SB-400

Refrigeration System

TK 51696-2-MS (Rev. 1, 09/04)

The information in this manual covers unit models:	
System SB-400 30 (918593)	
SB-400 (002004)	
For further information, refer to:	
THERMOGUARD µP-VI Microprocessor for Screw Compressor Applications Diagnostic Manual	**TK 51329**
SB-400 Maintenance Manual	**TK 51113**
SB-400 Operator’s Manual	**TK 51212**
SB-400 Parts Manual	**TK 51356**
DAS Data Acquisition System Manual	**TK 50565**
S391 Screw Compressor Overhaul Manual	**TK 50567**
Tool Catalog	**TK 5955**
Evacuation Station Operation and Field Application	**TK 40612**
ElectroStatic Discharge (ESD) Training Guide	**TK 40282**
The information in this manual is provided to assist owners, operators and service people in the proper upkeep and maintenance of Thermo King units.	

This manual is published for informational purposes only and the information so provided should not be considered as all-inclusive or covering all contingencies. If further information is required, Thermo King Corporation should be consulted.

Sale of product shown in this manual is subject to Thermo King’s terms and conditions including, but not limited to, the Thermo King Limited Express Warranty. Such terms and conditions are available upon request. Thermo King’s warranty will not apply to any equipment which has been “so repaired or altered outside the manufacturer’s plants as, in the manufacturer’s judgment, to effect its stability.”

No warranties, express or implied, including warranties of fitness for a particular purpose or merchantability, or warranties arising from course of dealing or usage of trade, are made regarding the information, recommendations, and descriptions contained herein. Manufacturer is not responsible and will not be held liable in contract or in tort (including negligence) for any special, indirect or consequential damages, including injury or damage caused to vehicles, contents or persons, by reason of the installation of any Thermo King product or its mechanical failure.

Recover Refrigerant

At Thermo King, we recognize the need to preserve the environment and limit the potential harm to the ozone layer that can result from allowing refrigerant to escape into the atmosphere.

We strictly adhere to a policy that promotes the recovery and limits the loss of refrigerant into the atmosphere.

In addition, service personnel must be aware of Federal regulations concerning the use of refrigerants and the certification of technicians. For additional information on regulations and technician certification programs, contact your local Thermo King dealer.

Table of Contents

Safety Precautions

General Practices

1. *Always wear goggles or safety glasses.* Refrigerant liquid and battery acid can permanently damage the eyes. See First Aid under Refrigeration Oil.
2. Never operate the unit with the compressor discharge valve closed.
3. Keep your hands clear of the fans and belts when the unit is running. This should also be considered when opening and closing the compressor service valves.
4. Make sure the gauge manifold hoses are in good condition. Never let them come in contact with a belt, fan motor pulley, or any hot surface.
5. Never apply heat to a sealed refrigeration system or container.
6. Fluorocarbon refrigerants, in the presence of an open flame or electrical short, produce toxic gases that are severe respiratory irritants capable of causing death.
7. Make sure all mounting bolts are tight and are the correct length for their particular application.
8. Use extreme caution when drilling holes in the unit. The holes may weaken structural components. Holes drilled into electrical wiring can cause fire or explosion.
9. Use caution when working around exposed coil fins. The fins can cause painful lacerations.
10. Use caution when working with a refrigerant or refrigeration system in any enclosed or confined area with a limited air supply (for example, a bus or garage). Refrigerant tends to displace air and can cause oxygen depletion, resulting in suffocation.
11. EPA Section 608 Certification is needed to work on refrigeration systems.

Auto Start/Stop

CAUTION: The unit may start automatically and at any time when the unit On/Off switch is in the On position or the optional On/Off/Sleep switch is in the On or Sleep position. Be sure to turn the switch off before opening doors or inspecting or working on any part of the unit.

Refrigerant

When removing refrigerant from a unit, a recovery process that prevents or minimizes refrigerant loss to the atmosphere is required by law.

Although fluorocarbon refrigerants are classified as safe refrigerants, certain precautions must be observed when handling them or servicing a unit in which they are used. When exposed to the atmosphere in the liquid state, fluorocarbon refrigerants evaporate rapidly, freezing anything they contact.

First Aid: In the event of frost bite, the objectives of First Aid are to protect the frozen area from further injury, to warm the affected area rapidly, and to maintain respiration.

- *Eyes:* For contact with liquid, immediately flush eyes with large amounts of water and get prompt medical attention.
- *Skin:* Flush area with large amounts of lukewarm water. Do not apply heat. Remove contaminated clothing and shoes. Wrap burns with dry, sterile, bulky dressing to protect from infection/injury. Get medical attention. Wash contaminated clothing before reuse.
- *Inhalation:* Move victim to fresh air and use CPR or mouth-to-mouth ventilation, if necessary. Stay with victim until arrival of emergency medical personnel.

Refrigerant Oil

Avoid refrigeration oil contact with the eyes. Avoid prolonged or repeated contact of refrigeration oil with skin or clothing. Wash thoroughly after handling refrigeration oil to prevent irritation.

First Aid: In case of eye contact, immediately flush with plenty of water for at least 15 minutes. *Call a physician.* Wash skin with soap and water.

Electrical

Microprocessor Service

Precautions must be taken to prevent electrostatic discharge when servicing the microprocessor and related components. A potential difference less than that required to produce a small spark between a finger and a doorknob can damage or destroy electronic components. Refer to the material in this manual and the Electrostatic Discharge Training Guide (TK 40282) for additional information.

Welding

Precautions must be taken before welding on the unit. Refer to Service Procedure A26A in the THERMOGUARD µP-VI Microprocessor for Screw Compressor Applications Diagnostic Manual (TK 51329) for additional information.

Low Voltage

Control circuits are 12 volt dc. This voltage potential is not considered dangerous, but the large amount of current available can cause severe burns if shorted to ground.

Do not wear jewelry, watches or rings when working on the unit. If these items contact an electrical circuit severe burns may result.

SB-400 System Description

History

The original screw compressor unit was the SB-III SSR, manufactured by Thermo King from 1995–1999. These units had se 2.2 engines and µP-IV microprocessor controllers.

The next generation screw compressor unit was the SB-III Magnum. The Magnum had increased capacity due to improved coil and expansion valve design. A discharge check valve was added to the discharge line to prevent hot gas from flowing backwards into the evaporator during the Null cycle. The Magnum uses a TK 486 engine and a µP-VI controller.

The SB-400 has more capacity than the Magnum and has additional refrigeration components and control algorithms that provide the following:

- Improved temperature control
- Improved fuel economy
- Improved capability to run in extreme conditions
- Improved pulldown capacity.

This table shows differences between the SB-400 and the SB-III Magnum unit:

SB-400 to Magnum System Comparison

SB-400	Magnum
Electronic throttling valve (ETV)	Mechanical throttling valve
Internal economizer bypass valve: Valve energized to load compressor	External economizer bypass valve: Valve energized to unload compressor
Internal compressor unloader	n/a
Liquid injection solenoid valve for discharge temperature control	n/a
Discharge pressure transducer	n/a
Suction pressure transducer	n/a

Software Revision History

To determine the software revision press and hold the Thermo King Logo key until the display shows [Pre] and [TRIP]. Press the Select key as required to display [REV] and the software revision.

Software can be changed by flash loading the new revision using Service Procedure A46A or A46B from Section 6 of the THERMOGUARD µP-VI Microprocessor for Screw Compressor Applications Diagnostic Manual (TK 51329).

The following table shows the software revision history.

Software Revision	Notable Changes
4300	First Production Release
4301	Changed ETV position of 20 steps open to 30 steps open in running null, heat, defrost, and other occurrences. Added TracKing/i-Box support features.
4310	Added Heat Mode Discharge Superheat Control (see page 48). Changed the control parameters for Discharge Pressure Control - Heat Mode (see page 42). Added Compressor Temperature Sensor Failure to Discharge Pressure Control - Heat Backup Modes (see page 42). Changed the minimum engine coolant temperature setting for Bucking Heat/Defrost from 120 F (49 C) to 140 F (60 C). See page 38. Added Heat Mode Charge Migration Cycle (see page 157). Changed Service Test Modes [MC1.0] and [MC0.0] so LV2 is energized if the Return Air Temperature is below the Fresh/Frozen Range Setpoint [FRFZ]. See “Service Test Mode” on page 119.

General Description

The SB-400 is equipped with a S391 screw compressor with loading valves, an integral heating coil, an economizer, electronic throttling valve, liquid injection and advanced microprocessor software. These components work together to allow the unit to provide extremely fast temperature pull down with precise temperature control, improved fuel economy and the ability to continue to operate under extreme conditions.

List of Components

Components are shown in Figure 1 on page 13 and described in detail on the following pages. Refer to the SB-400 Maintenance Manual (TK 51113) for information about repairing or replacing the components.

1.	Compressor	21.	LLSV—Liquid Line Solenoid (Normally Open)
2.	Discharge Check Valve (Internal)	22.	Drain Pan Heater
3.	Discharge Service Valve	23.	Heat Coil*
4.	Discharge Vibrasorber	24.	Evaporator Coil*
5.	PS—Pilot Solenoid (Normally Closed)	25.	Expansion Valve (Main Evaporator)
6.	Discharge Pressure Transducer	26.	ETV—Electronic Throttling Valve
7.	Condenser Pressure Bypass Check Valve	27.	Heating Bypass Orifice
8.	Three-way Valve	28.	Suction Pressure Transducer
9.	Condenser Coil	29.	Main Suction Vibrasorber
10.	Condenser Check Valve	30.	Suction Pressure Access Port
11.	Heat Check Valve	31.	Main Suction Service Valve
12.	Receiver Tank	32.	LV2—Loading Valve #2 (Normally Open)
13.	High Pressure Relief Valve	33.	LV1—Loading Valve #1 (Economizer Bypass Solenoid, Normally Open)
14.	Receiver Tank Sight Glass	34.	Economizer Suction Service Valve
15.	Receiver Tank Outlet Valve	35.	Economizer Suction Vibrasorber
16.	Subcooler (Part of Condenser)	36.	EWSV—Water Valve (Normally Closed)
17.	Dehydrator (Drier)	37.	High Pressure Cutout Switch (HPCO)
18.	Expansion Valve (Economizer)	38.	High Pressure Cut-In Switch (HPCI)
19.	LIV—Liquid Injection Valve (Normally Closed)	39.	Compressor Temperature Sensor
20.	Economizer Heat Exchanger		

* The evaporator coil, even though it is built as a unit, is divided into two separate circuits, one is used during heating and defrost and one during cooling.

Components Shown in Figure 1 on page 13

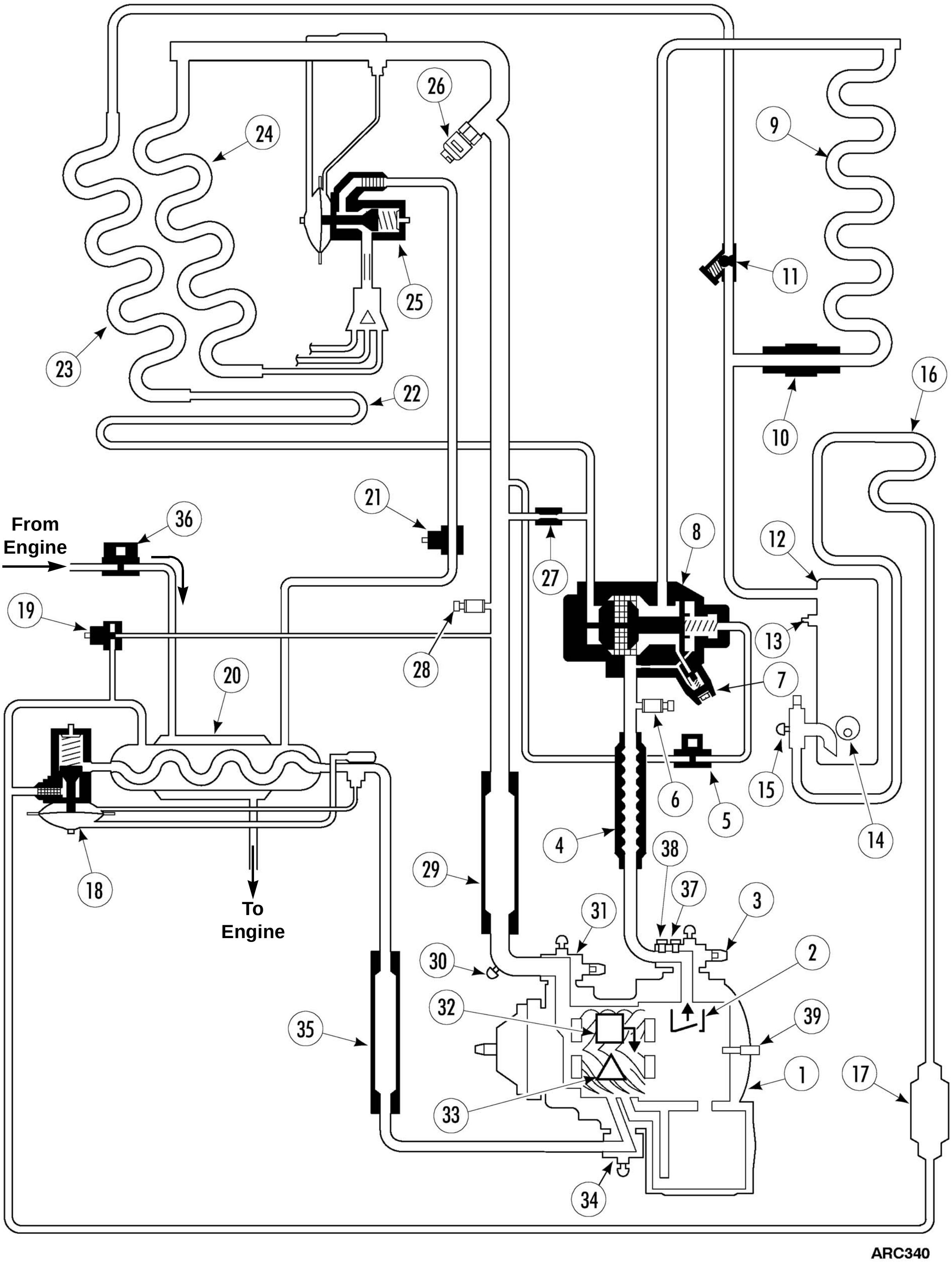


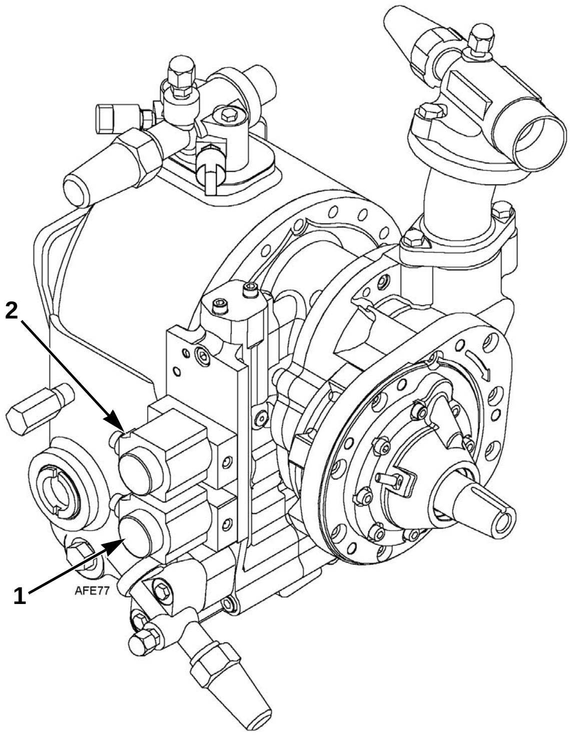
Figure 1: Refrigeration System Components

(1) Compressor

The SB-400 uses an S391 screw compressor with loading valves. This screw compressor is similar to those used on the SB-III Magnum units but it has two internal loading valves and the discharge check valve is now located inside the compressor.

The loading valves are called Loading Valve #1 (LV1) and Loading Valve #2 (LV2). These valves are electrically operated and normally open. Each loading valve bypasses pressure until its coil is energized, then pressure forces a piston to close the port. When the port is closed it lengthens the distance the refrigerant must travel up the rotor, thus increasing the volume of gas that is compressed.

The loading valves are energized and de-energized sequentially. LV2 is energized before LV1 is energized. LV1 is de-energized before LV2 is de-energized. The loading valves also use a time delay. After a loading valve is de-energized, it will stay de-energized for a minimum of 1 minute.



1.	Loading Valve #1 (LV1)
2.	Loading Valve #2 (LV2)

Figure 2: S391 Screw Compressor with Loading Valves

The suction pressure varies with the state of the loading valves. The suction pressure decreases as the loading valves are energized. The suction pressure increases as the loading valves are de-energized. This unit can have significantly higher suction pressures than a unit with a reciprocating compressor.

(2) Discharge Check Valve

The discharge check valve is a mechanical check valve that is located in the discharge housing of the compressor. The discharge check valve is open when the compressor is operating, and closed when the compressor stops. It stops gas from flowing back into the evaporator when the engine stops. If the gas is allowed to flow into the evaporator, it can cause early restarts in CYCLE-SENTRY mode.

(3) Discharge Service Valve

The discharge service valve is used for isolating and servicing the discharge side of the compressor. It contains the high pressure cutout switch and the high pressure cut in switch.

(4) Discharge Vibrasorber

The discharge vibrasorber reduces vibration transfer and allows for a flexible discharge line.

(5) Pilot Solenoid Valve (PS)

The pilot solenoid is an electrically operated, normally closed valve that determines if the three-way valve is in the cool or the heat/defrost position by blocking or draining gas flow from behind the three-way valve piston.

(6) Discharge Pressure Transducer

The discharge pressure transducer is tapped into the discharge line. It converts pressure readings from the discharge line into digital signals for the microprocessor. The microprocessor controls several functions based on the signals from the discharge and suction pressure transducers. Before performing a detailed diagnosis, always check the transducers with a gauge manifold.

The unit also has a number of backup modes if one or both of the transducers should fail.

(7) Condenser Pressure Bypass Check Valve

The condenser pressure bypass check valve improves three-way valve response time.

(8) Three-way Valve

The three-way valve directs the discharge gas to either the condenser coil for cooling or the heating system for heat or defrost.

(9) Condenser Coil

The condenser coil changes hot gas into high pressure liquid during cool.

(10) Condenser Check Valve

The condenser check valve is a mechanical, inline check valve that closes during the heat/defrost cycle to prevent refrigerant from flowing back into the condenser.

