacity is minimal because the diverted capacity is used to cool the gas entering the compressor. As the gas is cooled, it naturally becomes more dense, increasing the mass flow through the compressor, which partly compensates for the capacity diverted from the evaporator.

If there is substantial heat gain along the suction line, injection may result in a substantial loss in evaporator capacity during Demand Cooling operation. In order to minimize this loss, good practice indicates Demand Cooling operation be kept to a minimum through proper system design and installation practices. There are three areas which can be addressed to minimize the impact of Demand Cooling operation on performance.

1. Compressor Return Gas Temperature: Suction lines should be well insulated to reduce suction line heat gain. Return gas superheat should be as low as possible consistent with safe compressor operation.
2. Condensing Temperatures: It is important when using HCFC-22, HFC-407A, HFC-407C or HFC-407F as a low temperature refrigerant that condensing temperatures be minimized to reduce compression ratios and compressor discharge temperature.
3. Suction pressure: Evaporator design and system control settings should provide the maximum suction pressure consistent with the application in order to have as low a compression ratio as possible.

Demand Cooling™ Compressors

No new compressor models have been introduced for Demand Cooling. Instead, existing low temperature Discus CFC-502 compressors have been modified for use with HCFC-22, HFC-407A, HFC-407C or HFC-407F and Demand Cooling. The modifications are the addition of an injection port on the compressor body and a temperature sensor port in the head of the compressor. The locations of these ports are critical and were determined through an extensive development program.

The HCFC-22, HFC-407A, HFC-407C and HFC-407F rating data includes the effects of Demand Cooling injection when operating conditions require it based on 65 °F return gas.

Condenser Sizing

Condensers should be sized using conventional methods. Demand Cooling has virtually no effect on system heat of rejection.

Demand Cooling System Components

The Demand Cooling System (see **Figure 1**) consists of: The Demand Cooling Temperature Sensor (TS), The Demand Cooling Module (CM), and the Injection Valve (IV).

The TS uses a precision Negative Temperature Coefficient (NTC) Thermistor (thermistor resistance drops on temperature rise) to provide temperature signals to the CM.

The IV meters refrigerant flow from the liquid line to the compressor. The IV solenoid receives on-off signals from the CM. When compressor cooling is required the solenoid is energized and opens the IV orifice to deliver saturated refrigerant to the compressor for cooling. The valve orifice is carefully sized to meet the requirements of each body style of Discus compressors.

The CM has three functional groups:

A. The **Input signal and calculator circuits** compare the temperature sensor input signal to an internal set-point and decide whether to energize the IV solenoid or, in the case of a problem, the CM alarm relay.

B. The **output signal to the IV** is controlled by an electronic switch connected to the IV solenoid so that, when required, refrigerant vapor can be metered to the compressor to prevent compressor overheating. One side of the electronic switch is connected internally to "L1" and the other side to output terminal "S" (see **Figure 6**).

C. The **alarm signal for local or remote control**. The alarm relay is energized, after a one minute delay, by a continuous, low or high TS temperature signal. An alarm signal can indicate the following:
   1. Compressor discharge temperature has risen above the level designed to be controlled by Demand Cooling.
   2. A shorted sensor.
   3. An open sensor.

In order to avoid nuisance trips, a one minute time delay is provided before alarm after a continuous high or low resistance reading or over temperature condition.

The alarm relay uses a single-pole-double-throw contact. The contact terminals are “L”, “M”, and “A”:

“L” - Common (to “A” and “M”)

“L - M” - Normally Closed (compressor run. open on alarm)

“L - A” - Normally Open (alarm signal, close on alarm)

The Normally Closed (NC) contact of the alarm relay (“L” to “M”) should be wired in the compressor contactor control circuit so that opening this contact removes the compressor from the line and removes power to the CM. See **Figures 5A, B, C,** and **D**.

Figures **5A** and **B** also show a current sensing relay **(which must be used with compressors employing internal over current protection. The current sensing relay is already included when using CoreSense protection)** and Sentronic oil pressure switch. The control circuit is purposely arranged so that an internal overload protector trip removes power to both the Sentronic™ and the Demand Cooling module. This precaution prevents the oil pressure switch from timing out and the Demand Cooling solenoid from injecting when the compressor is not operating.

The alarm relay requires a manual reset in order to call attention to a system problem.

Demand Cooling

CoreSense Protection is compatible with Copeland Demand Cooling™. However, the discharge temperature protection is provided by the Demand Cooling module. Discharge temperature information will not be communicated to the CoreSense Protection module. See **Figure 5E**.

System Information

1. Demand Cooling is designed to work on all Copeland Discus™ compressors equipped with injection ports. A different kit is required for each compressor body style and control voltage. See **Table 2** for a listing of Demand Cooling Kit part numbers.

2. The system must be clean. A dirty system may have foreign material that can lodge in the solenoid orifice. Always install a liquid line filter dryer in the injection valve inlet line capable of removing particles as small as 25 microns.

3. Do not use any filters containing materials that can leave the filter and possibly clog the IV orifice.

4. The liquid refrigerant supply line must be a minimum of 3/8" and routed so it will not interfere with compressor maintenance. Liquid refrigerant must have sufficient subcooling at the injection valve to prevent flashing upstream of the valve.

5. The liquid refrigerant supply line to the IV must be supported so that it does not place stress on the IV and IV tubing or permit excess vibration. Failure to make this provision may result in damage to the IV and its tubing and/or refrigerant loss.

6. A head fan must be used to help lower compressor discharge temperatures for compressors using HCFC-22. Contact your Application Engineer for head fan requirements with other refrigerants.

7. Return gas temperatures must **NOT** exceed 65°F.

8. System designers are advised to review their defrost schemes to avoid floodback to the compressor which may occur at defrost termination with HCFC-22, HFC-407A, HFC-407C and HFC-407F. These refrigerants have a significantly higher heat of vaporization than does CFC-502, and if the same design parameters used with CFC-502 are used, floodback may occur.

Demand Cooling with Discus Compressor Unloading

Demand Cooling has been approved with unloading for 4D, 6D and 3D Copeland Discus Digital™. Demand Cooling has NOT been approved for 3D Moduload.

Note! For Discus compressors with CoreSense Diagnostics with the build of material (BOM) nomenclature beginning with -ADx (e.g. 4DKNF63KL-TSK-AD0) Demand Cooling capability is built in.