(11) Heat Check Valve

The heating check valve is an repairable piston-type, mechanical check valve that closes during the cooling cycle to prevent backflow of refrigerant into the heating coil. It opens during heating to allow condensed liquid to pass from the heating coil to the receiver tank.

(12) Receiver Tank

The receiver tank stores excess refrigerant when the unit is not using the full charge.

(13) High Pressure Relief Valve

The high pressure relief valve is a safety feature that relieves extremely high discharge pressure.

(14) Receiver Tank Sight Glass

The receiver tank sight glass allows visual inspection of the refrigerant level.

(15) Receiver Tank Outlet Valve (RTOV)

The receiver tank outlet valve allows refrigerant to flow out of the receiver tank and is used to service the low side.

(16) Condenser Subcooler

The condenser subcooler is a number of tube passes in the condenser coil that cools the liquid leaving the receiver tank. The warm liquid leaves the receiver tank, enters the condenser coil in the subcooler tubing, then leaves the condenser and continues on towards the economizer and the evaporator expansion valve.

(17) Filter/Drier

The filter/drier filters particles and moisture out of the refrigerant.

(18) Economizer Expansion Valve

The economizer expansion valve meters liquid refrigerant into the economizer. This is a Maximum Operating Pressure (MOP) valve. The MOP is set at 50 psig (345 kPa).

(19) Liquid Injection Valve (LIV)

The liquid injection valve is an electronically controlled, normally closed valve. If the compressor temperature rises above preset levels, the liquid injection valve will inject pulses of liquid refrigerant into the suction line to cool the compressor. The LIV has a small orifice to reduce the liquid line pressure to suction pressure.

The liquid injection valve is used to maintain a minimum suction pressure during the suction pressure control mode.

The liquid injection valve is also used to maintain a minimum discharge pressure or to control the discharge superheat in the heat/defrost mode.

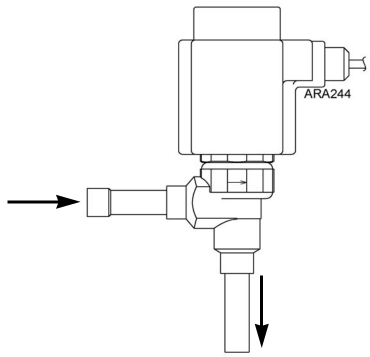


Figure 3: Liquid Injection Valve (LIV)

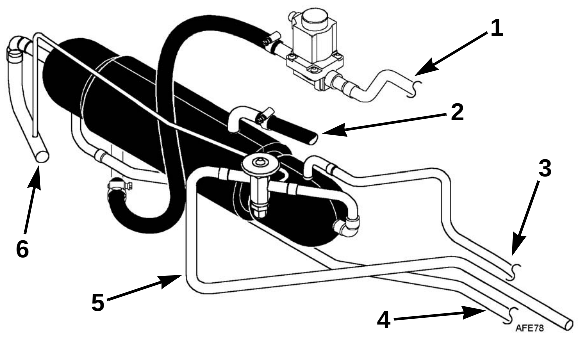
(20) Economizer

The economizer has two functions.

1. It cools the warm liquid that is traveling from the receiver tank to the evaporator expansion valve during the cooling cycle. Cooling the liquid increases unit capacity by increasing BTUs available for cooling. It also reduces flash gas, which in turn allows a more efficient flow through the evaporator expansion valve.
2. During the heating/defrost cycle the economizer acts as an evaporator. The heating coil acts as a condenser, giving up heat to the load. The liquid then goes back to the receiver tank, on to the economizer, and then is metered in by the economizer expansion valve. Heat is added to it from engine coolant circulated around the economizer tank.

The economizer has six inlets and outlets:

- Liquid IN and OUT as it travels to the evaporator coil. It goes in warm and comes out cool.
- Liquid IN to the economizer expansion valve and gas OUT through the economizer suction line does the cooling.
- Engine coolant IN and OUT as it heats the refrigerant during heating/defrost cycle.



1.	Coolant IN from Engine
2.	Coolant OUT to Engine
3.	Liquid IN from Drier
4.	Liquid OUT to Evaporator
5.	Liquid IN from Drier
6.	Gas OUT to Economizer Suction Line

Figure 4: Economizer

(21) Liquid Line Solenoid Valve (LLSV)

The liquid line solenoid is an electrically operated, normally open valve. It is open in the cool cycle and closed in the heat/defrost cycle so that liquid does flow into the evaporator coil.

In cold ambient temperatures, the liquid line solenoid valve opens during heating to warm the engine up rapidly. This is called the “bucking” cycle.

(22) Drain Pan Heater

The drain pan heater is used to melt ice in the drain pan during defrost.

(23) Heating Coil

During a heating/defrost cycle, the three-way valve diverts the hot discharge gas to the heating coil. The fan blows cool air from the load across the coil, warming the air and condensing the hot gas back into a liquid. The heating coil acts as a condenser. The liquid is sent back to the receiver tank and through the economizer and compressor again, picking up heat from both. Again it is sent through the heat coil.

The heat coil is not actually a separate coil, but is a separate circuit of passes in the evaporator coil.

(24) Evaporator Coil

The compressor keeps the pressure low in the evaporator. When the high pressure liquid flows into the low pressure evaporator, the refrigerant boils, absorbing heat from the air flowing through the coil.

(25) Evaporator Expansion Valve

The evaporator expansion valve precisely meters liquid refrigerant during the cooling cycle. It has no function during the heat/defrost cycle.

(26) Electronic Throttling Valve (ETV)

The ETV valve is an electronically controlled, variable opening valve. It replaces both the mechanical throttling valve and the modulation valve used in other units. An electric stepper motor, controlled by the microprocessor, varies the opening of the valve in relation to a number of inputs to the controller during cool or heat/defrost. Its primary function is to control the capacity of the unit during normal operation, but it also reduces capacity during conditions that would normally shut the unit down. This allows the unit to continue to operate until conditions improve.

The ETV is not typically active during heat/defrost and running null, except for minimum suction pressure control. During heat/defrost and running null, the ETV is set slightly open (30 steps, 20 steps in Software Revision 4300) to remove any refrigerant from the evaporator.

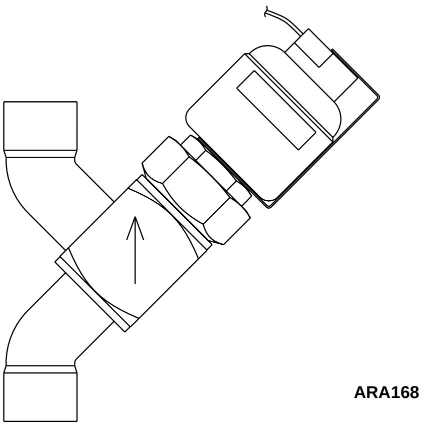


Figure 5: Electronic Throttling Valve (ETV)

(27) Heating Bypass Orifice

The heating bypass orifice is a brass fitting with a precision hole drilled into it and soldered to the suction line. A 0.25 in. tube connects it to the hot gas line. When the unit shifts from heat to cool mode, refrigerant may be trapped in the heating coil. The heating bypass orifice allows refrigerant to bleed from the heat coil back to the cool cycle. The small amount of hot gas that bleeds into the suction line is not enough to affect the heat cycle. The correct heating bypass orifice is identified by the groove around it (see “SI09 Heating Bypass Orifice Identification” on page 149).

(28) Suction Pressure Transducer

The suction pressure transducer converts pressure readings from the suction line into digital signals for the microprocessor. The microprocessor controls several functions based on the signals from the suction and discharge pressure transducers. Before performing a detailed diagnosis, always check the transducers with a gauge manifold.

The unit also has a number of backup modes if one or both of the transducers should fail.

(29) Suction Vibrasorber

The suction vibrasorber reduces vibration transfer and allows for a flexible suction line.

(30) Suction Pressure Access Port

With a gauge manifold connected, it allows you to check low side pressure reading when the suction service valve is closed.

(31) Suction Service Valve

The suction service valve is used for isolating and servicing the suction side of the compressor.

(32) Loading Valve #2 (LV2)

Loading valve #2 is an electrically operated, normally open valve. It works the same as LV1. When the microprocessor calls for more unloading, it turns off LV2 and loading piston #2 retracts, allowing a second unloading path to function. This is primarily for modulation.

LV2 is always energized during frozen operation. If both the loading valves were de-energized during frozen operation, the capacity would be too low to maintain a frozen load.

Note that the loading valves need to be energized to have full compressor capacity. The microprocessor de-energizes LV1 first, then de-energizes LV2 if less capacity is needed.

(33) Loading Valve #1 (LV1)

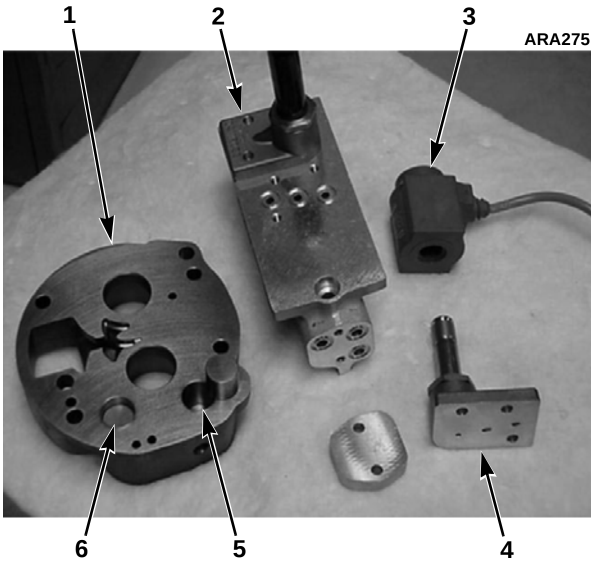
Loading valve #1 is an electrically operated, normally open valve located in the compressor. It replaces the economizer bypass valves used in previous screw compressor systems. When the valve is energized, it feeds discharge pressure to the back of loading piston #1 and closes off the unloading path. When the microprocessor asks for partial unloading, LV1 is de-energized. This allows suction gas behind the piston and opens the unloading path.

LV1 is always de-energized when the unit is in heat or defrost. The LLS is closed during the heat or defrost cycle so the compressor would be in a vacuum. De-energizing LV1 allows gas to flow to the suction cavity to prevent compressor damage.

Loading Valve Operation

The loading valves for the screw compressor are energized to increase compressor capacity. Unlike the unloaders used in previous units that were energized to decrease compressor capacity.

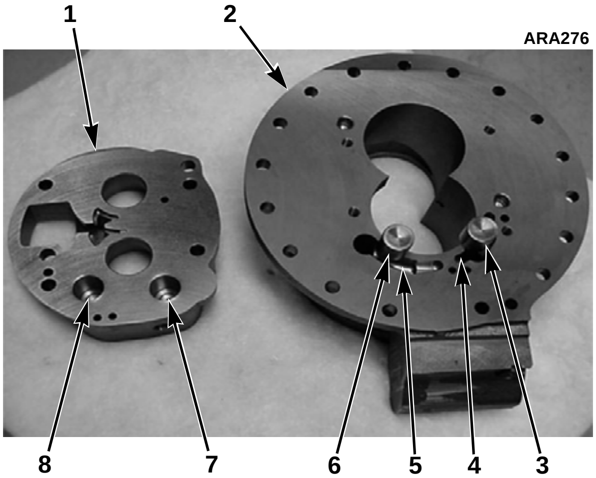
There are two pistons at the discharge end of the rotors in the discharge housing (Figure 8). The pistons are able to slide in a bore within the discharge housing. When a loading valve solenoid coil is energized, discharge pressure will be ported through the valve holder to pressurize the area behind the piston.



1.	Discharge Housing
2.	Loading Valve Holder
3.	Loading Valve Solenoid Coil
4.	Loading Valve Body
5.	LV1 Bore (with Piston beside it)
6.	LV2 Bore (with Piston in it)

Figure 6: Discharge Housing and Loading Valve Holder

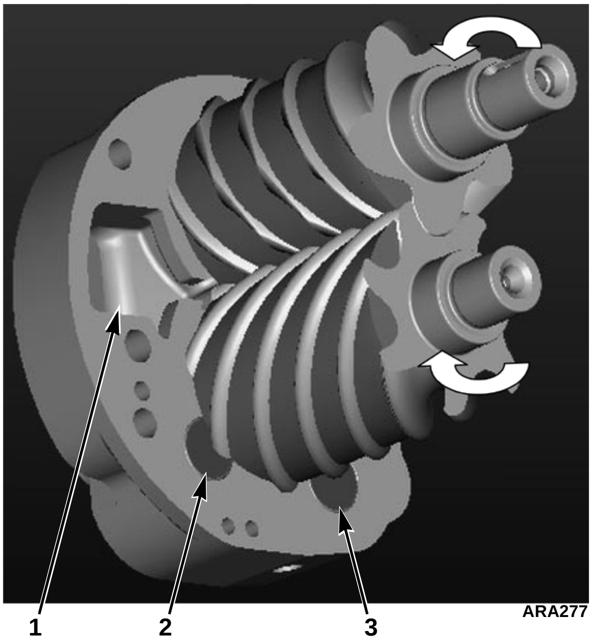
When the area behind the piston is pressurized, the piston will be pushed forward to block a machined passage in the rotor housing. The passages in the housing open up some of the pockets in the compression area of the rotors to the suction inlet cavity. This will not allow the rotors to compress the gas until the pockets are past the passage, reducing the compression area. A reduced compression area results in less effective compressor volume and reduced compressor capacity.



1.	Discharge Housing
2.	Rotor Housing
3.	Piston for LV1
4.	Machined Passage for LV1
5.	Machined Passage for LV2
6.	Piston for LV1
7.	LV1 Bore
8.	LV2 Bore

Figure 7: Discharge Housing and Rotor Housing

When the compressor is Fully Loaded (maximum capacity) both LV1 and LV2 are energized. The pistons are forward in the bore, which blocks both passages. The full length of the rotors is being used for compression. The darker color in the illustration below represents the area under compression.

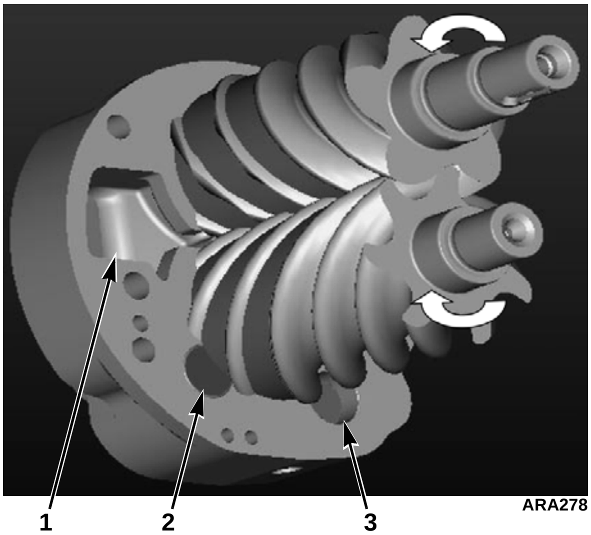


1.	Discharge Port
2.	LV2 Energized (Piston Forward)
3.	LV1 Energized (Piston Forward)

Figure 8: Fully Loaded (Maximum Capacity)

When the compressor is Partially Loaded (moderate capacity), LV1 is de-energized (Figure 9). The piston is retracted in the bore, allowing the passage to open. The passage extends the suction inlet cavity area, decreasing the area of compression in the rotors. Therefore, reducing compressor capacity.

This is the same function as the Economizer Bypass Solenoid used in earlier screw compressor systems, but LV1 is internal to the compressor.



1.	Discharge Port
2.	LV2 Energized (Piston Forward)
3.	LV1 De-energized (Piston Retracted)

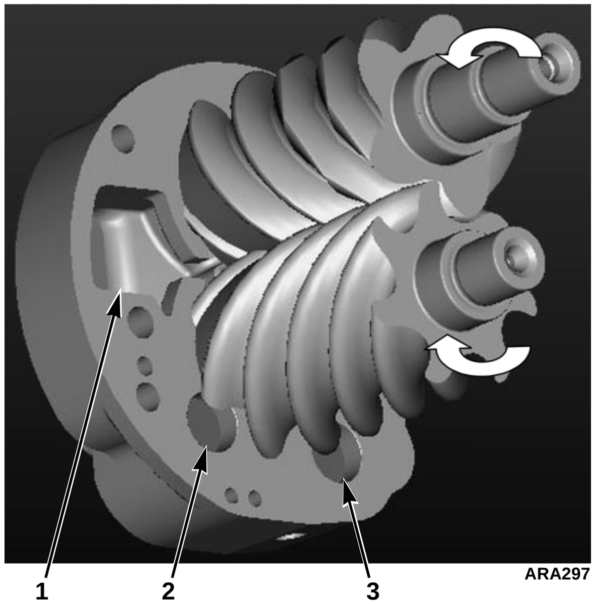
Figure 9: Partial Loaded (Moderate Capacity)

When the compressor is Unloaded (minimum capacity), LV1 and LV2 are both de-energized (Figure 10). Both pistons are retracted in the bores, opening up the passages to the suction inlet cavity. The area under compression has been reduced even further, reducing compressor capacity to a minimum.

LV1 will always be de-energized first, and then LV2 is de-energized to further reduce capacity when minimal cooling is required.

The engine and compressor start with the compressor unloaded (both loading valves de-energized), under a low horsepower/fuel demand for fuel efficiency. Once flow through the compressor is established, LV2 is energized. Then LV1 is energized for full capacity.

The loading valves are also used for Auxiliary Modes.



1.	Discharge Port
2.	LV2 De-energized (Piston Retracted)
3.	LV1 De-energized (Piston Retracted)

Figure 10: Unloaded (Minimum Capacity)

(34) Economizer Suction Service Valve

The economizer suction service valve is used for isolating and servicing the Economizer suction side of the compressor.

(35) Economizer Suction Vibrasorber

Reduces vibration transfer and allows for a flexible economizer suction line.

(36) Water Valve (EWSV)

The water valve (also called the engine coolant valve) is a normally closed valve that controls engine coolant flow around the economizer. It is closed during the cooling cycle and open during the heating/defrost cycle.

(37) High Pressure Cutout Switch (HPCO)

The high pressure cutout switch is a normally closed switch that monitors discharge pressure. If it reaches 450 psig (3103 kPa), it interrupts power to the fuel solenoid and the engine stops.

(38) High Pressure Cut-In Switch (HPCI)

The high pressure cut-in switch is a normally open switch that monitors discharge pressure. It closes at 425 psig (2930 kPa), closing a circuit to ground. It opens at 325 psig (2241 kPa). Its only function in the SB-400 is to back up the discharge pressure transducer.

(39) Compressor Temperature Sensor

The compressor temperature sensor supplies the compressor temperature to the microprocessor. The compressor temperature sensor is located on the compressor sump near the sight glass.

Startup Self Test

The startup self test happens every time the unit is turned on and starts to run, and on CYCLE-SENTRY startups. Because there are additional components in this unit, the startup self test checks some components to see if they are functioning properly.

Every time the SB-400 is started, it performs a self test of certain components. If components fail the startup self test, the unit records alarm codes associated with the failure.

When the On/Off switch is turned on, the startup self test will proceed as described below. A complete startup self test takes 60-120 seconds. No mode icons are displayed during the startup self test.

1. The microprocessor records the suction and discharge pressure transducer readings.
2. The ETV valve is closed.
3. LV1 and LV2 are energized and de-energized to check their electrical circuits. You may hear them click when they are energized and de-energized.
4. The preheat buzzer sounds as the unit preheats.
5. The engine starts and the unit runs in low speed cool. The compressor is unloaded (LV1 and LV2 are de-energized) when the engine is started.
6. The ETV is opened to 20 steps. This ensures a minimum amount of flow to the compressor during engine startup.
7. An ETV/loading valve check is performed to verify the correct operation of the pressure transducers, the ETV, and the loading valves. If the return air temperature or ambient air temperature is less than 15 F (–9.4 C), ETV/loading valve check in not performed because the suction pressure is too low.
   a. The microprocessor looks for a drop in suction pressure to verify the ETV is closed to step 20. The suction pressure must drop below 10 psig (69 kPa) or to less than 80% of its initial value.
   b. The ETV is opened and the microprocessor looks for a rise in suction pressure to verify the ETV is opening. The suction pressure must rise at least 5 psig (34 kPa) if either the return air temperature or ambient temperature is below 50 F (10 C). The suction pressure must rise at least 10 psig (39 kPa) if both the return air temperature and ambient temperature are at or above 50 F (10 C). The rate at which the ETV opens is dependent on the discharge pressure (the higher the discharge pressure, the slower the valve is opened).
   c. The ETV stops opening and is held in the current position.
   d. LV2 is energized and the microprocessor looks for a drop in suction pressure to verify that LV2 closed. The suction pressure must drop at least 3 psig (21 kPa) (5 psig [34 kPa] in Software Revision 4300 and 4301).
   e. LV1 is energized and the microprocessor looks for a drop in suction pressure to verify that LV1 closed. The suction pressure must drop at least 3 psig (21 kPa) (5 psig [34 kPa] in Software Revision 4300 and 4301).
8. The startup self test is now complete and the mode icons will appear.
9. The unit will shift to the mode required by the setpoint. The engine will run in low speed for a minimum of 2 minutes.

Unit Operation

The microprocessor uses a complex algorithm to determine the required operating mode for the unit. Therefore, it is difficult to predict the operating mode by comparing the setpoint to the box temperature.

In addition to the normal operating modes the unit has special modes and auxiliary modes for different conditions. The special modes are used when the engine coolant temperature is low. The auxiliary modes are used for extreme ambient temperatures, or other abnormal conditions. All modes are described in the following pages. The normal operating modes are described on pages 26 through 37. The special modes are described on page 38. The auxiliary modes are described on pages 39 through 47.

Normal Operating Modes

The unit usually runs in the following modes (see “Normal Operating Modes” on page 26):

- High Speed Cool
- Low Speed Cool
- Modulated Cool
- Running Null
- Null (CYCLE-SENTRY only)
- Low Speed Heat
- High Speed Heat
- Defrost.

NOTE: The microprocessor uses a complex program to continuously adjust the position of the ETV. There is no set position for the ETV except in Running Null, Heat, Defrost, and some service test modes. The ETV position can be displayed with the GAUGES key.

NOTE: Software Revision 4310 has a feature called the Heat Mode Charge Migration Cycle. It is used to increase the unit's heating capacity under certain conditions. See page 157 for more information.

Special Modes

The following modes are used when the engine coolant temperature is low (see “Special Modes” on page 38):

- Bucking Heat Mode
- Bucking Defrost

Auxiliary Modes

The microprocessor has the following auxiliary modes that provide unique protection features for extreme ambient temperatures and mechanical failures (see “Auxiliary Modes” on page 39):

- Discharge Pressure Control
- Compression Ratio Control
- Compressor Temperature Control
- Suction Pressure Control
- Heat Mode Discharge Superheat Control (Software Revision 4310)

Operating Modes Table

The Operating Modes Table on the following page shows the status of valves and components during the normal operating modes and the special modes.

Operating Modes Table

Operating Mode	Mode Type	High Speed	LLS N.O.	EWV N.C.	PSV N.C.	LV1 N.O.	LV2 N.O.	LIV N.C.	ETV	DS	Icon Display
Normal Operating Modes											
High Speed Cool	Max capacity cooling	On	Off	Off	Off	On (Active[1])	On (Active[1])	Off (Active[2])	Open to Step 800 (Active[1])	Off	Cool HS
Low Speed Cool	Reduced capacity cooling	Off	Off	Off	Off	On (Active[1])	On (Active[1])	Off (Active[2])	Open to Step 800 (Active[1])	Off	Cool
Modulation	Capacity balanced to equal heat load	Off	Off	Off	Off	Active	Active	Off (Active[2])	Active	Off	Cool Modulation
Running Null	No cooling. Slight heating.	Off	On	On	Off	Off	Off	Off (Active[2])	Fixed at Step 30[3]	Off	Heat Modulation
Low Speed Heat	Reduced capacity heating	Off	Active[4]	On	On	Off	On (Active[5])	Off (Active[2])	Fixed at Step 30[3]	Off	Heat
High Speed Heat	Max capacity heating	On	Active[4]	On	On	Off	On (Active[5])	Off (Active[2])	Fixed at Step 30[3]	Off	Heat HS
Defrost	Defrosts evap.	Off	Off	On	On	Off	On (Active[5])	Off (Active[2])	Fixed at Step 30[3]	On	Defrost
Special Modes											
Bucking Heat	Heating/cooling	Off	Off	On	On	Off	On	On	Reposition to Step 30[3]	Off	Cool Heat
Bucking Defrost	Heating/cooling	Off	Off	On	On	Off	On	On	Reposition to Step 30[3]	On	Defrost

1 Depending on discharge pressure. See explanation of discharge pressure control.

2 Depending on compressor discharge temperature and other conditions. See explanation of compressor temperature control and auxiliary modes.

3 Step 20 in Software Revision 4300.

4 LLS an ETV are used to maintain a minimum suction pressure during heating and defrost.

5 LV2 used to control discharge pressure during heat or defrost.

LLS: Liquid Line Solenoid
EWV: Engine Water Valve
PSV: Pilot Solenoid Valve
LV1: Loading Valve #1
LV2: Loading Valve #2
LIV: Liquid Injection Valve
ETV: Electronic Throttling Valve
DS: Damper Solenoid

Normal Operating Modes

The following descriptions of the normal operating modes show some approximate temperature and pressure readings for an ambient temperature of 100 F (38 C) and a box temperature of 35 F (2 C), unless stated otherwise.

High Speed Cool

Component	Status
Engine Speed	2200 rpm
High Speed Solenoid	On
LV1—Loading Valve #1 (Economizer Bypass Solenoid)	On (Closed)
LV2—Loading Valve #2	On (Closed)
EWSV—Water Valve	Off (Closed)
LLSV—Liquid Line Solenoid	Off (Open)
PS—Pilot Solenoid	Off (Closed)
LIV—Liquid Injection Valve	Off (Closed)
ETV—Electronic Throttling Valve	Full Open
Heat Check Valve	Closed
Condenser Check Valve	Open
Damper Solenoid	Off (Open)

Typical Conditions at Box Temperature of 35 F (2 C) and Ambient Temperature of 100 F (38 C).	
Temperatures	**Typical Reading**
Evaporator Temperature Differential [TPDF]	–17 ± 3 F (–9 ± 2 C)
Compressor Temperature [CTMP]	220 ± 20 F (104 ± 11 C)
Temperature of Liquid Line Entering Economizer	120 ± 7 F (49 ± 4 C)
Temperature of Liquid Line Leaving Economizer	100 ± 7 F (38 ± 4 C)
Economizer Liquid Line Temperature Differential	–20 ± 15 F (–11 ± 8 C)
Pressures	
Main Suction Pressure [SUC.P]	35 ± 20 psig (241 ± 138 kPa)
Economizer Suction Pressure	58 ± 15 psig (400 ± 103 kPa)
Discharge Pressure [DIS.P]	390 +10/–50 psig (2689 +69/–345 kPa)
Suction Line Conditions	**Typical Condition**
Main Suction Line Condition	Cold
Economizer Suction Line Condition	Cold

Typical Conditions at Box Temperature of 0 F (–18 C) and Ambient Temperature of 100 F (38 C).	
Temperatures	**Typical Reading**
Evaporator Temperature Differential [TPDF]	–11 ± 3 F (–6 ± 2 C)
Compressor Temperature [CTMP]	214 ± 20 F (101 ± 11 C)
Temperature of Liquid Line Entering Economizer	113 ± 7 F (45 ± 4 C)
Temperature of Liquid Line Leaving Economizer	44 ± 7 F (7 ± 4 C)
Economizer Liquid Line Temperature Differential	–69 ± 15 F (–38 ± 8 C)
Pressures	
Main Suction Pressure [SUC.P]	13 ± 7 psig (90 ± 48 kPa)
Economizer Suction Pressure	36 ± 15 psig (248 ± 103 kPa)
Discharge Pressure [DIS.P]	340 ± 30 psig (2344 ± 207 kPa)
Suction Line Conditions	**Typical Condition**
Main Suction Line Condition	Cold to Frosty
Economizer Suction Line Condition	Cold to Frosty

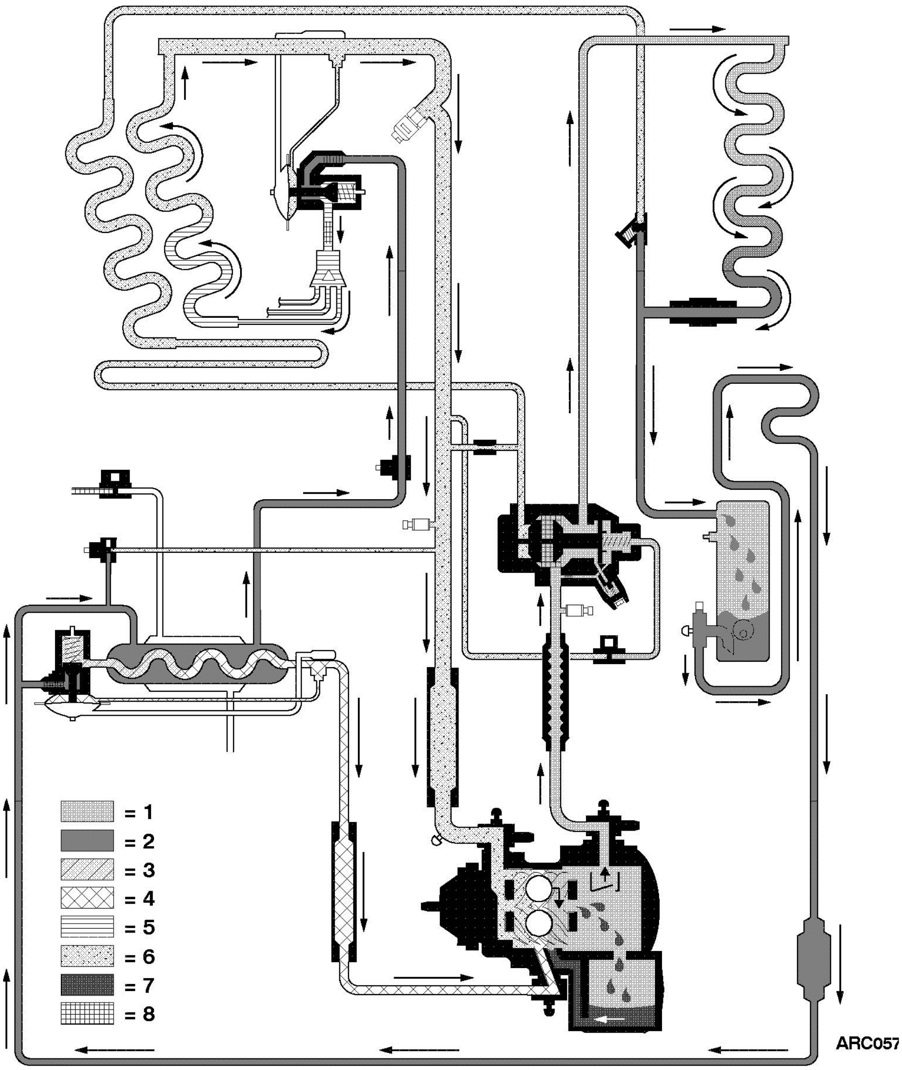
The engine is running on high speed.

Refrigerant leaves the compressor discharge and travels to the three-way valve. The valve is in the cool position because the pilot solenoid is closed. Refrigerant then travels to the condenser. Here it is condensed back to a liquid and then goes through the condenser check valve. The condenser check valve is open. The refrigerant cannot travel back to the heat coil because the heat check valve is closed by the low pressure in the heat circuit. The pressure is low because the heat circuit is cut off at the three-way valve and has been bled down to suction pressure by the heating bypass orifice.

The liquid refrigerant then flows to the receiver tank.

The refrigerant then passes through the condenser subcooler where more heat is removed from the refrigerant.

The refrigerant flows through the drier and arrives at a tee fitting located near the economizer expansion valve. The pressure of the liquid refrigerant is about the same here as it was at the receiver tank.



1.	High Pressure Gas	5.	Low Pressure Liquid
2.	High Pressure Liquid	6.	Low Pressure Gas
3.	Medium Pressure Liquid	7.	High Pressure Compressor Oil
4.	Medium Pressure Gas	8.	Engine Coolant

Figure 11: High and Low Speed Cool

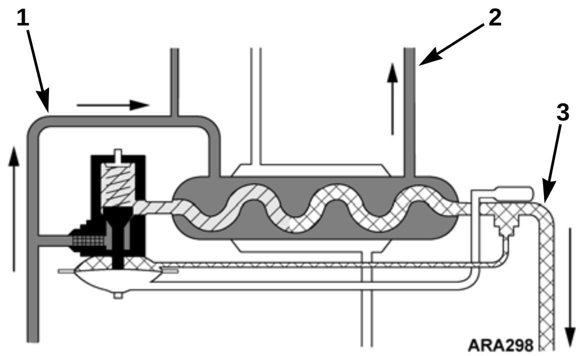
Most of the refrigerant enters the outer chamber of the economizer. A small portion of the refrigerant goes through the economizer expansion valve and evaporates in the inner coiled tube of the economizer. This cools the liquid going to the evaporator and again increases efficiency and capacity of the cooling cycle. The amount of liquid entering the valve will be proportional to the heat of the liquid refrigerant in the outer chamber (except when the economizer suction pressure is at or above the economizer expansion valve MOP). The hotter it is, the more refrigerant is metered in due to an increase in superheat across the economizer inner coil. The economizer is actually a refrigeration system in parallel with the main system, similar to a multi-temp unit. It shares the same condenser but it has its own expansion valve, evaporator, and compressor suction port.

The economizer liquid line temperature differential equals the temperature of the liquid line leaving the economizer minus the temperature of the liquid line entering the economizer (see "STP18 Checking Economizer Liquid Line Temperature Differential" on page 100).

Temperature of Liquid Line Leaving Economizer
– Temperature of Liquid Line Entering Economizer
= Economizer Liquid Line Temperature Differential

It is important to understand that the economizer liquid line temperature differential is affected by economizer suction pressure because the economizer expansion valve has an MOP of 50 psig (345 kPa).

- When the economizer suction pressure is below the MOP, the flow through economizer expansion valve is not limited and the economizer liquid line temperature differential will be –50 to –70 F (–28 to –39 C). This is normal for box temperatures at and below 0 F (–18 C).
- When the economizer suction pressure is at or above the MOP, the flow through economizer expansion valve is limited and the economizer liquid line temperature differential will be less than –50 F (–28 C). This is normal for box temperatures above 0 F (–18 C).



1.	Temperature of Liquid Line Entering Economizer 120 F (49 C) at Box Temperature of 35 F (2 C) 113 F (45 C) at Box Temperature of 0 F (–18 C)
2.	Temperature of Liquid Line Leaving Economizer 100 F (38 C) at Box Temperature of 35 F (2 C) 44 F (7 C) at Box Temperature of 0 F (–18 C)
3.	Economizer Suction Pressure 58 psig (400 kPa) at Box Temperature of 35 F (2 C) 36 psig (248 kPa) at Box Temperature of 0 F (–18 C)

Figure 12: Refrigerant Flow in Economizer

LV1 (economizer bypass solenoid) and LV2 are closed during full cool so the "suction" gas from the economizer travels to the compressor through the economizer suction line. The economizer suction gas enters the rotor case of the compressor at a slightly higher pressure than the main suction pressure. The suction pressure has already started to rise as the rotors are compressing refrigerant but is still low enough to pull refrigerant through the economizer.

The reason the refrigerant can not simply be piped over to the suction line is that the suction pressure from the economizer is higher than that from the evaporator, so it would lower the capacity of the main evaporator. Entering the compressor slightly downstream of the suction port does not allow the economizer gas to influence the suction pressure, but it does influence the discharge pressure because it adds its heat and volume to the discharge side.

The economizer suction pressure will always be higher than the main suction pressure, but the flow through the economizer expansion valve is controlled by its MOP. The flow through the economizer expansion valve starts to decrease as economizer suction pressure approaches the MOP, and then more or less stops when the economizer suction pressure is above the MOP.

The liquid refrigerant (cooled by the economizer) travels through the LLSV, which is open during the cool cycle. It then passes through the expansion valve and through the evaporator.

The refrigerant boils off in the evaporator and the low pressure suction gas travels through the ETV. The ETV regulates the suction pressure to the compressor to vary capacity in conjunction with the loading valves. The gas passes by the heat bypass orifice but there is no flow either way through the orifice. The heat circuit is closed at one end by the heat check valve and at the other end by the evaporator side of the three-way valve.