4D and 6D Unloading with Demand Cooling

Demand Cooling protection is applicable with compressors using conventional blocked suction unloading. Earlier application guidelines required that liquid injection only occur when the compressor is in its fully loaded state. This was to avoid flooding the compressor with saturated liquid. After further evaluation, Emerson engineering has determined that the Copeland Discus compressor will still flash the injected liquid refrigerant when the compressor is unloaded should the discharge temperatures govern the need for added cooling. The Demand Cooling module will only inject liquid when required. When the temperature decreases to an acceptable level, the module will stop injecting.

3D Copeland Discus Digital™ with Demand Cooling

Demand Cooling can be used with 3D Discus™ digital compressors without adding extra unloader control circuitry. The Demand Cooling temperature sensing probe must be installed to replace the temperature sensing probe that is provided with the Digital Compressor Controller (IDCM). The T1 to T2 connection on the Digital Compressor Controller should be jumpered with a 5 kOhm 1 Watt resistor. This allows the Demand Cooling module to protect against high discharge temperatures and inject liquid when needed.

Performance Adjustment Factors

Since compressor discharge temperature depends strongly on the return gas temperature, the amount of injection and its effect on evaporator capacity and mass flow will vary somewhat with return gas temperature. The approximate effects of return gas temperature on evaporator capacity and mass flow are tabulated in **Tables 3A** and **3B** for HCFC-22. These factors should be applied to the 65ºF return gas capacity and mass flow values in the published performance data sheets.

Performance values for HFC-407A, HFC-407C and HFC-407F are not provided in this bulletin. For actual performance values refer to the "Online Product Information" at www.emersonclimate.com. As a general rule of thumb, Emerson Climate Technologies recommends assuming that HFC-407A, HFC-407C and HFC-407F produce about 10% to 15% less evaporator capacity than R-22 for low temperature applications.

Demand Cooling Specifications

Demand Cooling is designed to operate and protect the compressor within the evaporating and condensing envelope identified in **Figure 2**. Operating setpoints and control actions are listed in **Table 1**.

Attached is the Demand Cooling Diagnostic Troubleshooting Guide (**Form No. 92-91**)

See also:

Demand Cooling Installation Instruction Guides

Emerson Climate Technologies Publication Nos.

90-130 for 2D/3D Compressors

90-131 for 4D Compressors

90-133 for 6D Compressors

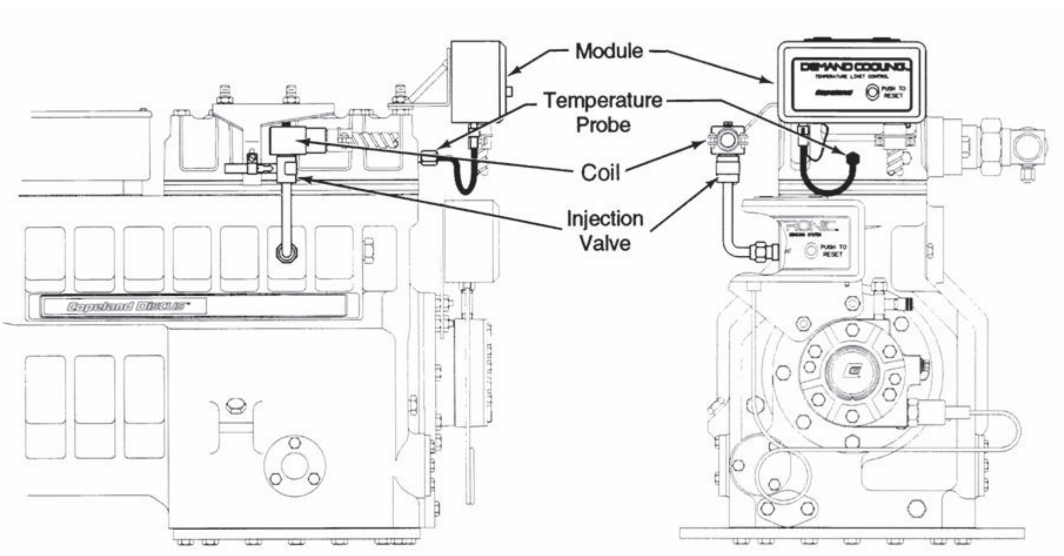


Figure 1 – Demand Cooling System

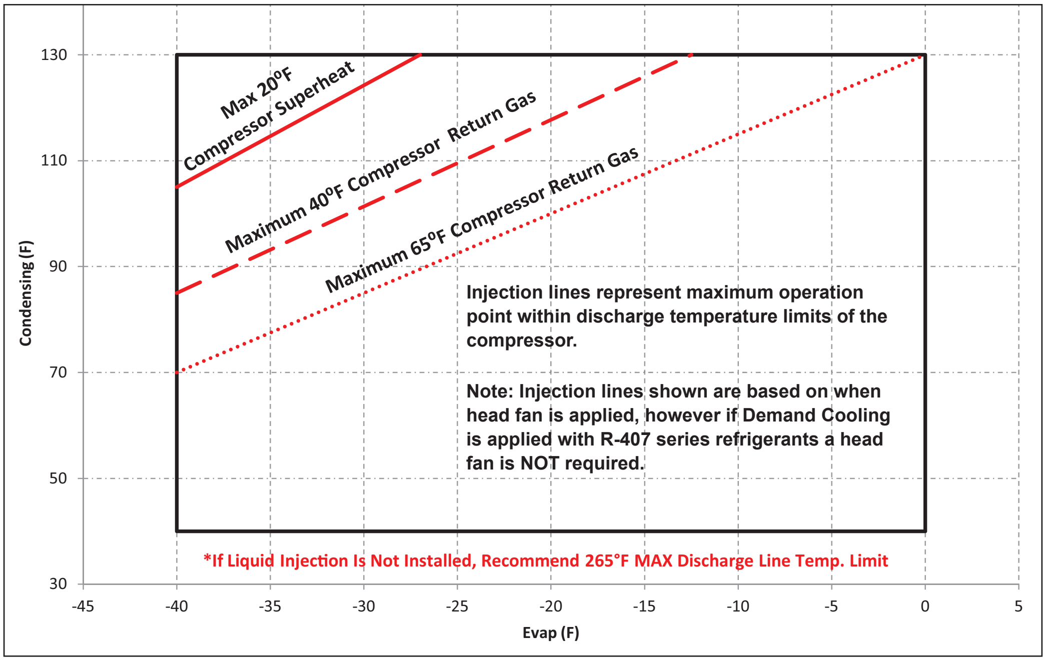


Figure 2 – Low Temperature Operating Envelope with Demand Cooling for R-407A, R-407C and R-407F

* Copeland Discus Operating Map with head fan for R407A/C/F with average injection line depending on compressor superheat/return gas. Points below the line Demand Cooling Injection would not be active. For example at -25°F evaporating temperature 80°F condensing and 65°F return gas there would not be injection, but at the same evaporating temperature and return gas temperature at 120°F condensing temperature the Demand Cooling would inject.