The suction gas now returns to the compressor and into the suction cavity to be compressed and go through the cycle again.

Low Speed Cool

Low speed cool is the same as high speed cool except the engine speed drops to 1450 rpm.

Component	Status
Engine Speed	1450 rpm
High Speed Solenoid	Off
LV1—Loading Valve #1 (Economizer Bypass Solenoid)	On (Closed)
LV2—Loading Valve #2	On (Closed)
EWSV—Water Valve	Off (Closed)
LLSV—Liquid Line Solenoid	Off (Open)
PS—Pilot Solenoid	Off (Closed)
LIV—Liquid Injection Valve	Off (Closed)
ETV—Electronic Throttling Valve	Full Open
Heat Check Valve	Closed
Condenser Check Valve	Open
Damper Solenoid	Off (Open)

Typical Conditions at Box Temperature of 35 F (2 C) and Ambient Temperature of 100 F (38 C).	
Temperatures	**Typical Reading**
Evaporator Temperature Differential [TPDF]	–17 ± 3 F (–9 ± 2 C)
Compressor Temperature [CTMP]	210 ± 20 F (99 ± 11 C)
Temperature of Liquid Line Entering Economizer	120 ± 7 F (49 ± 4 C)
Temperature of Liquid Line Leaving Economizer	115 ± 7 F (46 ± 4 C)
Economizer Liquid Line Temperature Differential	–5 +3/–15 F (–3 +2/–8 C)
Pressures	
Main Suction Pressure [SUC.P]	41 ± 20 psig (283 ± 138 kPa)
Economizer Suction Pressure	56 ± 15 psig (386 ± 103 kPa)
Discharge Pressure [DIS.P]	373 +20/–50 psig (2689 +138/–345 kPa)
Suction Line Conditions	**Typical Condition**
Main Suction Line Condition	Cold
Economizer Suction Line Condition	Cold

Typical Conditions at Box Temperature of 0 F (–18 C) and Ambient Temperature of 100 F (38 C).	
Temperatures	**Typical Reading**
Evaporator Temperature Differential [TPDF]	–11 ± 3 F (–6 ± 2 C)
Compressor Temperature [CTMP]	222 ± 20 F (105 ± 11 C)
Temperature of Liquid Line Entering Economizer	113 ± 7 F (45 ± 4 C)
Temperature of Liquid Line Leaving Economizer	31 ± 7 F (–1 ± 4 C)
Economizer Liquid Line Temperature Differential	–82 ± 15 F (–46 ± 8 C)
Pressures	
Main Suction Pressure [SUC.P]	13 ± 7 psig (90 ± 48 kPa)
Economizer Suction Pressure	44 ± 15 psig (303 ± 103 kPa)
Discharge Pressure [DIS.P]	341 ± 30 psig (2351 ± 207 kPa)
Suction Line Conditions	**Typical Condition**
Main Suction Line Condition	Cold to Frosty
Economizer Suction Line Condition	Cold to Frosty

Modulated Cool

Component	Status
Engine Speed	1450 rpm
High Speed Solenoid	Off
LV1—Loading Valve #1 (Economizer Bypass Solenoid)	Cycles*
LV2—Loading Valve #2	Cycles* Fresh On (Closed) Frozen
EWSV—Water Valve	Off (Closed)
LLSV—Liquid Line Solenoid	Off (Open)
PS—Pilot Solenoid	Off (Closed)
LIV—Liquid Injection Valve	Off (Closed)
Heat Check Valve	Closed
ETV—Electronic Throttling Valve	0-200 Fresh 0-400 Frozen
Condenser Check Valve	Open
Damper Solenoid	Off (Open)

** LV1 and LV2 are turned On (Closed) and Off (Open) as determined by the microprocessor to control the capacity of the compressor.*

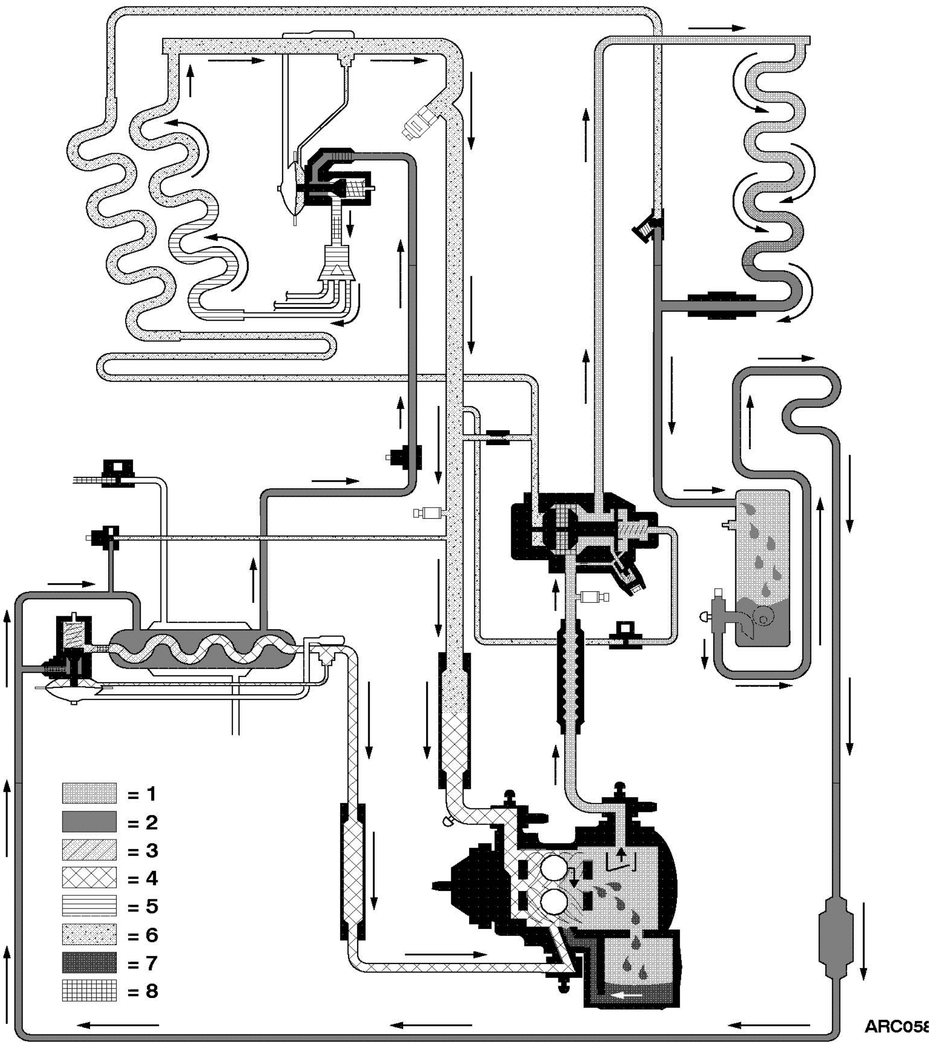
The engine remains at low speed. The microprocessor controls the cooling capacity by controlling the ETV position. The microprocessor also opens and closes the loading valves to change the compressor capacity.

When LV1 (economizer bypass solenoid) is opened to reduce the capacity, the economizer suction gas travels into the main suction line because the pressure there is normally lower than the gas coming from the economizer. This adds flow to the suction side of the compressor, reducing the amount of flow allowed from the main evaporator and reducing the capacity.

Opening both LV1 and LV2 gives the rotors less distance to compress the refrigerant. This reduces the capacity of the compressor which reduces the capacity of the system.

At setpoints in the fresh range, the unit typically enters modulated cool with LV1 and LV2 both open. To increase the capacity, the microprocessor closes LV2 first and closes LV1 second. To reduce the capacity, the microprocessor opens LV1 first and opens LV2 second.

At setpoints in the frozen range, the unit typically enters modulated cool with LV1 and LV2 both closed. The microprocessor opens LV1 to reduce the capacity, and closes LV1 to increase the capacity. LV2 is always closed at setpoints in the frozen range in modulated cool. If both the loading valves were open during frozen operation, the capacity would be too low to maintain a frozen load.



1.	High Pressure Gas	5.	Low Pressure Liquid
2.	High Pressure Liquid	6.	Low Pressure Gas
3.	Medium Pressure Liquid	7.	High Pressure Compressor Oil
4.	Medium Pressure Gas	8.	Engine Coolant

Figure 13: Modulated Cool with LV1 Open

Running Null

Component	Status
Engine Speed	1450 rpm
High Speed Solenoid	Off
LV1—Loading Valve #1 (Economizer Bypass Solenoid)	Off (Open)
LV2—Loading Valve #2	Off (Open)
EWSV—Water Valve	On (Open)
LLSV—Liquid Line Solenoid	On (Closed)
PS—Pilot Solenoid	Off (Closed)
LIV—Liquid Injection Valve	Off (Closed)
ETV—Electronic Throttling Valve	30 Steps Open*
Heat Check Valve	Closed
Condenser Check Valve	Open
Damper Solenoid	Off (Open)
** 20 Steps Open in Software Revision 4300*	

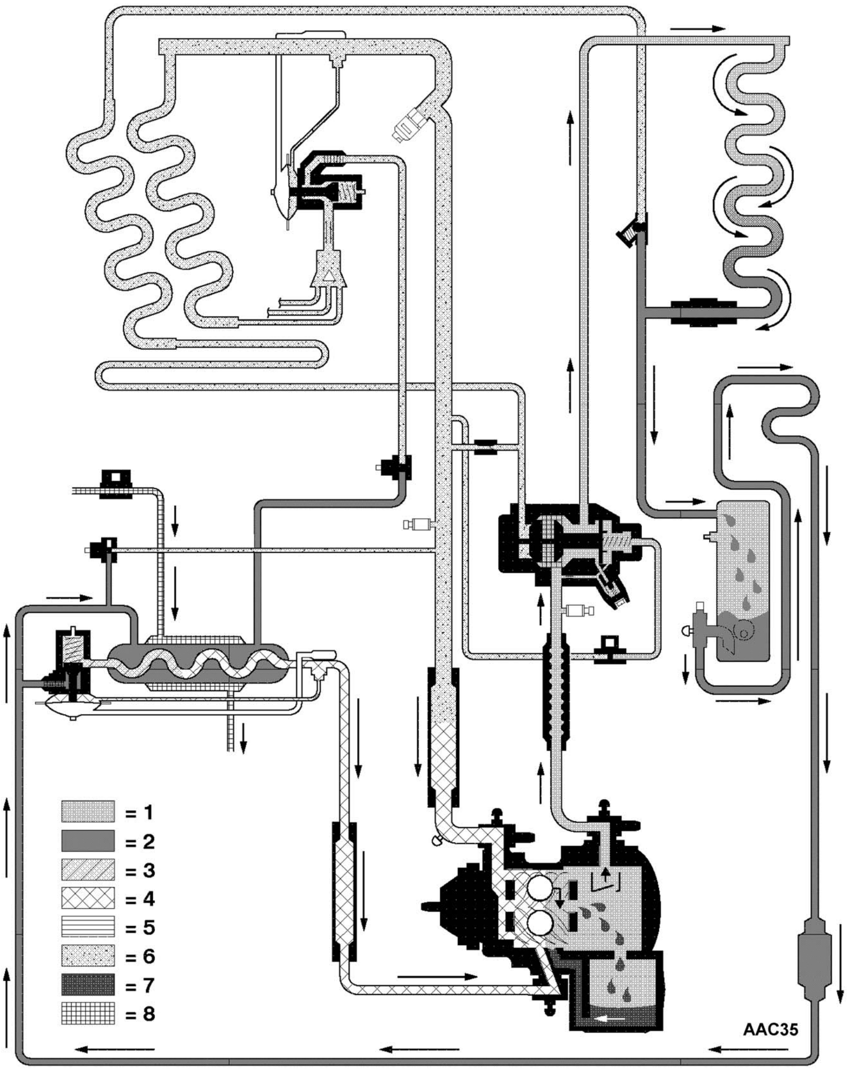
Running null is used when the engine should be running and the fan should be turning, but the refrigeration system should not be cooling or heating. This happens when the unit is operating in Continuous Run and the return air temperature is near the setpoint.

The engine runs in low speed. LV1 and LV2 are both opened to minimize the compressor capacity. LLSV is closed and the EWSV is opened.

The system stops cooling when the LLSV is closed because that stops the flow of refrigerant through the evaporator expansion valve and the evaporator coil. The system does not heat because the three-way valve is in the cool position and there is no flow of hot gas through the heat coil.

The EWSV is opened to keep the suction pressures from getting extremely low. The economizer is now acting as the only evaporator in the system.

The refrigerant flow in running null goes from the compressor discharge through the three-way valve in the cool position, the condenser, condenser check valve, receiver tank, subcooler, drier, economizer expansion valve, economizer, LV1 (economizer bypass valve), and the rotors to the compressor discharge. With the flow of liquid refrigerant stopped to the main evaporator and the loading valves de-energized to reduce compressor capacity, no cooling occurs in the evaporator, there is airflow over the load, and the compressor has discharge pressure for lubrication.



1.	High Pressure Gas	5.	Low Pressure Liquid
2.	High Pressure Liquid	6.	Low Pressure Gas
3.	Medium Pressure Liquid	7.	High Pressure Compressor Oil
4.	Medium Pressure Gas	8.	Engine Coolant

Figure 14: Running Null

Low Speed Heat

Component	Status
Engine Speed	1450 rpm
High Speed Solenoid	Off
LV1—Loading Valve #1 (Economizer Bypass Solenoid)	Off (Open)
LV2—Loading Valve #2	On (Closed)
EWSV—Water Valve	On (Open)
LLSV—Liquid Line Solenoid	On (Closed)
PS—Pilot Solenoid	On (Open)
LIV—Liquid Injection Valve	Cycles*
ETV—Electronic Throttling Valve	30 Steps Open**
Heat Check Valve	Open
Condenser Check Valve	Closed
Damper Solenoid	Off (Open)

** Software Revision 4310 uses Heat Mode Discharge Superheat Control to maintain a consistently high heating capacity. The LIV goes On (Open) when the discharge superheat is above 30 F (17 C), pulses on and off when the discharge superheat is between 30 F (17 C) and 15 F (8 C), and goes Off (Closed) when the discharge superheat is below 15 F (8 C). See “Heat Mode Discharge Superheat Control” on page 48 for more information.*

** Software Revision 4300 and 4301; the LIV goes On (Open) when the discharge pressure falls below 100 psig (689 kPa), pulses on and off at discharge pressures between 100 and 150 psig (689 and 1034 kPa), and goes Off (Closed) when the discharge pressure rises to 150 psig (1034 kPa).*

*** 20 Steps Open in Software Revision 4300.*

In the heat cycle, the hot gas travels from the compressor discharge to the three-way valve. The pilot solenoid has been energized and the three-way valve has shifted. Hot gas now travels to the heat coil. This unit has two separate coils in the evaporator assembly. The evaporator coil is used for the cool cycle. The heat coil is used for heat and defrost cycles. The hot gas condenses in the heat coil and becomes a liquid. The heat/defrost system is really a reverse cycle system: the heat coil is the condenser and the economizer is the evaporator.

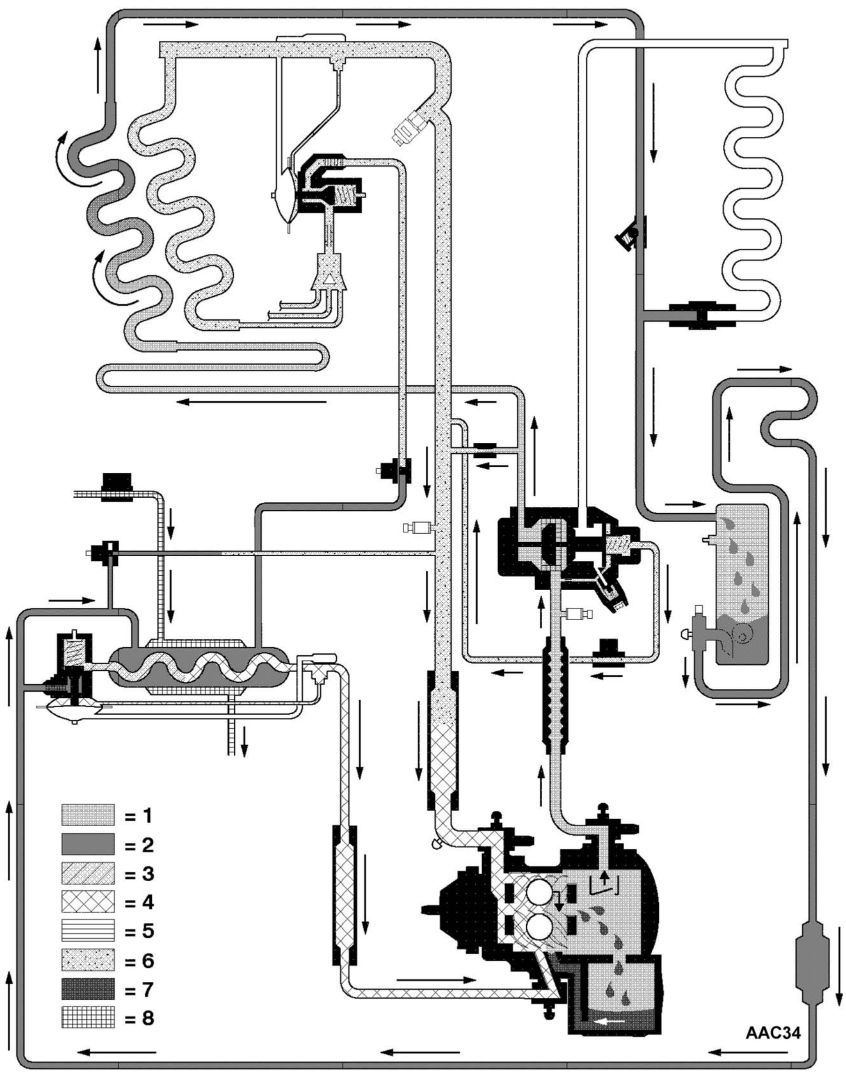
The liquid now flows through the heat check valve and is blocked from entering the condenser by the condenser check valve. The condenser is blocked off on one end by the condenser end of the three-way valve and on the other by the condenser check valve. The liquid enters the receiver tank and then travels to the economizer expansion valve. All liquid will now have to travel through the economizer expansion valve because the liquid line solenoid is closed during the heat/defrost cycle. The economizer acts like an evaporator. The EWSV is opened after a 90 second delay, and hot engine coolant circulates around the economizer tank. The heat in the economizer tank warms the inner coil and boils off the liquid. The gas now contains the heat added from the coolant. The warm gas flows through LV1 (economizer bypass solenoid), which is open (de-energized) during the heat/defrost cycle.