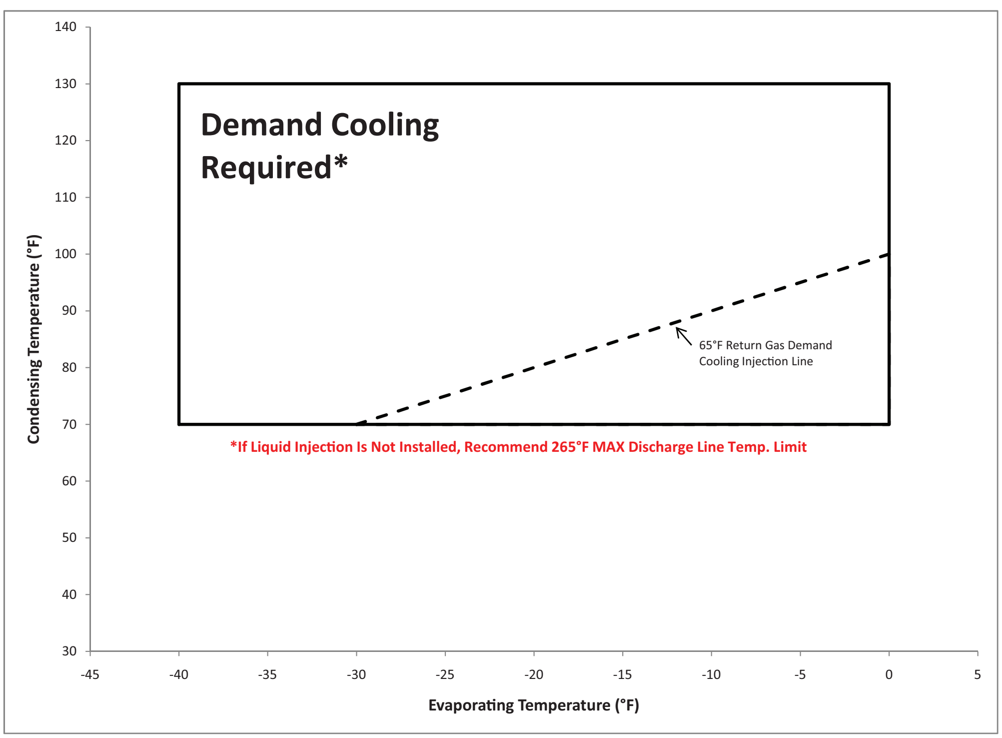


Figure 3 – Low Temperature Operating Envelope for R-22 at 65°F Return Gas (with Head Fan)

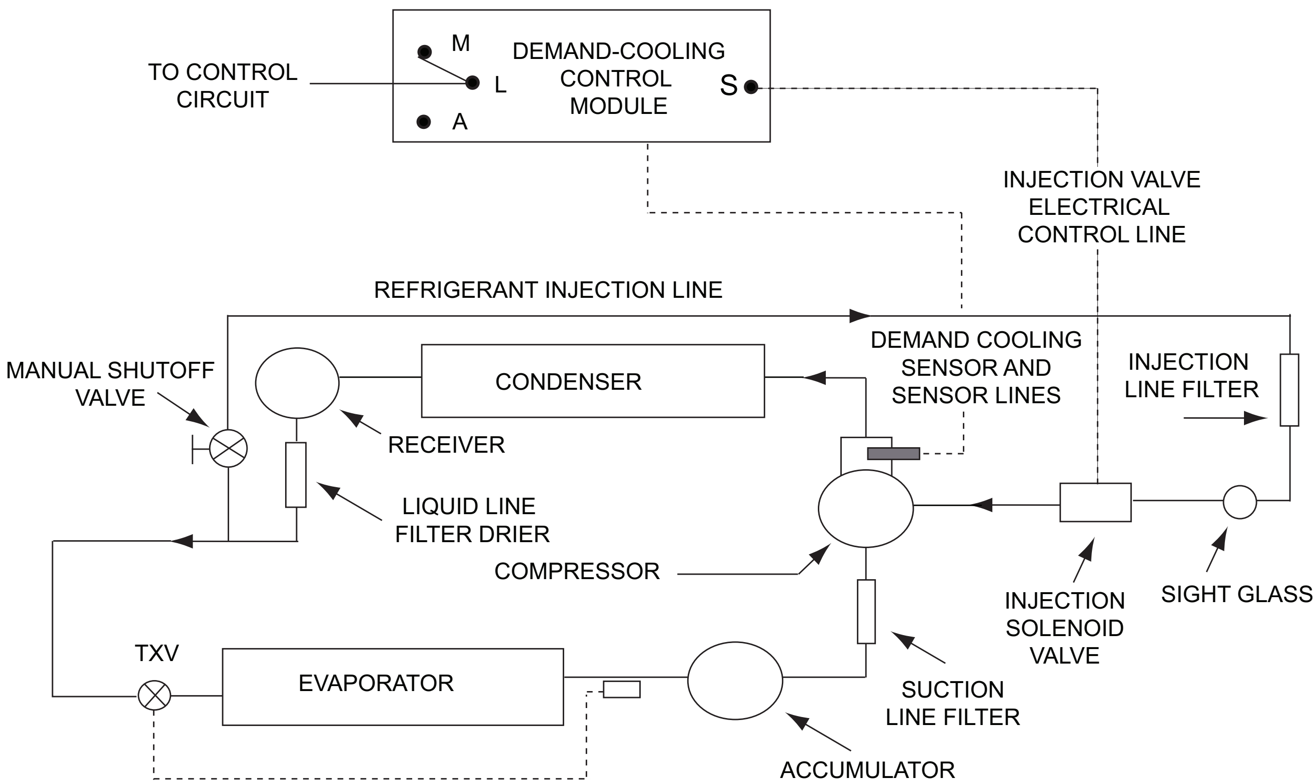


Figure 4
Demand Cooling System Diagram

NOTE: Compressors with internal overload protection MUST have some means, such as a current sensing relay, to deenergize the Demand Cooling Module and the Sentronic when the compressor is not running!