During the heat cycle, a small amount of hot gas flows between the heat circuit and the suction line through the heat orifice. This short cycling is harmless. The purpose of the orifice is to return liquid from the heat circuit to the cool circuit when the unit shifts from heat to cool. Immediately after the shift occurs, the suction line pressure drops and the remaining liquid in the heat circuit boils off and returns to the cool circuit through the bypass orifice.

A second function of the orifice is to accelerate heating or defrosting at low box and low ambient temperatures. If the unit goes into a heat or defrost cycle, the pressures in the heat circuit are very low and it is difficult to build enough pressure in the receiver tank to push refrigerant through the economizer expansion valve. The discharge gas travels through the orifice and into the suction line because the pressure in the suction line is very low. The gas actually short cycles through the orifice and back to the compressor. This accelerates the pressure buildup and ultimately pushes refrigerant through the economizer. The heat circuit will now heat normally. To enhance the speed of building discharge pressure, the LIV is energized by one of the following control methods:

Software Revision 4310 uses Heat Mode Discharge Superheat Control (see page 48) when the ambient temperature is below 32 F (0 C), or when the TPDF is below 7.2 F (4.0 C) and the ambient temperature is above 32 F (0 C). The LIV is energized when the discharge superheat is above 30 F (17 C), pulses on and off when the discharge superheat is between 30 F (17 C) and 15 F (8 C), and is de-energized when the discharge superheat is below 15 F (8 C).

In Software Revision 4300 and 4301 the LIV is energized when the discharge pressure is below 150 psig (1034 kPa) to add liquid refrigerant to the suction line. The LIV is fully open at discharge pressures below 100 psig (689 kPa), and pulses on and off at discharge pressures from 100 to 150 psig (689 to 1034 kPa). Once the discharge pressure rises to 150 psig (1034 kPa), the LIV is de-energized.



1.	High Pressure Gas	5.	Low Pressure Liquid
2.	High Pressure Liquid	6.	Low Pressure Gas
3.	Medium Pressure Liquid	7.	High Pressure Compressor Oil
4.	Medium Pressure Gas	8.	Engine Coolant

Figure 15: Low Speed Heat

High Speed Heat

Component	Status
Engine Speed	2200 rpm
High Speed Solenoid	On
LV1—Loading Valve #1 (Economizer Bypass Solenoid)	Off (Open)
LV2—Loading Valve #2	On (Closed)
EWSV—Water Valve	On (Open)
LLSV—Liquid Line Solenoid	On (Closed)
PS—Pilot Solenoid	On (Open)
LIV—Liquid Injection Valve	Cycles*
ETV—Electronic Throttling Valve	30 Steps Open**
Heat Check Valve	Open
Condenser Check Valve	Closed
Damper Solenoid	Off (Open)
** Software Revision 4310 uses Heat Mode Discharge Superheat Control to maintain a consistently high heating capacity. The LIV goes On (Open) when the discharge superheat is above 30 F (17 C), pulses on and off when the discharge superheat is between 30 F (17 C) and 15 F (8 C), and goes Off (Closed) when the discharge superheat is below 15 F (8 C). See “Heat Mode Discharge Superheat Control” on page 48 for more information.* ** Software Revision 4300 and 4301; the LIV goes On (Open) when the discharge pressure falls below 100 psig (689 kPa), pulses on and off at discharge pressures between 100 and 150 psig (689 and 1034 kPa), and goes Off (Closed) when the discharge pressure rises to 150 psig (1034 kPa).* *** 20 Steps Open in Software Revision 4300.*	

High speed heat is the same as low speed heat except the high speed solenoid is energized.

Defrost

Component	Status
Engine Speed	1450 rpm
High Speed Solenoid	Off
LV1—Loading Valve #1 (Economizer Bypass Solenoid)	Off (Open)
LV2—Loading Valve #2	On (Closed)
EWSV—Water Valve	On (Open)
LLSV—Liquid Line Solenoid	On (Closed)
PS—Pilot Solenoid	On (Open)
LIV—Liquid Injection Valve	Cycles*
ETV—Electronic Throttling Valve	30 Steps Open**
Heat Check Valve	Open
Condenser Check Valve	Closed
Damper Solenoid	On (Closed)

** Software Revision 4310; the LIV is controlled by Suction Pressure Control (see page 46).*

** Software Revision 4300 and 4301; the LIV goes On (Open) when the discharge pressure falls below 100 psig (689kPa), pulses on and off at discharge pressures between 100 and 150 psig (689 and 1034 kPa), and goes Off (Closed) when the discharge pressure rises to 150 psig (1034 kPa).*

*** 20 Steps Open in Software Revision 4300.*

Software Revision 4310 does not use Heat Mode Discharge Superheat Control in defrost. The LIV is controlled by Suction Pressure Control (see page 46).

In Software Revision 4300 and 4301, defrost is the same as low speed heat except the damper solenoid is energized.

The evaporator coil temperature must be below 45 F (7 C) to allow defrost. Defrost can be initiated in following three ways:

- Defrost is initiated manually through the defrost screen using the microprocessor **MODES** and **ENTER** keys. The data logger records defrost initiated manually as Defrost Initiated.
- Defrost is initiated automatically, on demand by the microprocessor if the differences between the return air temperature, discharge air temperature, and coil temperature are greater than predetermined values. The data logger records defrost initiated on demand as Defrost Forced.
- Defrost is initiated automatically by a defrost timer. The data logger records defrost initiated by a defrost timer as Defrost Timed.

If the unit is in CYCLE-SENTRY Null mode, the engine will start when defrost is initiated. The In-Range icon will remain on if it was on when defrost was initiated.

The unit will stay in defrost until the evaporator coil temperature rises to 57 F (14 C). If the evaporator coil temperature does not rise above 57 F (14 C) within the Defrost Duration (DDUR) time limit, the microprocessor will terminate defrost. The Defrost Duration can be set for either 30 or 45 minutes.

When any defrost cycle is terminated normally on temperature, a 20 minute timer in the microprocessor is started. When the timer times out, the return, discharge and coil sensor readings are compared. These sensor readings must fall within 30 F (17 C) of each other. If they do not, alarm code 13 (Check Sensor Calibration) is set.

Special Modes

The microprocessor has special modes that are used when the engine coolant temperature is below the minimum setting and the unit is in heat or defrost.

- The minimum engine coolant temperature setting is 140 F (60 C) in Software Revision 4310.
- The minimum engine coolant temperature setting is 120 F (49 C) in Software Revision 4300 and 4301.

The special modes normally occur when the ambient temperature is low, and the unit starts and then shifts into heat or defrost.

The special modes can also occur if the engine thermostat is stuck open, or if the engine coolant temperature sensor is out of calibration or defective. An interesting example of this is a unit with the thermostat stuck open that runs in Bucking Heat or Bucking Defrost when it is outside in cold weather, but runs normally when brought into a heated shop.

Bucking Heat Mode

Component	Status
Engine Speed	1450 rpm
High Speed Solenoid	Off
LV1—Loading Valve #1 (Economizer Bypass Solenoid)	Off (Open)
LV2—Loading Valve #2	On (Closed)
EWSV—Water Valve	On (Open)
LLSV—Liquid Line Solenoid	Off (Open)
PS—Pilot Solenoid	On (Open)
LIV—Liquid Injection Valve	On (Open)
ETV—Electronic Throttling Valve	30 Steps Open*
Heat Check Valve	Open
Condenser Check Valve	Closed
Damper Solenoid	Off (Open)
** 20 Steps Open in Software Revision 4300*	

The bucking heat mode occurs when unit starts and then shifts to the heat mode with the engine coolant temperature below the minimum setting. The microprocessor senses the low engine coolant temperature and the setpoint calling for heat, so it opens the LLSV. The unit is now heating and cooling at the same time, putting maximum load on the engine. The increased load quickly warms the engine coolant temperature above the minimum setting, and the unit then goes back into the mode required by the box temperature and setpoint.

The Heat Icon and the Cool Icon are both displayed when the unit is in the bucking heat mode.

This mode opens the EWSV to allow the engine coolant to flow through the economizer. This prevents the engine coolant from freezing (by the refrigerant boiling in the economizer coil) when the unit is started in extremely low ambient temperatures (usually less than 0 F [–18 C]).

Bucking Defrost

Component	Status
Engine Speed	1450 rpm
High Speed Solenoid	Off
LV1—Loading Valve #1 (Economizer Bypass Solenoid)	Off (Open)
LV2—Loading Valve #2	On (Closed)
EWSV—Water Valve	On (Open)
LLSV—Liquid Line Solenoid	Off (Open)
PS—Pilot Solenoid	On (Open)
LIV—Liquid Injection Valve	On (Open)
Heat Check Valve	Open
ETV—Electronic Throttling Valve	30 Steps Open*
Condenser Check Valve	Closed
Damper Solenoid	On (Closed)
** 20 Steps Open in Software Revision 4300*	

Bucking defrost is the same as bucking heat except the damper solenoid is energized.

Auxiliary Modes

The auxiliary modes are normally used to control conditions that affect the compressor and the engine. The conditions that affect the compressor are compressor temperature, main suction pressure, and discharge pressure. The conditions that affect the engine are engine coolant temperature and the discharge pressure, which is directly related to the maximum horsepower requirement. The auxiliary modes control these conditions as necessary to provide safe and reliable operation. If this cannot be accomplished, the unit may shut down to protect the compressor and other system components. The auxiliary modes are listed below:

- Discharge Pressure Control
- Compression Ratio Control
- Compressor Temperature Control
- Suction Pressure Control
- Heat Mode Discharge Superheat Control (Software Revision 4310)

Auxiliary modes can occur in the course of normal operation for extremely high or low ambient temperatures, or for other abnormal conditions. The auxiliary modes are described on the following pages.

Discharge Pressure Control

A characteristic of the screw compressor system is that the compressor horsepower requirement is closely related to the discharge pressure.

This is different from the reciprocating compressor system where the compressor horsepower requirement is closely related to the suction pressure.

In the reciprocating compressor/ETV system the compressor horsepower requirement is calculated and controlled using the suction pressure input.

In the screw compressor/ETV system the compressor horsepower requirement is calculated and controlled using the discharge pressure input.

The SB-400 uses discharge pressure control to allow the unit to run at maximum capacity while preventing high discharge pressure shutdowns (alarm code 10) and preventing the compressor from overloading the engine (limiting the maximum compressor horsepower requirement).

The discharge pressure is controlled by using the ETV to reduce the flow of gas in the main suction line to compressor, and by using the compressor loading valves to reduce the pumping volume of the compressor.

Previous screw compressor systems used a mechanical throttling valve and an economizer bypass solenoid valve to control refrigerant pressures and limit the compressor horsepower requirement.

Discharge Pressure Control - Cool Mode

When the unit is started the microprocessor assigns a value of 415 psig (2861 kPa) as the maximum discharge pressure. This is a programmable setting that can be changed through Super Guarded Access.

The unit is allowed to run with both loading valves on and the ETV in the full open position until that pressure is reached.

When the discharge pressure reaches the programmed limit [default setting is 415 psig (2861 kPa)] the microprocessor begins to monitor the time and pressure above 415 psig (2861 kPa). The higher the pressure, the less time it will take for the microprocessor to initiate corrective actions. The lower the pressure, the more time it will take for the microprocessor to initiate corrective actions.

When the limits are exceeded the microprocessor will take corrective actions. The corrective actions will affect the unit capacity. The microprocessor will first use the corrective action that has the least effect on the capacity. This is called Stage 1. If further corrective actions are required, the microprocessor goes to Stage 2, and then to Stage 3. The stages are described below:

- **Stage 1:**

  If the unit is on high speed cool - It begins to close the ETV down, reducing the amount of suction pressure.

  If the unit is on low speed cool - It begins to close the ETV and puts the unit on high speed to increase the condenser airflow.

  If the unit is in modulation - As long as the unit is close to set point the unit will stay in low speed and use the ETV and both loading valves to stay within the Discharge Pressure Control limit. It will not switch the unit to high speed. If the unit drifts up from set point and into the low cool mode the microprocessor calls for high speed.

  NOTE: The minimum position that the ETV can close to is controlled by the Compression Ratio Control (see page 43) mode and the Suction Pressure Control (see page 46) mode.

- **Stage 2:** If the discharge pressure continues to try to rise Stage 2 is activated. The engine is in high speed, the ETV is still active and now LV1 is turned off. This reduces the load further.
- **Stage 3:** If Stage 3 is needed the unit stays in high speed to keep good airflow through the condenser and turns LV2 off, unless the unit is running in the frozen range (based on the actual return air temperature). Closing the ETV and turning off both loading valves reduces the capacity to a very low level. In frozen range LV2 is left on and the discharge pressure will rise until the unit shuts down from either high engine temperature (alarm code 18), high compressor temperature (alarm code 82), or high discharge pressure (alarm code 10). In fresh range LV2 is turned off for Stage 3. As in frozen range, if the discharge pressure continues to climb even with LV2 turned off, the unit will then shut down due to engine overheat, compressor overheat, or high discharge pressure.

NOTE: The unit capacity may be reduced in the Discharge Pressure Control mode.

Discharge Pressure Control - Cool Backup Modes

If any of the following components fail during Discharge Pressure Control operation, a backup mode will become active.

- **Discharge Pressure Transducer Failure:** If the discharge transducer fails (alarm code 109), the microprocessor no longer knows the discharge pressure so it switches over to controlling on the High Pressure Cut-in Switch (HPCI). The HPCI closes at approximately 425 psig (2930 kPa). The HPCI was used in previous screw units to initiate the prevent modes. It is used on the SB-400 as a backup to the discharge pressure transducer.
- **Discharge and Suction Pressure Transducer Failure:** If the suction (alarm code 87) and discharge (alarm code 109) pressure transducers fail, the discharge pressure will be regulated by controlling the compressor loading valves and ETV states based on the HPCI switch input. The liquid injection valve will be pulsed to help maintain a minimum suction pressure.
- **ETV Failure:** If the ETV fails (alarm code 89), the unit will try to continue to run. Discharge pressure will be controlled by using both the loading valves.

  NOTE: The microprocessor will continue to step the ETV in case of a false fail alarm. The discharge pressure control point is lowered to prevent interference with the backup pressure control. If the suction pressure (alarm code 93), compression ratio (alarm code 99), or unit capacity (alarm codes 26 or 32) are below specified levels the unit will shutdown

- **ETV and Suction Pressure Transducer Failure:** If the ETV (alarm code 89) and the suction pressure transducer (alarm code 87) both fail, the unit cannot read the suction pressure or control the ETV. The microprocessor disables the low suction pressure control because it can no longer read suction pressure and it continues to try to control discharge pressure by using both of the loading valves. Because it doesn't know what the suction pressure is, it starts to inject liquid to maintain a minimum flow into the compressor. The amount of liquid injected is based on the ETV position (the microprocessor continues to step the ETV in case of a false alarm code 89) and the discharge pressure transducer reading.

- **ETV and Discharge Pressure Transducer Failure:** If the ETV (alarm code 89) and the discharge pressure transducer (alarm code 109) fail, the discharge pressure will be regulated based on the same algorithm as though the discharge and suction transducer failed.

Discharge Pressure Control - Heat Mode

During heat mode the maximum and the minimum discharge pressures are regulated. The maximum pressure is regulated to prevent high discharge pressure shutdowns. The minimum pressure is regulated to insure adequate heating capacity. The minimum pressure is regulated indirectly by Heat Mode Discharge Superheat Control in Software Revision 4310 (see page 48).

The discharge pressure is controlled using LV2, the liquid injection valve, and the pilot solenoid. The ETV is not active during heat mode, except for low suction pressure control. The ETV is normally maintained at a slight open position (30 steps in Software Revision 4301 and 4310, 20 steps in Software Revision 4300) during heat to remove any refrigerant trapped in the evaporator.

LV1 is always de-energized during heat mode. This opens the economizer outlet to the main compressor suction port and prevents low pressures at the main suction inlet.

When the unit enters heat, the microprocessor looks at the discharge pressure. It tries to maintain the discharge pressure between 350 and 450 psig (2413 and 3103 kPa) in Software Revision 4310, and between 250 and 400 psig (1724 and 2758 kPa) in Software Revision 4300 and 4301.

Software Revision 4310

- If the discharge pressure falls below 350 psig (2413), LV2 is turned on, loading the compressor. LV2 will be energized when heat is entered if the discharge pressure is less than 415 psig (2861 kPa).
- If the discharge pressure rises above 415 psig (2861 kPa), LV2 is turned off
- If the discharge pressure climbs above 450 psig (3103 kPa) the pilot solenoid is turned off until the discharge pressure drops to 385 psig (2654 kPa), or for a maximum of 15 seconds.

NOTE: The unit capacity may be reduced in the Discharge Pressure Control mode.

Software Revision 4300 and 4301

- If the discharge pressure falls below 250 psig (1724 kPa), LV2 is turned on, loading the compressor. LV2 will be energized when heat is entered if the discharge pressure is less than 350 psig (2413 kPa).
- If the discharge pressure rises above 350 psig (2413 kPa), LV2 is turned off
- If the discharge pressure continues to fall, the liquid injection valve begins to pulse liquid into the suction line. The pulse duration is controlled by an algorithm that measures time and pressure.
- If the discharge pressure climbs above 400 psig (2758 kPa) the pilot solenoid is turned off until the discharge pressure drops to 360 psig (2482 kPa), or for a maximum of 15 seconds.

NOTE: The unit capacity may be reduced in the Discharge Pressure Control mode.

Discharge Pressure Control - Heat Backup Mode

Discharge Transducer Failure: If the discharge pressure transducer fails (alarm code 109) during heat, the microprocessor uses the High Pressure Cut-in switch to monitor the discharge pressure. This is the only backup. The ETV and the suction pressure transducer are not used in heat.

Compressor Temperature Sensor Failure (Software Revision 4310): If the compressor temperature sensor fails (alarm code 80) during heat, the Heat Mode Discharge Superheat Control is disabled. The microprocessor then uses the discharge pressure to control the LIV (like Software Revision 4300 and 4301). The LIV is fully open at discharge pressures below 100 psig (689 kPa). The LIV pulses on and off at discharge pressures from 100 to 150 psig (689 to 1034 kPa). The LIV is closed at discharge pressures above150 psig (1034 kPa).

Compression Ratio Control

Unlike an automotive engine, a high compression ratio in a compressor is not a desirable thing. An overly high compression ratio in an SB-400 can affect the oil flow through the compressor. Although the screw compressor is not as sensitive to a high compression ratio as a reciprocating compressor, it still has to be controlled if it reaches extreme levels. The compression ratio is computed by dividing the discharge pressure by the suction pressure.

NOTE: Compressor compression ratios are always calculated in pounds per square inch absolute (PSIA). PSIA is determined by adding 15 psi to pounds per square inch gauge (PSIG).

<u>Discharge 390 psig + 15 psi = 405 psia</u>
divided by
<u>Suction 10 psig + 15 psi = 25 psia</u>

COMPRESSION RATIO = 16:1

A high compression ratio can occur in operating modes with high discharge pressures or low suction pressures. The first condition may occur during a high ambient pulldown. The second condition may occur during modulation operation with a low cooling load.

The the unit is limited to a maximum compression ratio of 25:1. That is the highest compression ratio allowed.

NOTE: The unit capacity may be reduced in the Compression Ratio Control mode.

Compression Ratio Control Operation

If the computed pressure ratio is greater than the 25:1, the controller begins compression ratio control. The control actions taken during compression ratio control depends on the operating mode and are outlined below.

Compression Ratio Control Inactive Modes

Compression ratio control is inactive during the following modes:

- Running Pretrip, (shutdown alarm conditions remain enabled).
- Service Test Mode, (Shutdown alarm conditions remain enabled).
- ETV check, (shutdown alarm conditions remain enabled).
- Suction pressure transducer failed, (alarm code 87). Shutdown alarm conditions disabled.
- Discharge pressure transducer failed, (alarm code 109 alarm). Shutdown alarm conditions disabled.

Full Cool - Discharge Pressure Control Inactive

If the unit is operating in full cool and discharge pressure control is not active, the compression ratio will be regulated using both the loading valves and the liquid injection valve. The compressor loading valves are first de-energized to provide two steps of compression ratio control. (Unloading the compressor increases the suction pressure.) If the compression ratio remains above the limit, the liquid injection valve will be pulsed on and off to lower the compression ratio by raising the suction pressure.

Full Cool - Discharge Pressure Control Active

If the unit is operating in full cool and discharge pressure control is active, the compression ratio will be regulated using the loading valve(s) and liquid injection valve. The compressor loading valves are de-energized to provide two steps of compression ratio reduction. (Unloading the compressor increases the suction pressure.) If the pressure ratio remains above the limit, an algorithm calculates the liquid injection pulse width for the liquid injection valve and liquid injection begins. If the compression ratio remains above the limit after the loading valves are de-energized and the liquid injection valve is 100% on, the ETV is locked in it’s current position so it will not be able to close and increase the compression ratio. The downside of locking the ETV is if the unit is in high ambient conditions and the discharge pressure control is active, the ETV will not be able to be used to reduce discharge pressure and the unit may shutdown with a high compression ratio (alarm code 99) and high discharge pressure (alarm code10).

Modulated Cool - Discharge Pressure Control Inactive

If the unit is operating in modulated cool and discharge pressure control is not active, the compression ratio will be regulated using the liquid injection valve. An algorithm is used to determine the length of the refrigerant pulse.

Running Null Mode

Running Null mode compression ratio control is limited to energizing the liquid injection valve, (both loading valves are de-energized during this mode).

Heat / Defrost Mode

Heat / Defrost mode compression ratio control is similar to cool mode. The first stage of control will be to de-energize LV2 followed by energizing the liquid injection valve. The heat mode algorithms differences are due to the following being true during heat mode operation.

- LV1 will always be de-energized, (compressor unloaded) during heat.
- The liquid injection valve may be energized by the minimum discharge pressure control or Heat Mode Discharge Superheat Control.
- ETV is not active and is set to step 30 (step 20 in Software Revision 4300) during heat.

Bucking Heat / Defrost Mode

During Bucking Heat / Defrost operation, the liquid line solenoid remains de-energized (open), until the engine coolant temperature reaches 140 F (60 C) (120 F [49 C] in Software Revision 4300 and 4301).

The first stage of compression ratio control in this mode is to de-energize compressor LV2. If that does not lower the compression ratio enough the liquid injection valve is energized and liquid refrigerant is pulsed into the system.

If the compression ratio is still not reduced below the limit, the unit will shut down with a alarm code 99 (high compressor pressure ratio). If this alarm code occurs make sure to check the engine thermostat. The engine may not be warming up.

Compression Ratio Control Backup Modes

Failure of the either the discharge pressure transducer or suction pressure transducer will place limits on the refrigeration system to prevent operating conditions that could cause compressor damage.

Pressure Transducer Failure(s): If the suction pressure transducer (alarm code 87), the discharge pressure transducer (alarm code 109), or both fail, the ETV minimum step position will be limited to 50. During cool mode operation, liquid injection will be enabled to help maintain suction pressure. Liquid injection will start at ETV step 300 and will be full on at ETV step 50.

Discharge Pressure Transducer Failure: If the discharge pressure transducer fails (alarm code 109), the compression ratio is calculated based on the suction pressure transducer input and the HPCI switch. A closed (grounded) HPCI would indicate discharge pressure above 425 psig (2930 kPa) and an open (ungrounded) HPCI indicates a discharge pressure below 325 psig (2241 kPa).

The standard compression ratio control algorithm will then be used to determine the required actions to control the compression ratio.

The high compressor pressure ratio alarm (alarm code 99) is disabled if alarm code 109 (discharge pressure transducer failure) is set. This is to prevent a nuisance shutdown from the Compression Ratio Control mode.

Discharge Pressure Transducer, Suction Pressure Transducer and ETV Failure: If alarm codes 87 (suction pressure transducer failure), 109 (discharge pressure transducer failure), and 89 (ETV failure) are all active, the only actions taken is to activate the liquid injection valve at a pulse rate of 3 seconds on / 3 seconds off.

Compressor Temperature Control

The SB-400 is equipped with a system to control the compressor discharge temperature. The system consists of the compressor discharge temperature sensor (CTMP), mounted in the compressor oil sump, (oil sump is directly exposed to the compressor discharge gas) and an on/off pulsing solenoid valve (LIV) that injects refrigerant into the compressor suction line. The LIV has a small orifice to reduce the liquid line pressure to suction pressure. The liquid boils off which cools the refrigerant liquid/gas flowing through the suction line into the compressor.

The system is primarily used for regulation of the maximum compressor discharge temperature.

It is also used to control:

- Low compressor suction pressure in Suction Pressure Control mode.
- Compression ratio in Compression Ratio Control mode.
- Minimum discharge pressure in the Heating/Defrost mode.

Compressor Temperature Control Operation

The liquid injection valve, (LIV), operates as a pulsing device that pulses liquid into the suction line depending on inputs the microprocessor is monitoring. The microprocessor uses an algorithm that determines the length of the refrigerant pulse depending on input levels.

The LIV begins to inject at a CTMP of 270 F (132 C). The pulses are very short. If the temperature continues to climb the pulses will lengthen. When the CTMP reaches 290 F (143 C) the LIV is full on.

NOTE: The unit capacity may be reduced in the Compressor Temperature Control mode.

Compressor Temperature Alarm Codes

Alarm Code 80: Alarm code 80 will be set and logged if the CTMP sensor system has failed. The display will read **- - -**. If alarm code 80 is set the LIV will be energized. We don’t know if there is a CTMP overheat, but without being able to monitor CTMP the Micro is taking precautionary action.

If alarm code 80 is set the LIV will be energized and controlled by an algorithm that monitors the discharge pressure and the ETV position in the cool mode.

Alarm Code 81: Alarm code 81 will be set and logged if the CTMP is greater than 290 F (143 C) for one minute. This is not a shutdown alarm and it will self clear when the CTMP goes back below 290 F (143 C). The LIV is already fully injecting when the alarm code 81 is set.

Alarm Code 82: The unit will be shutdown and alarm code 82 alarm is set if:

- The CTMP is between 295 F and 310 F (146 C and 154 C) for 15 minutes. If the CTMP goes below 295 F (146 C), the 15 minute timer will reset.
- The CTMP goes above 310 F (154 C) for one minute.

The unit will automatically restart (alarm code 84) 15 minutes after the CTMP drops below 250 F (121 C).

Compressor Temperature Control Inactive Modes

Compressor temperature control is inactive during the following modes:

- Certain portions of running pretrip.
- Service Test Mode
- ETV check

The high compressor discharge temperature shutdown alarms remain enabled during these modes.

Suction Pressure Control

This suction pressure control is used to control the minimum operating suction pressure to prevent damage to the compressor rotors.

Suction pressure control is active in all modes, except the inactive modes mentioned below. It is most likely to occur during light-load modulated cool operation, or with low box temperatures in low ambient temperatures. It may also be one of the first indications that the unit is low on refrigerant.

Suction Pressure Control Operation

The microprocessor constantly monitors the main suction pressure through the suction pressure transducer. If the suction pressure drops below a 12 inch vacuum [–6 psig (–41 kPa)], the microprocessor takes actions to raise the suction pressure. The method used depends on the mode that the unit is operating in.

Suction pressure control uses the loading valves and liquid injection valve (LIV), to maintain the suction pressure above an 12 inch vacuum [–6 psig (–41 kPa)]. De-energizing the loading valves increases suction pressure by reducing the compressor pumping volume. Energizing the liquid injection valve increases suction pressure by increasing flow to the compressor. The loading valve(s) are de-energized before liquid injection valve is energized.

If the suction pressure drops below an 18 inch vacuum [–9 psig (–62 kPa)] for more than one minute, alarm code 93 will be set and a shutdown will occur. The unit will restart (alarm code 84) 15 minutes after the suction pressure rises above 5 psig (34 kPa).

If three alarms occur within one hour no further restarts will be attempted.

NOTE: The unit capacity may be reduced in the Suction Pressure Control mode.

Suction Pressure Control Inactive Modes

Suction pressure control is inactive during the following modes:

- Service Test Mode
- ETV check

Shutdown alarm code 93 remains enabled at all times.

Modulation - Fresh Setpoint - Cool Operation

During modulation or full cool / fresh set point operation the microprocessor tries to raise the suction pressure by de-energizing both loading valves (if not all ready de-energized). If the suction pressure does not raise above an 12 inch vacuum [–6 psig (–41 kPa)] the liquid injection valve will begin pulsing liquid refrigerant into the suction line.

Frozen Cool

During operation in frozen setpoint full cool operation the action will be the same as above except LV2 will remain energized.

Heat Mode

Low suction pressure is raised in the heat mode by opening the LLSV to increase mass flow to the compressor. The ETV, which is normally locked at step 30 (step 20 in Software Revision 4300) during heat, is used to regulate the flow through the evaporator to minimize heating capacity reduction. The ETV can be opened from step 30 (or step 20) to step 100 during this mode to raise the suction pressure. This will typically occur during heat pull up from low box temperatures or if the engine coolant temperature is low. The increased load will also help raise the engine coolant temperature. LV2 is not de-energized to regulate suction pressure. LV1 is always de-energized during heat. Liquid injection is also utilized as a last resort in the heat mode to increase suction pressure. To prevent compressor flooding, Software Revision 4310 will not allow liquid injection if the compressor discharge superheat is too low.

Defrost Mode

Low suction pressure is raised in the defrost mode by opening the LIV to increase mass flow to the compressor. To prevent compressor flooding, Software Revision 4310 will not allow liquid injection if the compressor discharge superheat is too low. LV2 is not de-energized to regulate suction pressure. LV1 is always de-energized during defrost.

Running Null Mode

Running Null mode low suction pressure control is limited to energizing liquid injection, (both loading valves are already de-energized during this mode).

Suction Pressure Control Backup Modes

Suction Pressure Transducer Failure: If the suction pressure transducer fails (alarm code 87) the low suction pressure control mode is disabled. Compressor protection is provided by the high compression ratio backup mode.

Liquid Injection Valve Failure: If the liquid injection valve fails (alarm code -82 during pretrip), the low suction pressure control mode still functions. When the liquid injection valve is failed or restricted, the low suction pressure algorithm will still function and shut the unit down.

Heat Mode Discharge Superheat Control

Software Revision 4310 adds Heat Mode Discharge Superheat Control to maintain a consistently high heating capacity. Heat Mode Discharge Superheat Control usually functions at ambient temperatures below 32 F (0 C), but will function at higher ambient temperatures if the heating TPDF is below 7.2 F (4.0 C).

The microprocessor uses the readings from the discharge pressure transducer and the compressor temperature sensor to calculate the discharge superheat. See “Discharge Superheat Calculation Table” on page 49.

If the discharge superheat is above 30 F (17 C), the LIV is energized. This increases the refrigerant flow, which increases the discharge pressure and the heating capacity.

If the discharge superheat is between 30 F (17 C) and 15 F (8 C), the LIV pulses on and off. This maintains a relatively high refrigerant flow, which maintains the high discharge pressure and the heating capacity.

If the discharge superheat is below 15 F (8 C), the LIV is de-energized. This limits the flow of liquid refrigerant to prevent compressor flooding.

The compressor discharge superheat calculation is also used to limit liquid injection during low suction pressure control operation to prevent compressor flooding.

Heat Mode Discharge Superheat Control is not used for Defrost and is disabled if the compressor temperature sensor fails (alarm code 80). The microprocessor then uses the discharge pressure to control the LIV (like Software Revision 4300 and 4301). The LIV is fully open at discharge pressures below 100 psig (689 kPa). The LIV pulses on and off at discharge pressures from 100 to 150 psig (689 to 1034 kPa). The LIV is closed at discharge pressures above150 psig (1034 kPa).

You can use the “Discharge Superheat Calculation Table” on page 49 to determine the discharge superheat from the discharge pressure and the compressor temperature. The shaded cells in the table show where the LIV is energized during Heat Mode Discharge Superheat Control.

Discharge Superheat Calculation Table

Discharge Pressure (psig) versus Compressor Temperature (CTMP Degrees F)
= Discharge Superheat (Degrees F)

	Compressor Temperature (CTMP Degrees F)										
Discharge Pressure (psig)	**50**	**75**	**100**	**125**	**150**	**175**	**200**	**225**	**250**	**275**	**300**
50	24.8	49.8	74.8	99.8	124.8	149.8	174.8	199.8	224.8	249.8	274.8
75	12.5	37.5	62.5	87.5	112.5	137.5	162.5	187.5	212.5	237.5	262.5
100	0.9	25.9	50.9	75.9	100.9	125.9	150.9	175.9	200.9	225.9	250.9
125		15.0	40.0	65.0	90.0	115.0	140.0	165.0	190.0	215.0	240.0
150		4.7	29.7	54.7	79.7	104.7	129.7	154.7	179.7	204.7	229.7
175			20.1	45.1	70.1	95.1	120.1	145.1	170.1	195.1	220.1
200			11.2	36.2	61.2	86.2	111.2	136.2	161.2	186.2	211.2
225			3.0	28.0	53.0	78.0	103.0	128.0	153.0	178.0	203.0
250				20.4	45.4	70.4	95.4	120.4	145.4	170.4	195.4
275				13.6	38.6	63.6	88.6	113.6	138.6	163.6	188.6
300				7.4	32.4	57.4	82.4	107.4	132.4	157.4	182.4
325				1.8	26.8	51.8	76.8	101.8	126.8	151.8	176.8
350					22.0	47.0	72.0	97.0	122.0	147.0	172.0
375					17.8	42.8	67.8	92.8	117.8	142.8	167.8
400					14.3	39.3	64.3	89.3	114.3	139.3	164.3
425					11.5	36.5	61.5	86.5	111.5	136.5	161.5
450					9.3	34.3	59.3	84.3	109.3	134.3	159.3
475					7.8	32.8	57.8	82.8	107.8	132.8	157.8

(dark grey)	= LIV On
(light grey)	= LIV Pulsing On and Off
(white)	= LIV Off

Identifying Auxiliary Modes

You can determine when a unit is in an auxiliary mode by using the Valve Position Displays (see "SI02 Valve Position Displays" on page 142) to check the actual component status. Compare the actual component status with what the component status should be (shown in "Operating Modes Table" on page 25). The auxiliary modes and the main conditions that cause them to occur are listed below:

- Discharge Pressure Control — Discharge pressure above 415 psig (2861 kPa).
- Compression Ratio Control — Compression ratio above 25:1.
  Calculate the compression ratio by dividing the discharge pressure by the suction pressure using pounds per square inch absolute (PSIA). PSIA is determined by adding 15 psi to pounds per square inch gauge (PSIG). See the following example:

  Discharge Pressure 390 psig + 15 psi = 405 psia divided by Suction Pressure 10 psig + 15 psi = 25 psia

  405 psia ÷ 25 psia = 16:1 Compression Ratio
- Compressor Temperature Control — Compressor temperature at or above 270 F (132 C).
- Suction Pressure Control — Main suction pressure below a 12 inch vacuum [–6 psig (–41 kPa)].
- Heat Mode Discharge Superheat Control (Software Revision 4310) — Discharge superheat above the Full Off Limit.

The following examples show how to use the Valve Position Displays to determine the auxiliary mode.

Example 1: Discharge Pressure Control

For High Speed Cool the Operating Modes Table shows that LV1 is on and the ETV is 800.

Using the Valve Position Displays shows that LV1 is off. Using the **GAUGES** key shows that the compressor temperature is 220 F, the suction pressure is 30 psig, the discharge pressure is 418 psig, and the ETV position is 600. The unit is operating in the discharge pressure control mode because the discharge pressure is above 415 psig, but the compressor temperature is below 270 F, the suction pressure is above a 12 inch vacuum, and the compression ratio is less than 25:1.

Example 2: Compression Ratio Control

For High Speed Cool the Operating Modes Table shows that LV1 is on.

Using the Valve Position Displays shows that LV1 is off. Using the **GAUGES** key shows that the compressor temperature is 220 F, the suction pressure is 0 psig, and the discharge pressure is 390 psig. The unit is operating in the compression ratio control mode because the compression ratio is above than 25:1 [(390 psig + 15 psi) ÷ (0 psig + 15 psi) = 27], but the compressor temperature is below 270 F, the discharge pressure is below 415 psig, and the suction pressure is above –6 psig (12 inch vacuum).

Example 3: Compressor Temperature Control

For High Speed Cool the Operating Modes Table shows that LIV is off.

Using the Valve Position Displays shows that LIV is pulsing on and off. Using the GAUGES key shows that the compressor temperature is 280 F, the suction pressure is 30 psig, and the discharge pressure is 360 psig. The unit is operating in the compressor temperature control mode because the compressor temperature is above 270 F, but the discharge pressure is below 415 psig, the suction pressure is above a 12 inch vacuum, and the compression ratio is less than 25:1.