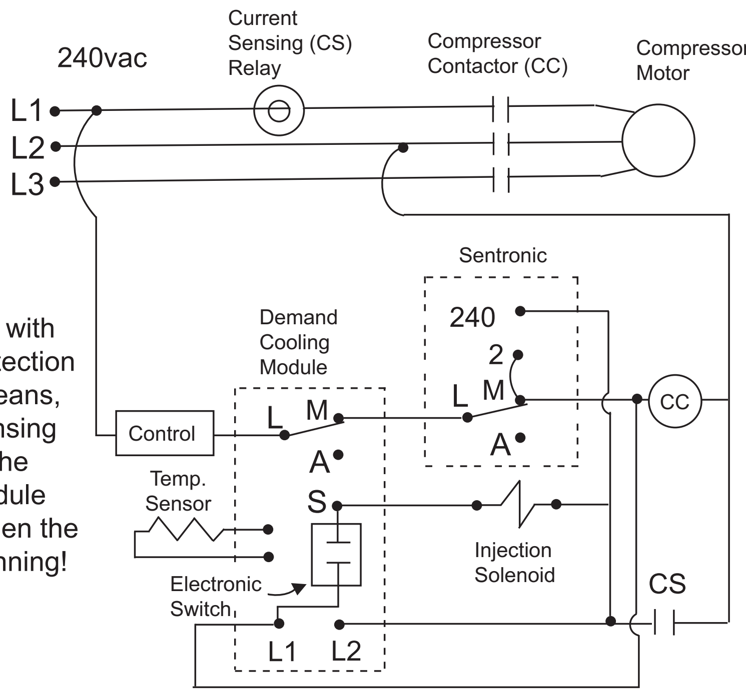


Figure 5A
Demand Cooling Wiring Schematic with Sentronic Oil Pressure Control and Current Sensing Relay

NOTE: The control circuit must be arranged so that the Demand Cooling Module and the Sentronic are deenergized when the compressor is not running!

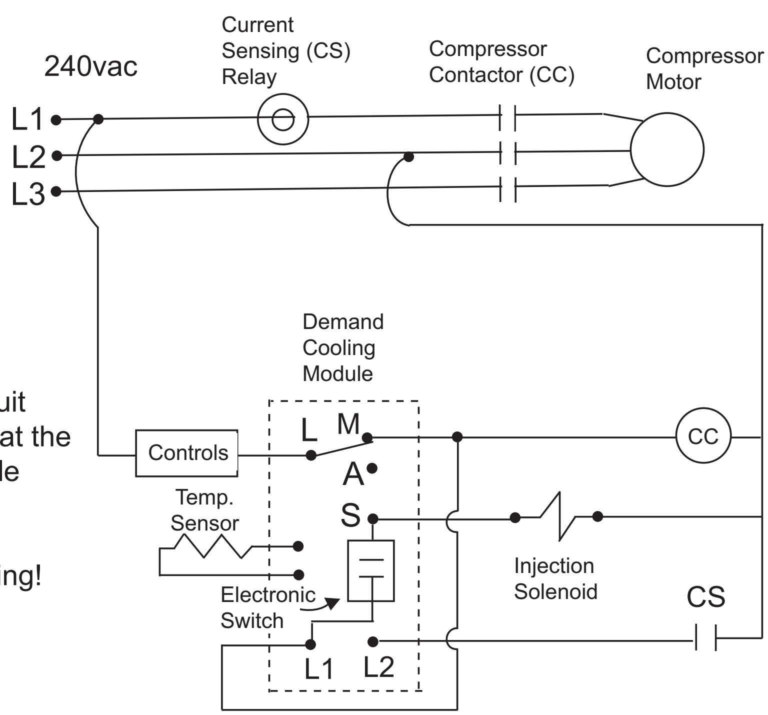
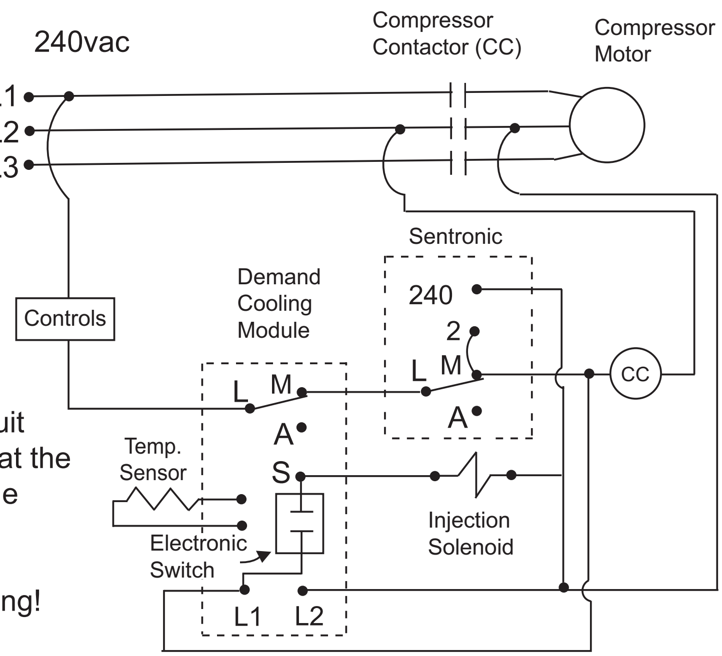
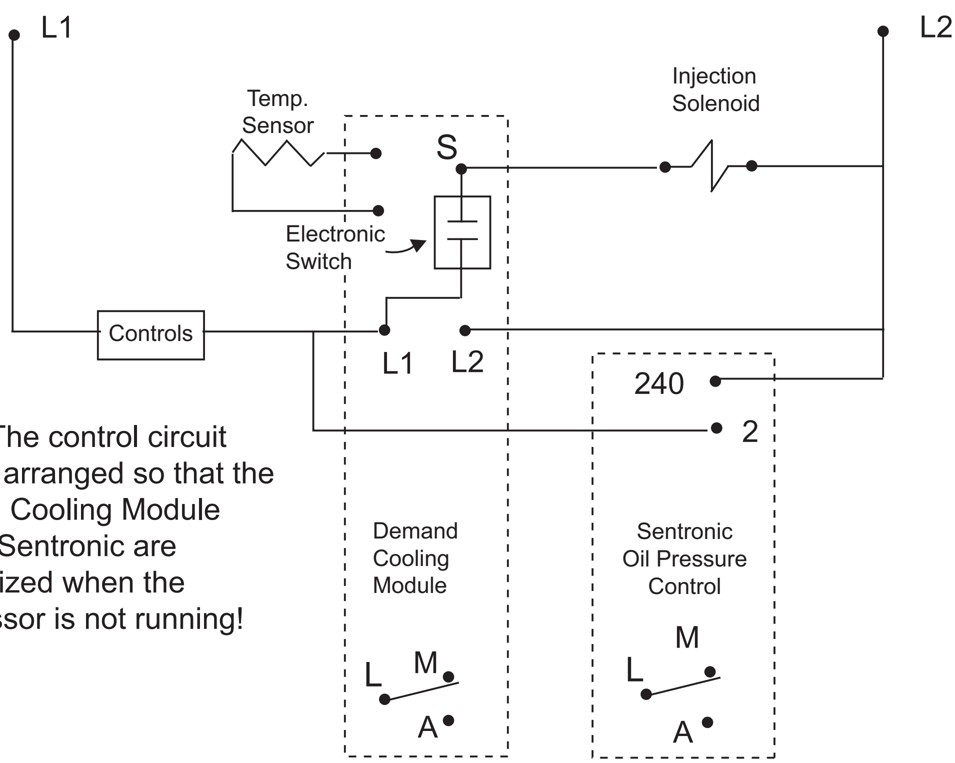


Figure 5B
Demand Cooling Wiring Schematic less Sentronic Oil Pressure Control



NOTE: The control circuit must be arranged so that the Demand Cooling Module and the Sentronic are deenergized when the compressor is not running!

Figure 5C
Demand Cooling Wiring Schematic with Sentronic Oil Pressure Control less Current Sensing Relay



NOTE: The control circuit must be arranged so that the Demand Cooling Module and the Sentronic are deenergized when the compressor is not running!

Figure 5D
Demand Cooling Wiring Schematic with Isolated Control Contacts

NOTE: The CoreSense module is dual rated for 120v / 240v.
The Demand Cooling module must be matched to the line voltage.

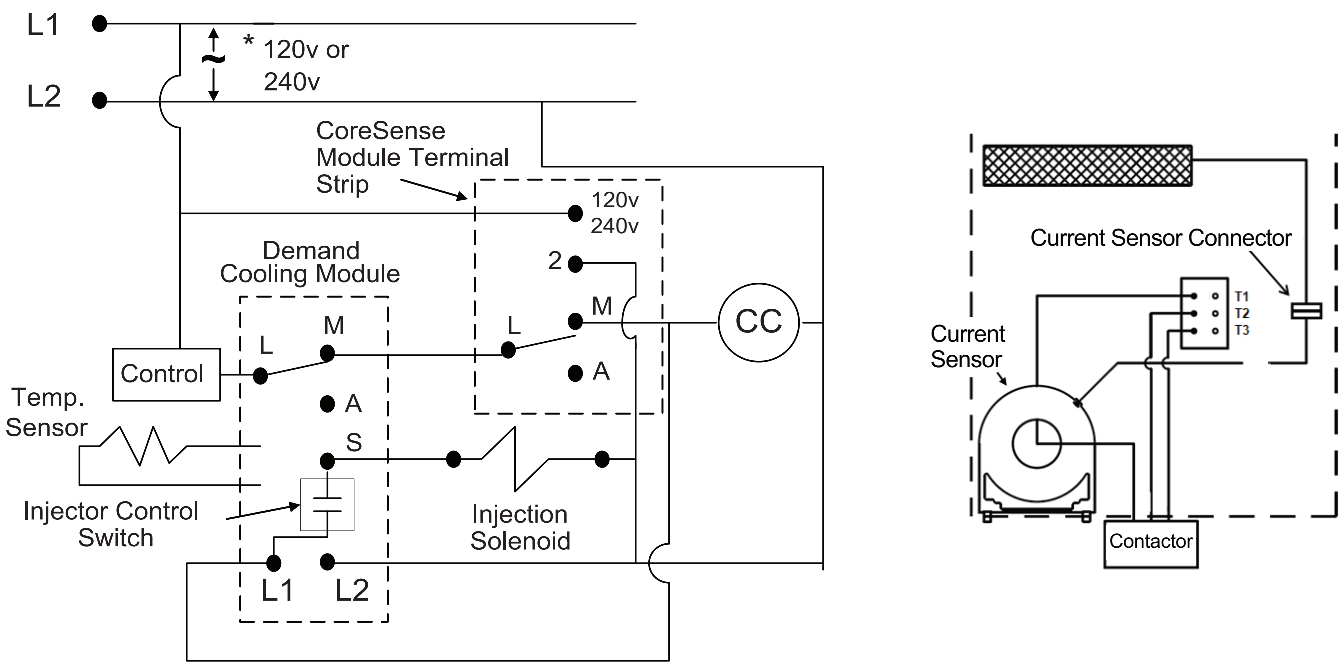


Figure 5E
Coresense Protection with Copeland Demand Cooling

Table 1
Demand Cooling Operating Setpoints and Control Actions

Internal Head Temperature	CM Operation	Approximate Sensor Resistance
Rising through 292°F	Demand Cooling Solenoid On	2100 Ohms
Falling through 282°F	Demand Cooling Solenoid Off	2400 Ohms
Rising through 310°F	Alarm Contact Energized	1700 Ohms
At Room Temp. (77°F)	Demand Cooling Solenoid Off	90,000 Ohms

Maximum Contact Ratings: 720VA, 120/240VAC, 60HZ Maximum Solenoid Output ("S" Terminal) Rating: 16W (The IV solenoid must be the only load on this output.)