Example 4: Suction Pressure Control

For High Speed Cool the Operating Modes Table shows that LV1 is on.

Using the Valve Position Displays shows that LV1 is off. Using the GAUGES key shows that the compressor temperature is 220 F, the suction pressure is –6.5 psig (13 inch vacuum), and the discharge pressure is 180 psig. The unit is operating in the suction pressure control mode because the suction pressure is below a 12 inch vacuum, but the compressor temperature is below 270 F, the discharge pressure is below 415 psig, and the compression ratio is less than 25:1.

Example 5: Heat Mode Discharge Superheat Control (Software Revision 4310)

For High Speed Heat the Operating Modes Table shows that LIV cycles.

Using the Valve Position Displays shows that LIV is on. Using the SELECT key shows that the ambient temperature is 30 F. Using the GAUGES key shows that the compressor temperature is 200 F, the suction pressure is 4 psig, and the discharge pressure is 300 psig. The unit is operating in the heat mode discharge superheat control mode because the discharge superheat is above 30 F (82.4 F using the “Discharge Superheat Calculation Table” on page 49), but the discharge pressure is below 415 psig, the compressor temperature is below 270 F, the suction pressure is above a 12 inch vacuum, and the compression ratio is less than 25:1.

Pretrip Test

The pretrip test is a functional test of the unit's operating capability. Use it to check the control circuits and components. Alarm codes are recorded (in the data logger and on the display) if problems are detected during the pretrip test. An alarm occurring during Pretrip is identified by a dash (–) preceding the code.

The pretrip test is a quick check. Passing the pretrip does not mean the unit is operating at full capacity.

CAUTION: Monitor the return air temperature when performing a Pretrip Test on a loaded trailer. The controller may not maintain setpoint during the Pretrip Test.

General Information

The following section covers conditions that prevent or terminate the pretrip test, and components that are disabled or enabled during the pretrip test.

Conditions that Prevent the Pretrip Test

The Pretrip cannot start if any of the following conditions are present:

- If any check or shutdown alarm is active.

  NOTE: Pretrip will be allowed if a log alarm is active. If log alarm Pretrip Reminder Code 64 is active, code will self-clear when entering Pretrip.

- If the unit is in sleep mode. (Upon sleep mode exit, the unit does a pretrip test before going to temperature control.)
- If the unit is in Service Test Mode.
- If the unit is in Relay Board Test Mode.
- If the controller is in Guarded Access.

Conditions that Terminate the Pretrip Test

Shutdown Alarm Code –28 (Pretrip Abort) occurs if the test is terminated before completion. The pretrip test will be terminated by the following conditions:

- Unit is switched off
- A shutdown alarm occurs during the pretrip test
- A check alarm is present at the end of the amps check
- A check alarm is generated before entering the running test.

Information Available on the Controller Display

The following information is accessible on the controller display during the pretrip test:

- During the amps check, the amps display is enabled but all other gauge displays are disabled. The amps display can be viewed on the screen by pressing the GAUGES key. The amps display can be locked on the screen by pressing the ENTER key.
- During the display check, all gauge displays are disabled.
- During the running part of the test, all gauge displays and the valve position displays are enabled.
- The TPDF (accessed through the SELECT key) is enabled. To lock the TPDF display on the screen, press the ENTER key. To unlock the TPDF display, press the SELECT key.
- All hourmeters are enabled.

Disabled Features

The following features are disabled during the pretrip test:

- Some auxiliary modes
- Restarts
- Timed defrost
- Demand defrost
- Setpoint temperature control

- High speed lockout
- SELECT key displays, except for TPDF.
- Alarm clear: the ALARM CLEAR key is locked out until the pretrip test is exited.

Enabled Features

The following Auxiliary Modes are enabled during the pretrip test:

- Discharge pressure control (heat, cool, and defrost)
- Suction pressure control (heat, cool, and defrost)
- Compression ratio control (heat, cool, and defrost)
- Compressor temperature control (heat, cool, and defrost), except during the LLSV check and the initial part of the LIV check
- Engine coolant temperature control.

Pretrip Test Sequence

This section describes the complete pretrip test sequence. It is called the Full Pretrip Test. You can start the Pretrip Test with the engine running. That is called the Engine Running Pretrip Test. It bypasses the non-running portion of the Full Pretrip Test and begins at the display check just after the engine starts (see step 11 below). The Full Pretrip Test is a more complete test so it should be used when diagnosing the system.

1. Place the On/Off switch in the On position.
2. Note and clear alarms using the **CODE** and **CLEAR** keys. Pretrip will not begin if an alarm code is stored in memory. All alarm codes must be corrected and cleared before starting the Pretrip Test.
3. Before the engine starts, press the **PRETRIP** key. The letters PrE TRIP will appear on the screen.
4. Press the **ENTER** key.

   NOTE: If the* ENTER *Key is not pressed within 10 seconds, the standard display will appear on the screen.

   - The letters PrE LOAD will appear on the screen and the Pretrip test will begin. The pretrip test may take up to 30 minutes depending on the operating conditions, but can be run unattended.
5. The controller de-energizes all outputs.
6. The controller checks battery volts. If the voltage is greater than 15.0 V or less than 11.5 V, the pretrip test is aborted. Shutdown Alarm Codes –28 (Pretrip Abort), and –61 (Low Battery Volts) are logged.
7. The controller checks the sensors for 10 seconds. If the controller detects a open or short circuit in a sensor, it logs alarm code –28 and any accompanying sensor alarm codes.
8. The controller energizes the buzzer output for 3 seconds, then de-energizes it.
9. The letters PrE AMPS will appear on the screen and the amps check will be performed on the electrical components.
   - If desired, to display the Amps Check reading as each component is tested, press the **GAUGES** Key. To lock the Amps display on the screen, press the **ENTER** key. To unlock the Amps display, press the **SELECT** key.
10. After the Amps Check is complete, the engine will start automatically.

NOTE: The Pretrip Test can be stopped at any time by switching the On/Off switch to the Off position. However, when the unit is turned off during the Pretrip Test, the controller will sense this shutdown as one or more alarms. These alarms must be cleared before the unit can be started.

11. After the unit starts, a display check will be performed as follows:
    - All symbols and segments will be displayed.
    - The standard screen will be displayed.
    - The settings of the programmable features will be briefly displayed.
12. The controller checks the engine speeds by running the unit in high speed cool for about 30 seconds and then shifting to low speed cool for about 30 seconds. If the engine RPM is not within 100 RPM of the high speed setting (2200) or the low speed setting (1450), the controller records alarm code 33 (Check Engine RPM).

13. The controller runs the unit in low speed fully loaded cool to check the capacity. If the TPDF does not reach a minimum requirement (see the following table) within 15 minutes, the controller records alarm code –21 (Cooling Cycle Check), or alarm code –32 (Refrigeration Capacity Low), and alarm code –28 (Pretrip Abort) and terminates the pretrip test.

Ambient or Return Air Temperature (whichever is lower)	Minimum TPDF
Above 80 F (26.7 C)	–10 F (–5.6 C)
Above 70 F (21.1 C)	–8 F (–4.4 C)
Above 50 F (10.0 C)	–6 F (–4.4 C)
Above 30 F (–1.1 C)	–4 F (–2.2 C)
Above 20 F (–6.7 C)	–2 F (–1.1 C)
At or Below 20 F (–6.7 C)	–1 F (–0.6 C)
NOTE: The ambient or return air temperature, whichever is lower, determines the minimum TPDF.	

14. The controller checks the operation of the liquid line solenoid valve. This check is bypassed if alarm codes 87 or 67 are active.

    a. The unit runs for 30 seconds in low speed fully loaded cool mode, and liquid injection is disabled.

    b. The controller then checks the suction pressure reading. If the suction pressure is below –3 psig (–21 kPa), the controller bypasses the liquid line solenoid valve check and goes to the check for heat capacity and EWSV.

    c. The liquid line solenoid is then energized (closed).

    d. After 2 minutes, the controller checks the suction pressure. If the suction pressure is above –3 psig (–21 kPa), indicating the liquid line solenoid did not close, the controller records alarm code –67 (Liquid Line Solenoid Circuit, a check alarm) and goes to the check for the heat capacity and EWSV.

NOTE: A flooding economizer expansion valve or a defective compressor can cause a false alarm code –67 (Liquid Line Solenoid Circuit). A defective compressor can cause a false alarm code –67 if it cannot pull the suction pressure down to –3 psig (–21 kPa). See page 112 for information about testing the compressor.

    e. The liquid line solenoid is then de-energized (opened).

    f. After 1 minute, the controller checks the suction pressure. If the suction pressure is below +1 psig (+7 kPa), indicating the liquid line solenoid did not open, the controller records alarm code –67 (Liquid Line Solenoid Circuit, a check alarm).

15. The controller checks the heat capacity and the EWSV. This check is bypassed if alarm code 52 is active. If the engine coolant temperature drops below 90 F (32 C) after this check has started, the controller records alarm code –83 (Low Engine Coolant Temperature) and goes to the check for the damper solenoid.

    a. If the engine coolant temperature is below 140 F (60 C)[120 F [49 C] in Software Revision 4300 and 4301) when the test is started, the LLSV is de-energized to place the unit in the bucking heat mode and raise the engine coolant temperature. If the engine coolant temperature does not reach 140 F (60 C)[120 F [49 C] in Software Revision 4300 and 4301) within 15 minutes, the controller records alarm code –83 (Low Engine Coolant Temperature) and goes to the check for the damper solenoid.

    b. The unit goes into the low speed heat mode to start the check.

    c. The EWSV is energized 90 seconds after the unit goes into the low speed heat mode. The controller records the engine coolant temperature one second before the EWSV opens. If alarm code 06 (Engine Coolant Temp Sensor) is active, this step and the next step are bypassed.

d. After the EWSV is energized the controller monitors the engine coolant temperature. If the engine coolant temperature does not drop a minimum amount (calculated from an algorithm) within one minute, the controller records alarm code –39 (Coolant Valve Circuit).

e. The controller monitors the TPDF after the unit goes into the low speed heat mode. If the TPDF does not rise to 4 F (2 C) within 15 minutes, the controller records alarm code –52 (Heat Circuit).

16. The controller checks the damper solenoid. This check is bypassed if the unit is configured with a damper motor (DMOT = YES).

    a. The defrost damper solenoid output (DDS) is energized.

    b. After the 30 seconds, the defrost damper solenoid output (DDS) is de-energized.

17. The controller checks the optional damper motor. This check is bypassed if the unit is configured with a damper solenoid (DMOT = NO), or if the return air temperature or the ambient air temperature is below 25 F (–3.9 C).

    a. The defrost damper output is energized and the unit is placed is low speed fully loaded cool.

    b. The controller monitors the TPDF after the damper is closed. If the TPDF does not reach –30 F (–17 C) when AMBT and RAT greater than 50 F (10 C), or –25 F (–14 C) when AMBT or RAT less than 50 F (10 C), within 20 minutes, the controller records alarm code –29 (Damper Circuit) and goes to the check for return to cool. These TPDF requirements are high because there is no airflow with the damper closed.

    c. The defrost damper output is de-energized to open the damper.

    d. The controller monitors the TPDF after the damper is opened. If the TPDF does not drop by 5 F (cooling TPDF drops from –30 F [–17 C] to –25 F [–14 C] or –25 F [–14 C] to –20 F [–11 C]), the controller records alarm code –30 (Damper Stuck Closed).

18. The controller checks the return to cool (checks to see that the three-way valve shifts to the cool position).

    a. The unit runs in low speed cool with the ETV set to position 200. LV1 and LV2 are de-energized unless the RAT is less than the FRFZ setpoint, then LV2 will be energized.

    b. The controller looks for a minimum TPDF of –2 F (–1.1 C) to verify the return to cool.

19. The controller checks the liquid injection valve. If the CTMP is less than 131 F (55 C), the CTMP sensor has failed, or the discharge pressure is less than 100 psig (689 kPa) after the return to cool is verified, this check is bypassed.

    a. The controller records an initial CTMP.

    b. The liquid injection valve is energized.

    c. After a 5 minutes, the controller checks the CTMP. If the CTMP has dropped less than 3 F (2.7 C) the controller records alarm code –121 (Liquid Injection Valve Failure) and alarm code –28 (Pretrip Abort) and terminates the pretrip test.

NOTE: A flooding main expansion valve or a flooding economizer expansion valve can cause a false alarm code –121 (Liquid Injection Valve Failure).

20. The pretrip test is finished at the end of the liquid injection valve check. The pretrip results are the reported as follows, but the message remains on the display until any key is pressed:
    - If the words PASS TRIP appear, the Pretrip test was a success and no alarms were sensed by the controller. The unit will resume setpoint control.
    - If the words CHEC TRIP appear, “check” alarms were sensed by the controller. The unit will resume setpoint control.
    - If the words FAIL TRIP appear, “shutdown” alarms were sensed by the controller and the pretrip test was terminated.
21. If 'Enter Sleep Mode on Successful Pretrip' has been programmed, the unit will enter Normal Sleep Mode when a Successful Pretrip Test is completed.
    - Successful Pretrip Test is Pass or Check.
    - Controller will display SLEEP.

Diagnosing the System

Diagnostic Overview

The Thermo King SB-400 screw compressor unit has industry leading heating and cooling capacities. It also has been designed to run in extreme temperatures without shutting down. To generate and control these high capacities, and to let the unit run at the edge of the ambient envelope, these units are equipped with sophisticated refrigeration and control systems.

IMPORTANT: Always check the accuracy of the transducers against a gauge manifold set before diagnosing the unit. See "STP20 Checking Pressure Transducers" on page 102.

IMPORTANT: Always check the compressor oil level if the refrigeration capacity is low (Alarm Codes 21, 23, 26, and 32). See "STP03 Checking Compressor Oil" on page 81.

Even though the control systems contain numerous components and advanced control algorithms the diagnosis of the system has been made easier by the up front inclusion of extra Service Test modes and increased operational display capabilities.

The most important thing to remember is that the SB-400 control parameters are different than previous Thermo King designs. Previous units almost always set an alarm or shutdown when they could no longer run in conditions beyond their design limits. The SB-400 will always try to continue to run in any condition. It has numerous auxiliary modes that pull back capacity to attempt to keep the unit running. The unit does watch the setpoint and box temperature and if it finally sees that it can not stay within a specified limit of setpoint, it will eventually shutdown but it will have tried a number of things to reduce the capacity to the minimum required under those conditions.

During these auxiliary modes a code indicating the reduced capacity will not normally be displayed. That means if you try to diagnose an SB-400 **you must use Service Test Modes if you want a true picture of the function of the unit.**

The SB-400 control system also has the ability to work around component failures. Normally there will be a code present that indicates a component failure. In previous unit control logic the unit would have shut down with that failure, the SB-400 can continue to run, but it may have reduced capacity.

NOTE: Because the transducers play such an important part in the operation of the unit, many of these back-up modes are used during a transducer failure, and these back-up modes may reduce capacity. Always check the accuracy of the transducers against a gauge manifold set before diagnosing the unit.

A unit usually requires repair because of the following reasons:

- The unit is running close to but not holding setpoint, but is not setting alarm codes. This usually means the unit is running in extreme ambients, and is running in an auxiliary mode causing a capacity loss. Eventually, if the problem continues there will be alarm codes and shutdowns.
- It is running, holding setpoint, but setting an alarm code(s). Something has failed, but the unit has worked around it and is probably running on an auxiliary or back-up mode.
- It is running, can not hold setpoint, and is setting an alarm code(s). Something has failed, the unit has probably tried to work around it, but the conditions are too extreme.
- It keeps shutting down and is setting an alarm code(s). There is a problem and the unit could not work around it.

System Diagnosis

It is important that you use the alarm codes to diagnose the system.

Alarm codes that refer to specific component failures are called **Hardware Alarm Codes**. Examples of hardware alarm codes are 04–Discharge Air Sensor and 94–Loading Valve #1.

Alarm codes that refer to abnormal conditions in the refrigeration system are called **Condition Alarm Codes**. The following are the main condition alarm codes that indicate problems in the refrigeration system:

- 10 High Discharge Pressure
- 21 Cooling Cycle Check
- 22 Heating Cycle Check
- 23 Cooling Cycle Fault
- 24 Heating Cycle Fault
- 26 Check Refrigeration Capacity
- 32 Refrigeration Capacity Low
- 81 High Compressor Temperature
- 82 High Compressor Temperature Shutdown
- 93 Low Compressor Suction Pressure
- 99 High Compressor Pressure Ratio

Always test and repair the components specified in any hardware alarm codes before trying to diagnose any condition alarm codes. Refer to the “Alarm Code Overview” on page 77 and “Alarm Codes, Their Causes and Corrective Actions” on page 80 for information about troubleshooting the hardware alarm codes.

Diagnostic Procedure

1. Interview the driver. Find out what the driver knows. Assuming the driver is with the trailer and it wasn't just dropped off in the yard, ask the driver the following:
   - How long has the problem existed?
   - What codes have you seen? (or hopefully recorded)
   - Has anybody worked on the unit recently?

   If it is an owner-operator, you may get the entire history of the unit. If it is a company driver, he may have just picked up the trailer and you will get no information.
2. Record any existing alarm codes.
3. Download the DAS and the microprocessor data logger. You must use pass through mode to get through to the data logger and bypass the DAS. Refer to the THERMOGUARD µP-VI Microprocessor for Screw Compressor Applications Diagnostic Manual (TK 51329) and the WinTrac Manual for information about downloading the DAS and the microprocessor data logger. A whole manual could be written on interpreting a download, but the main things to look for are:
   - When did the problem start?
   - What alarm codes are set?
   - What kind of TPDF does the unit develop.
   - Is there any place on the download that the unit performs well? How does that compare with the problem areas?
   - Does it occur at any special time like after a defrost, or just after start-up?
4. Repair any hardware alarm codes that were recorded.
5. If any components were repaired or replaced to correct hardware alarm codes, perform a Pretrip Test (see “Pretrip Test Sequence” on page 55) and test run the unit to see if the alarm codes reappear.
6. Run the Initial Component and System Checks (see “Initial Component and System Checks” on page 63) to check some basic items.
7. Repair any problems or hardware alarm codes that were found during the Initial Component and System Checks.
8. If any repairs were made, perform a Pretrip Test (see “Pretrip Test Sequence” on page 55) and test run the unit to see if any problems or alarm codes reappear.