Time Delay For Demand Cooling Alarm Actuation (after a continuous low or high resistance TS signal input): 1 minute

Table 2
Demand Cooling Kit Part Numbers

Frequency	Voltage	2D	3D	4D	6D	4D*X,4D*N[1]	6D*X,6D*N[1]
50HZ	120V	998-1000-12	998-1001-13	998-1001-14	998-1001-16	998-2001-14	998-2001-16
	240V	998-1000-22	998-1001-23	998-1001-24	998-1001-26	998-2001-24	998-2001-26
60HZ	120V	998-1000-12	998-1000-13	998-1000-14	998-1000-16	998-2000-14	998-2000-16
	240V	998-1000-22	998-1000-23	998-1000-24	998-1000-26	998-2000-24	998-2000-26

Demand Cooling Kits Include:

- Demand Cooling Module with 2 Mounting Screws
- Temperature Sensor with 3ft. Shielded cable
- Injection Valve and Solenoid (without mounting hardware)
- Installation/Troubleshooting Guide

Optional Demand Cooling Module Mounting Brackets

2D and 3D Models	998-0700-09
4D and 6D Models	998-0700-10

Temperature Sensors

3ft. Shielded Cable (Standard)	085-109-00
10ft. Shielded Cable (Optional)	085-109-01

[1] 4D*X, 4D*N, 6D*X, 6D*N Indicate Discus III Models

Table 3A – Demand Cooling Evaporator Capacity Adjustment Factors for HCFC-22

Return Gas Temperature (°F)	Condensing Temperature (°F)	Saturated Suction Temperature (°F) -40	-35	-30	-25	-20	-15	-10	-5	0
50	70	1.003	1.003	1.004	1.004	1.004	1.005	1.005	1.005	1.005
	80	.976	.994	1.002	1.003	1.003	1.003	1.004	1.004	1.004
	90	1.000	.997	.995	.992	1.002	1.002	1.003	1.003	1.003
	100	1.004	1.001	.998	.995	.993	.990	1.001	1.002	1.002
	110	1.007	1.004	1.002	.999	.996	.993	.990	.998	1.000
	120	1.010	1.008	1.005	1.002	.999	.997	.994	.991	.988
	130	1.013	1.011	1.008	1.005	1.002	1.000	.997	.994	.991
35	70	1.007	1.007	1.008	1.008	1.009	1.009	1.010	1.010	1.011
	80	1.005	1.005	1.006	1.006	1.007	1.007	1.008	1.008	1.009
	90	1.000	.996	1.004	1.004	1.004	1.005	1.006	1.006	1.007
	100	1.006	1.001	.997	.993	1.002	1.002	1.003	1.003	1.004
	110	1.010	1.006	1.002	.998	.994	.989	1.000	1.000	1.001
	120	1.016	1.011	1.007	1.003	.990	.995	.991	.986	1.000
	130	1.020	1.016	1.012	1.007	1.003	.999	.994	.990	.985
20	70	1.012	1.012	1.013	1.014	1.015	1.016	1.017	1.018	1.019
	80	1.009	1.009	1.009	1.010	1.011	1.013	1.014	1.014	1.015
	90	1.006	1.006	1.006	1.070	1.008	1.009	1.010	1.010	1.011
	100	.990	.985	1.003	1.003	1.003	1.004	1.005	1.006	1.007
	110	1.003	.998	.993	.988	.999	1.000	1.001	1.002	1.003
	120	1.016	1.011	1.005	1.000	.995	.990	1.000	.998	.995
	130	1.027	1.022	1.017	1.012	1.006	1.001	.996	.990	.991

Table 3B – Demand Cooling Evaporator Mass Flow Adjustment Factors for HCFC-22

Return Gas Temperature (°F)	Condensing Temperature (°F)	Saturated Suction Temperature (°F) -40	-35	-30	-25	-20	-15	-10	-5	0
50	70	1.020	1.017	1.015	1.012	1.009	1.006	1.004	1.001	1.000
	80	1.025	1.022	1.020	1.017	1.014	1.012	1.009	1.006	1.004
	90	1.030	1.027	1.025	1.022	1.019	1.017	1.014	1.011	1.009
	100	1.035	1.032	1.030	1.027	1.024	1.022	1.019	1.016	1.014
	110	1.040	1.037	1.035	1.032	1.029	1.027	1.024	1.021	1.019
	120	1.045	1.042	1.040	1.037	1.034	1.032	1.029	1.026	1.024
	130	1.050	1.047	1.045	1.042	1.039	1.037	1.034	1.031	1.029
35	70	1.025	1.023	1.019	1.015	1.010	1.006	1.002	1.000	1.000
	80	1.042	1.038	1.034	1.030	1.025	1.021	1.016	1.011	1.006
	90	1.061	1.057	1.053	1.049	1.045	1.041	1.037	1.033	1.029
	100	1.070	1.066	1.062	1.058	1.054	1.050	1.046	1.042	1.038
	110	1.078	1.074	1.070	1.066	1.062	1.058	1.054	1.050	1.046
	120	1.087	1.083	1.079	1.075	1.071	1.067	1.063	1.059	1.055
	130	1.096	1.092	1.088	1.084	1.079	1.075	1.071	1.069	1.062
20	70	1.031	1.026	1.021	1.016	1.011	1.006	1.001	1.000	1.000
	80	1.050	1.045	1.040	1.035	1.030	1.025	1.020	1.015	1.010
	90	1.069	1.064	1.059	1.054	1.049	1.044	1.039	1.034	1.029
	100	1.088	1.083	1.078	1.073	1.068	1.063	1.058	1.053	1.048
	110	1.107	1.102	1.097	1.092	1.087	1.082	1.077	1.072	1.067
	120	1.126	1.121	1.116	1.111	1.106	1.101	1.096	1.091	1.086
	130	1.145	1.140	1.135	1.130	1.125	1.120	1.115	1.110	1.105

Appendix

Copeland® Demand Cooling® Diagnostics

Demand Cooling Operating Characteristics

The Copeland® Demand Cooling® control uses a Negative Temperature Coefficient Thermistor (NTC). Incorporated in the Demand Cooling Temperature Sensor (hereafter called "sensor"), is a compressor discharge temperature monitor. When the temperature sensed by the NTC Thermistor rises, its resistance falls, and when temperature sensed by the thermistor drops, its resistance increases.

The sensor resistance signal is coupled to the Demand Cooling Module (hereafter called "module"). The module uses the signal to determine when the compressor discharge temperature has risen to a point where Demand Cooling is required. When Demand Cooling is required the module energizes the Demand Cooling Injection Valve (hereafter called "injection valve") and the injection valve injects saturated refrigerant into the compressor suction cavity until the discharge temperature drops to an acceptable level.

Whenever the compressor starts and the module first receives power, there is a one minute delay during which the Demand Cooling system injects saturated refrigerant if it is required, but waits for compressor discharge temperature to stabilize before checking for alarm conditions. After one minute, if the resistance of the probe is too low (the resistance equivalent of 310°F), or too high (the resistance equivalent of 4°F) the module will trip and deenergize the compressor.

Bench Testing Demand Cooling Components

Bench Check of the Sensor

Required Equipment:

- A digital thermometer of +/- 1 % full scale accuracy. The thermometer probe should be checked for calibration in an ice water bath or compared with another accurately known temperature source.
- A digital ohmmeter capable of +/- 1 % accuracy. The ohmmeter should be checked for accuracy with a known resistance value such as a +1 % resistor.

Room temperature should be stable and between 60°F and 110°F.

1. Wrap the end of the digital thermometer probe and the metal end of the Demand Cooling sensor probe together with electrical tape or "Velcro". The end of the probe and the end of the thermometer must touch.
2. Place the wrapped probe-sensor inside an insulation shield to protect it from air currents. Use a material such as "Permagum" or piping insulation such as "ArmafleX". The insulating material should be tightly wrapped around the taped-sensor and the wrap should be secured with wire or tiewraps if necessary. There should be no free air movement over the metal part of the taped-sensor.
3. Connect the digital ohmmeter to the two pins on the plug of the sensor. Make sure there is a good connection. Do not take a sensor resistance measurement until there is no change in the ohmmeter display.
4. Measure the temperature of the thermometer sensor and find the corresponding calculated sensor resistance value from Table 1. Since the values of Table 1 are not continuous, you may have to interpolate.
5. The sensor resistance reading should be within +/- 5% of the calculated resistance value of Step 4.

End of Test

Appendix Table 1

Thermometer Temp. (F°)	Calculated Sensor Resistance (Ohms)
59	141426
60.8	135000
62.6	128907
64.4	123129
66.2	117639
68	112437
69.8	107478
71.6	102762
73.4	98289
75.2	94041
77	90000
78.8	86139
80.6	82476
82.4	78984
84.2	75663

Thermometer Temp. (F°)	Calculated Sensor Resistance (Ohms)
86	72504
87.8	69480
89.6	66609
91.4	63864
93.2	61254
95	58770
96.8	56394
98.6	54126
100.4	51966
102.2	49914
104	47943
105.8	46053
107.6	44262
109.4	42543

Bench Check of the Module and Injection Valve

Required equipment:

- A controlled voltage source the same as the rating of the module and the injection valve.
- A multimeter.
- If the jumper supplied on the sensor plug of the module is not available you may use a small paper clip for the test.

Before starting the test, make sure you have the correct module and injection valve.

1. With the module control voltage disconnected, short the module sensor plug female terminals with the jumper or the paperclip. Press the module reset button.
2. Attach the injection valve leads to terminals "L2" and "S" of the module. The injection valve should be propped in an upright position.
3. You should read zero ohms between the "L" and "M" terminals of the module. This is the Normally Closed (NC) contact of the Single Pole Double Throw (SPDT) module alarm relay. You should read an open circuit between "L" and "A". This is Normally Open (NO) contact of the alarm relay.
4. Energize the module by bringing module rated voltage to terminals "Ll" and "L2".

   *When the sensor connection at the module is shorted, a very low resistance is seen by the module as a very high temperature, and an injection signal is sent to the injection valve.
5. The injection valve will be energized by the closing of an electronic switch in the module. The control voltage to energize the injection valve may be measured across module terminals "S" and "L2".

   *Because this measurement is made across an electronic switch some "leakage" voltage may be measured when the switch is deenergized. This voltage is much less than the control voltage which is measured when the electronic switch is closed.

   The injection valve operation may also be checked by listening to the "click" heard each time the coil of the injection valve is energized and the injection valve solenoid plunger seats itself.

   If background noise prevents an audible check of the injection valve coil and magnant operation, grip the injection valve magnet housing and loosen its housing cover screw until magnet vibration is felt. This proves solenoid operation. Retighten the magnet housing cover screw after this check.
6. After one minute, the module should trip. The run contact "L" to "M" should open, and the alarm contact "L" to "A" should close. Deenergize the module and disconnect the injection valve. The resistance should be zero ohms between "L" and "A", and between "L" and "M" there should be an open circuit.
7. Reset the module. Remove the jumper from the module probe plug so there is an open circuit at the plug input.
8. Energize the module.

   When the sensor connection to the Demand Cooling Module is opened the very high resistance is interpreted by the module as a very low temperature. Consequently no injection signal is sent to the injection valve.
9. The injection valve should be energized. A recheck of Step 5 will confirm this.
10. Refer to the test of Step 6 to check the alarm circuit. Reset the module after the test. If the module or injection valve fails any of the checks it should be replaced.

End of Test

Installed System Checks of Demand Cooling Components

When the Demand Cooling control injects saturated refrigerant into the suction cavity of the compressor, the outlet tube of the injection valve frosts. If the module sensor connection is opened or shorted while the module is energized, the module will trip after one minute of operation and must be reset to continue.

Before starting the test, make sure you have the correct module and injection valve.

If the Injection Valve is Not Injecting

1. With the system deenergized, disconnect the sensor from the module and jumper the terminals of the module connector. Energize the system so the compressor is running and the module is activated. The injection valve should begin injecting, and frost should form on the outlet tube of the injection valve. If frost forms, go to Step 4 otherwise continue to Step 2.
2. If frost does not form in Step 1, check to see if there is control voltage on the coil of the injection valve (terminals "L2" and "S" of the module).

   *Because this measurement is made across an electronic switch in the module some "leakage" voltage may be measured when the switch is deenergized. This voltage is much less than the control voltage which is measured when the switch is closed. If correct control voltage is not present, replace the module.

3. If correct control voltage is present, make sure there is a full sight glass of liquid from the receiver at the injection valve. If there is not a full sight glass of liquid, the piping from the receiver should be checked before proceeding.

   Piping connections and sizes must be chosen to assure a full sight glass of liquid for the injection valve during any phase of the refrigeration system operation. Piping that is too small, or connections taken from the tops of manifolds rather from the bottom may result in a lack of refrigerant available for the injection valve just when it needs it most, such as after a defrost.

   If a full sight glass is present and frost still does not form, replace the injection valve.

4. With the module sensor connector shorted or open and the module and compressor running, the module should trip in one minute and stop the compressor.

   If the compressor does not stop, check the control circuit wiring to be sure the module is wired to stop the compressor when the module trips. If the wiring is correct, replace the module.

5. Check the discharge temperature by performing Steps 1-6 of the Injection Valve is Cycling On and Off test.

   If the discharge temperature is higher than the allowable Table 2 selection, remove the sensor from the compressor and use the Bench Check of the Sensor Test to check the probe. Replace the sensor if necessary.

End of Test

If the Injection Valve is Continually Injecting

1. Make sure there is a full sight glass of liquid from the receiver. If there is not a full sight glass of liquid, there may not be enough liquid to allow Demand Cooling to cycle because it uses all available liquid to keep the discharge temperature below a dangerous level. The piping from the receiver to the injection valve should be checked before proceeding.

   Piping connections and sizes must be chosen to assure a full sight glass of liquid for the injection valve during any phase of the refrigeration system operation. If the suction pressure rises then go to Step 6.

2. Deenergize the system and disconnect the sensor from the module. Energize the system so the compressor is running. The frosting should stop.

   If Step 2 is successful, go to Step 4 otherwise continue to Step 3.

3. If frosting does not stop, with the sensor disconnected, deenergize the system. Disconnect the voltage supply to the injection valve and restart the compressor. If frosting does not stop, replace the injection valve. If frosting stops, replace the module.

4. If frosting stops when the sensor is disconnected, check the system for high suction and/or condensing temperatures before proceeding. As suction and/or discharge temperatures rise toward the Demand Cooling limits (40° F evaporator temperature, 130°F condensing temperature), Demand Cooling will call for injection for longer periods of time and may appear to be continuously injecting. Use Figure 1 to check Demand Cooling operating areas. Figure 1 shows where injection begins for two return gas temperatures (65°F and 20°F) for R-22. The arrows marked (A) and (B) on the graph show the lowest allowable evaporating temperatures using a given condensing temperature.

   Point (A) shows that with 65°F return gas and 110° F condensing temperature, the lowest evaporating temperature without Demand Cooling injection is -5°F. Point (B) shows that if the return gas temperature can be lowered to -20°F, while still at a condensing temperature of 110°F, the evaporating temperature may be lowered to -20°F without Demand Cooling operation.

   Your injection point can be approximated by drawing a line representing your return gas temperature in between and parallel to the two return gas temperatures on the Figure 1 (Area 2). The higher your return gas temperature is, the closer it will be to the “65°F line”. The lower it is, the closer it will be to the “20°F line”. You can then draw your own dotted lines representing your condensing and evaporating temperatures to see if you are in the in a Demand Cooling injection zone.

   The higher your condensing temperatures are for a given evaporating temperature, the more injection is required until finally Demand Cooling may be energized constantly.

   If the suction and condensing temperatures are lower than, or borderline to the injection areas of Figure 1 then go to Step 5.

   If they are much higher the system should be corrected to lower the temperatures or there may be occasional Demand Cooling trips. If lowering system temperatures corrects the continuous problem, the test is ended, if not go to Step 5.

5. Deenergize the refrigeration system. Close the suction service valve. Turn the system on and pump down the compressor to 2-3 psig. Turn the system off. Wait one minute. The pumpdown should hold and the pressure should not rise.

   If the suction pressure rises then go to Step 6. If the suction pressure does not rise the sensor is calling for injection when it is not required and should be replaced.

6. If the suction pressure rises, the suction service valve may not be entirely closed, the valve plate or valve plate gasket may have been damaged. Damage to the valve plate or its gasket can cause discharge gas to be introduced to the suction cavity, resulting in an artificially high suction temperature. The artificial suction temperature, in turn, causes an earlier than required Demand Cooling injection.

   Replace the compressor valve plate and gaskets if required.

End of Test

If the Injection Valve is Cycling On and Off

When the saturated refrigerant is injected into the compressor suction cavity it lowers the temperature sensed by the sensor. The lower temperature in turn causes the injection valve to shutoff. After shutoff the temperature in the suction cavity rises again until it is high enough for injection to start. The result of this cycling is that frost on the injection valve outlet tubing alternately appears during injection, and then disappears after injection stops.

Appendix Table 2

Compressor Model	Room Temp. (°F)	Condensing Temp. (°F)	Discharge Temp. (°F)
2D	80	80	250-270
	110	110	270-280
3D	80	80	240-256
	110	110	265-280
4D	80	80	230-260
	110	110	260-280
6D	80	80	250-270
	110	110	250-270

1) Measure the room temperature.

2) Connect the temperature sensor probe to the compressor discharge line 6” from the discharge valve. The probe must be tightly secured to the discharge line, and must be well insulated so that moving air will not produce a false reading (a poorly insulated probe may cause errors of more than 30°F!).

3) Using Table 2, check the conditions that are closest to your system. (The evaporator temperature used for Table 2 was -25°F). There may be deviation from the table due to system variation, however, within 5-10% of the published discharge pressures is acceptable.

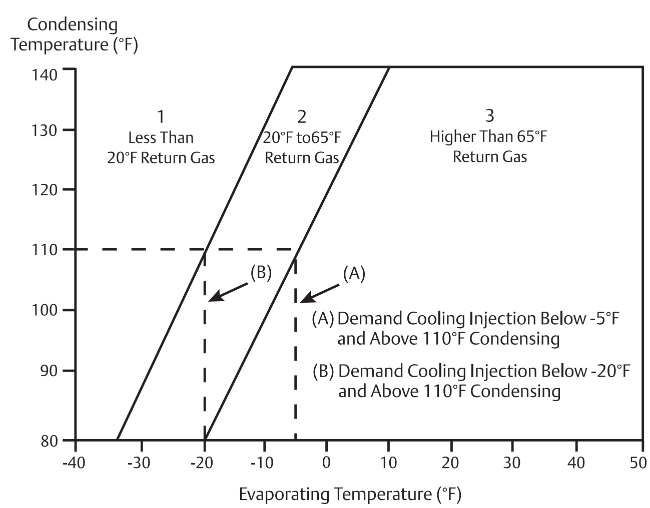
   Note! Table 2 is for HCFC-22. Emerson Climate Technologies recommends assuming that HFC-407A, HFC-407C and HFC-407F run about 10°F to 15°F cooler per the approved operating ranges.

4) When operating under published conditions, the discharge temperature should never be more than 280°F or less than 200°F. If successful, the test is ended. Otherwise continue to the next step.

5) If the measured discharge temperature is lower by more than 10% of the discharge temperature of Table 2, perform Steps 5-8 of the “If The Injection Valve Is Continually Injecting” test.

   If the measured discharge temperature is more than 280°F, replace the sensor.

End of Test



Appendix Figure 1
Demand Cooling Areas of Expected Injection