9. Refer to the “Table of Information Recorded in Service Test Modes” on page 62 and run the unit for at least five minutes in each Service Test Mode (see “Operating the Service Test Mode” on page 121). Record the pressures, temperatures, and suction line conditions in a copy of the table.

   NOTE: It is important to have this information recorded when diagnosing the system.

10. Refer to the flow charts on pages 64 through 76 and the “Component Failure Symptoms Table” on page 163 to diagnose any remaining condition alarm codes.

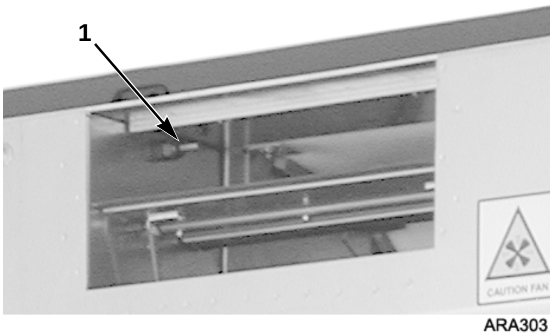
Table of Information Recorded in Service Test Modes

Mode	Pressures			Temperatures						Suction Line Conditions (Frosty, Warm)	
	Main Suction	Economizer Suction	Discharge	RETA	DISA	TPDF	COIL	AMBT	CTMP	Main Suction	Economizer Suction
HS.C											
LS.C											
LSC.P											
LSC.U											
RNU.L											
LS.H											
HS.H											

Initial Component and System Checks

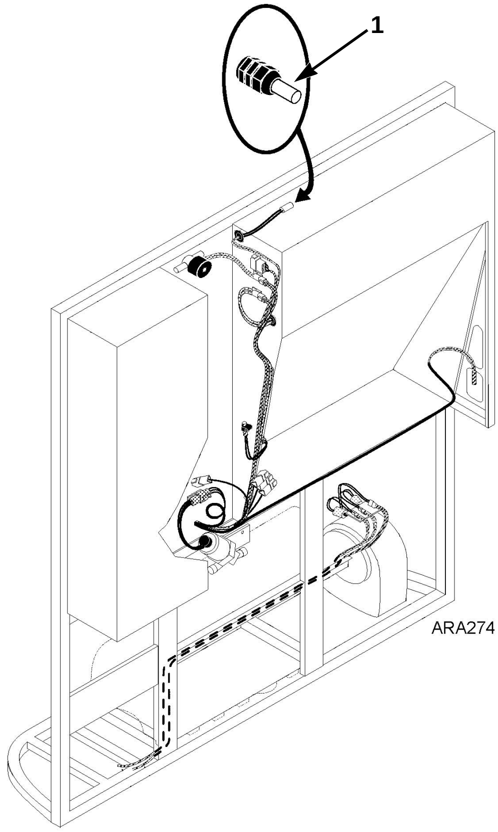
1. Install a calibrated gauge manifold on the compressor. See “STP01 Gauge Installation” on page 78.
2. Check the accuracy of the pressure transducer readings. Inaccurate transducer readings cause problems. Press the **GAUGES** key to display the suction pressure [SUC.P] and the discharge pressure [DIS.P]. Compare these readings with those on the gauge manifold.
   - The suction pressure transducer reading should within 7 psig (48 kPa) of the low side gauge reading.
   - The discharge pressure transducer reading should within 17.5 psig (121 kPa) of the high side gauge reading.
   - The the suction and discharge pressure transducer readings should be within 5 psig (34 kPa) when the suction and discharge pressures have been equalized.

   See “STP20 Checking Pressure Transducers” on page 102 for more information.
3. Check the position of the Discharge Air Sensor. The discharge sensor should protrude a minimum of 1.0 in. (25.4 mm) from its clamp (see “SI03 Discharge Air Sensor Position” on page 143). An incorrectly positioned Discharge Air Sensor can cause an incorrect Temperature Differential reading (see “SI01 Temperature Differential” on page 141). An incorrect Temperature Differential reading will cause operational problems.



1.	Discharge Air Sensor

Figure 1: Discharge Air Sensor Location



1.	Protrudes a Minimum of 1.0 in. (25.4 mm)

Figure 2: Discharge Air Sensor Position

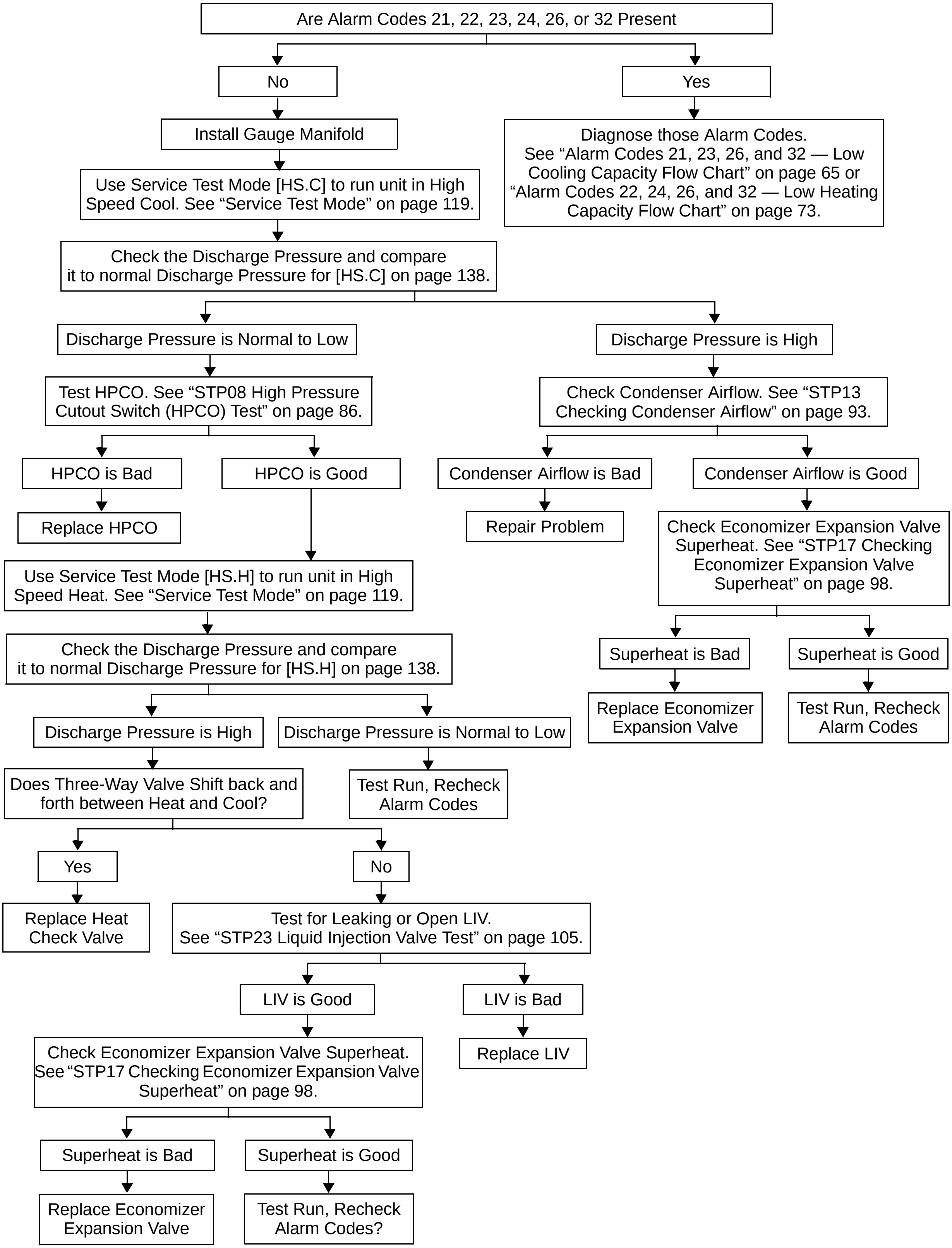
4. Run a pretrip. See “Pretrip Test Sequence” on page 55.

CAUTION: Monitor the return air temperature when performing a Pretrip Test on a loaded trailer. The controller may not maintain setpoint during the Pretrip Test.

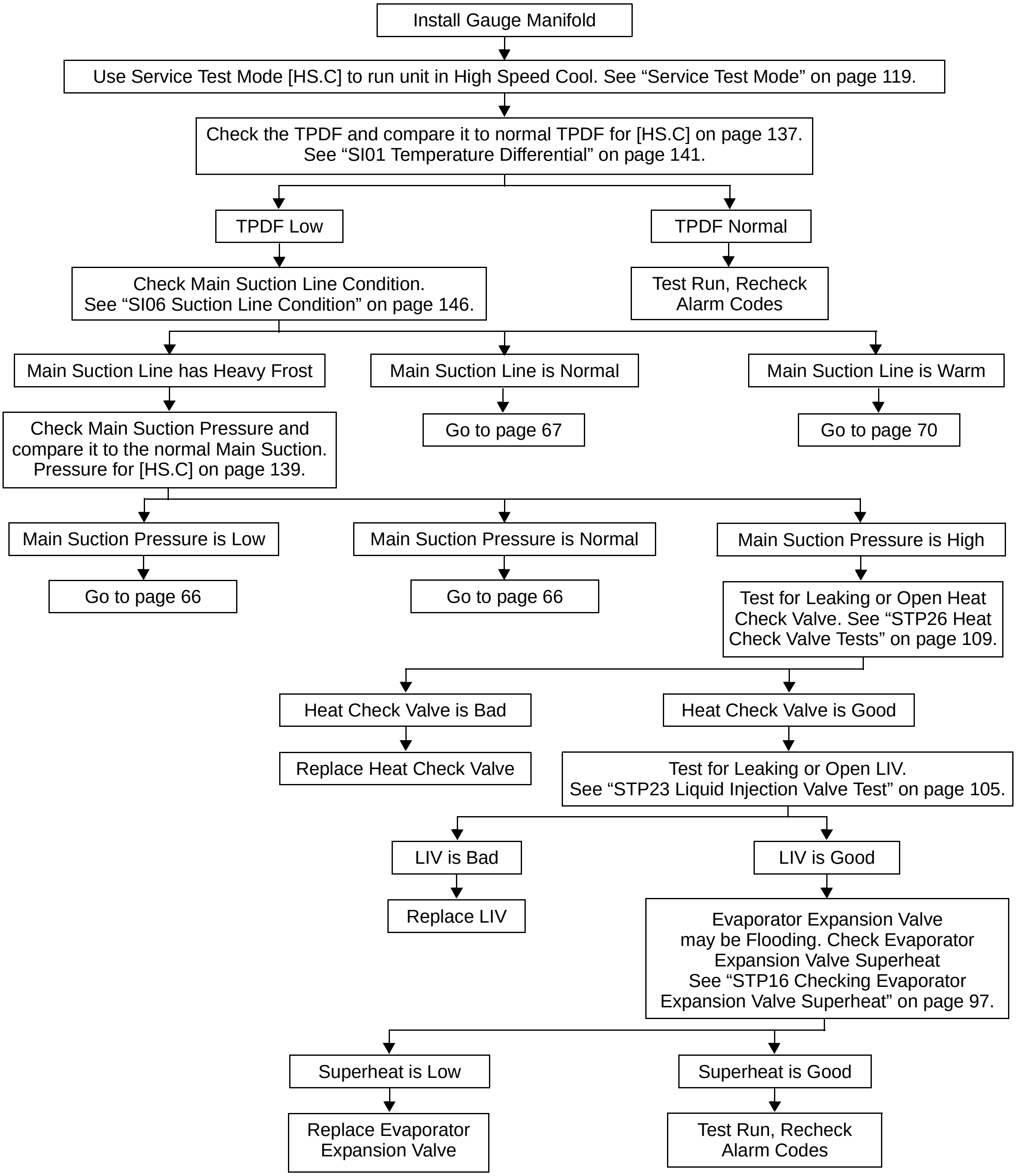
5. Check the refrigerant level. See “STP02 Checking Refrigerant Charge” on page 79.
6. Check compressor oil level. See “STP03 Checking Compressor Oil” on page 81.

   NOTE: Too much oil in the compressor can cause low refrigeration capacity (Alarm Codes 21, 23, 26, and 32).

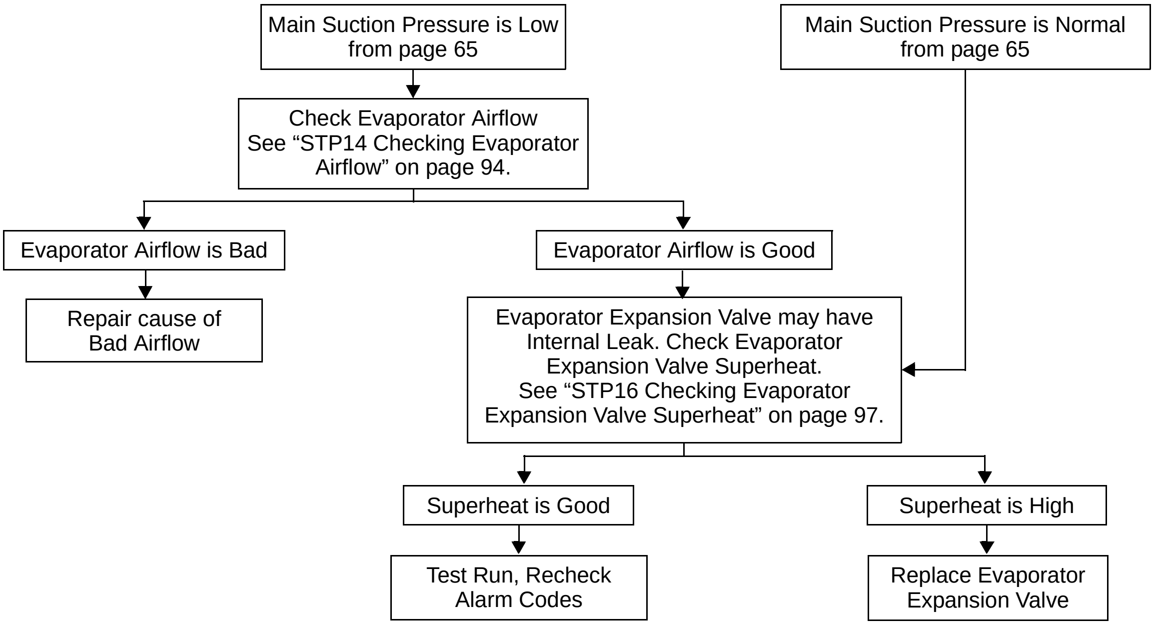
Alarm Code 10 — High Discharge Pressure Flow Chart



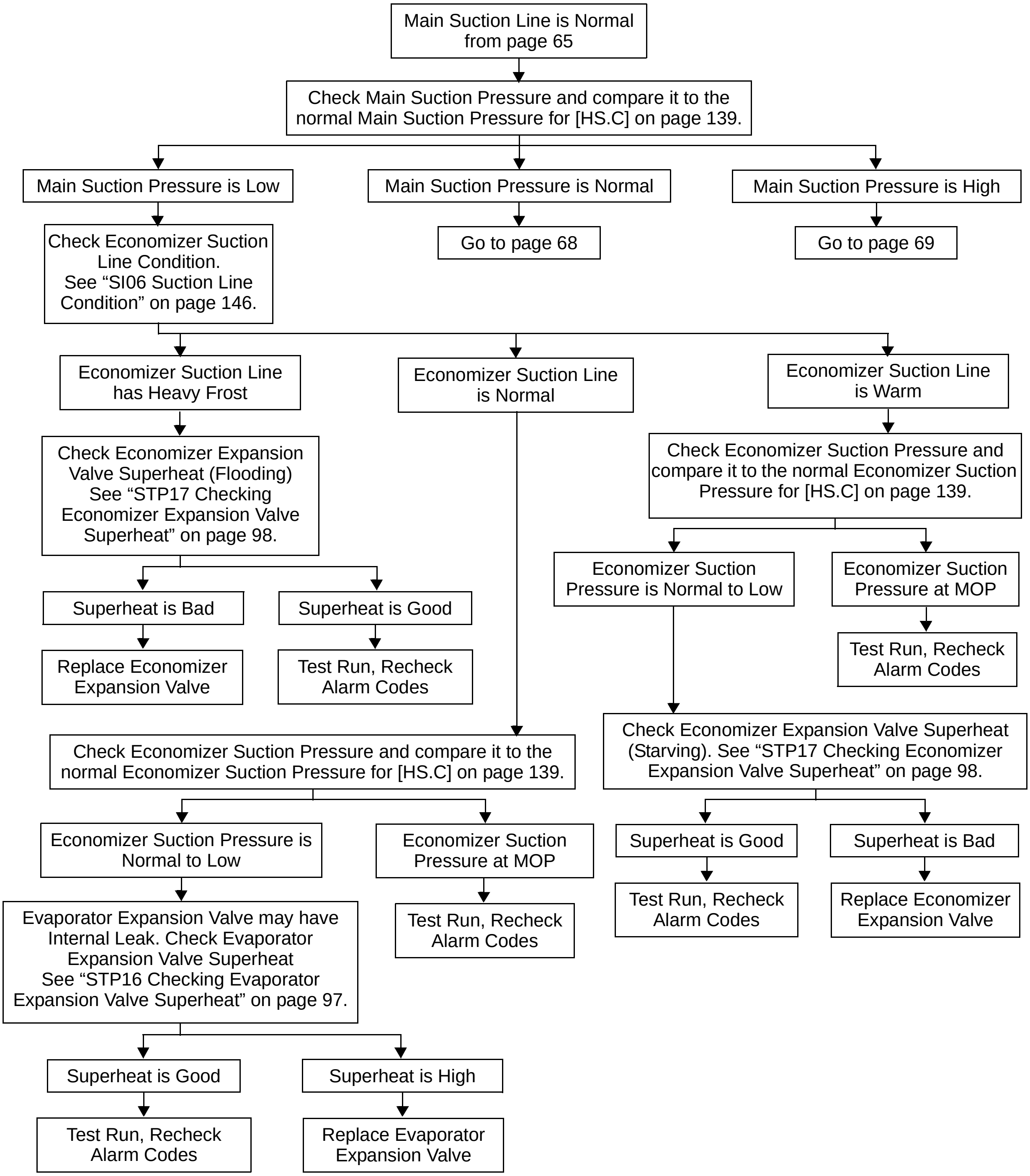
Alarm Codes 21, 23, 26, and 32 — Low Cooling Capacity Flow Chart



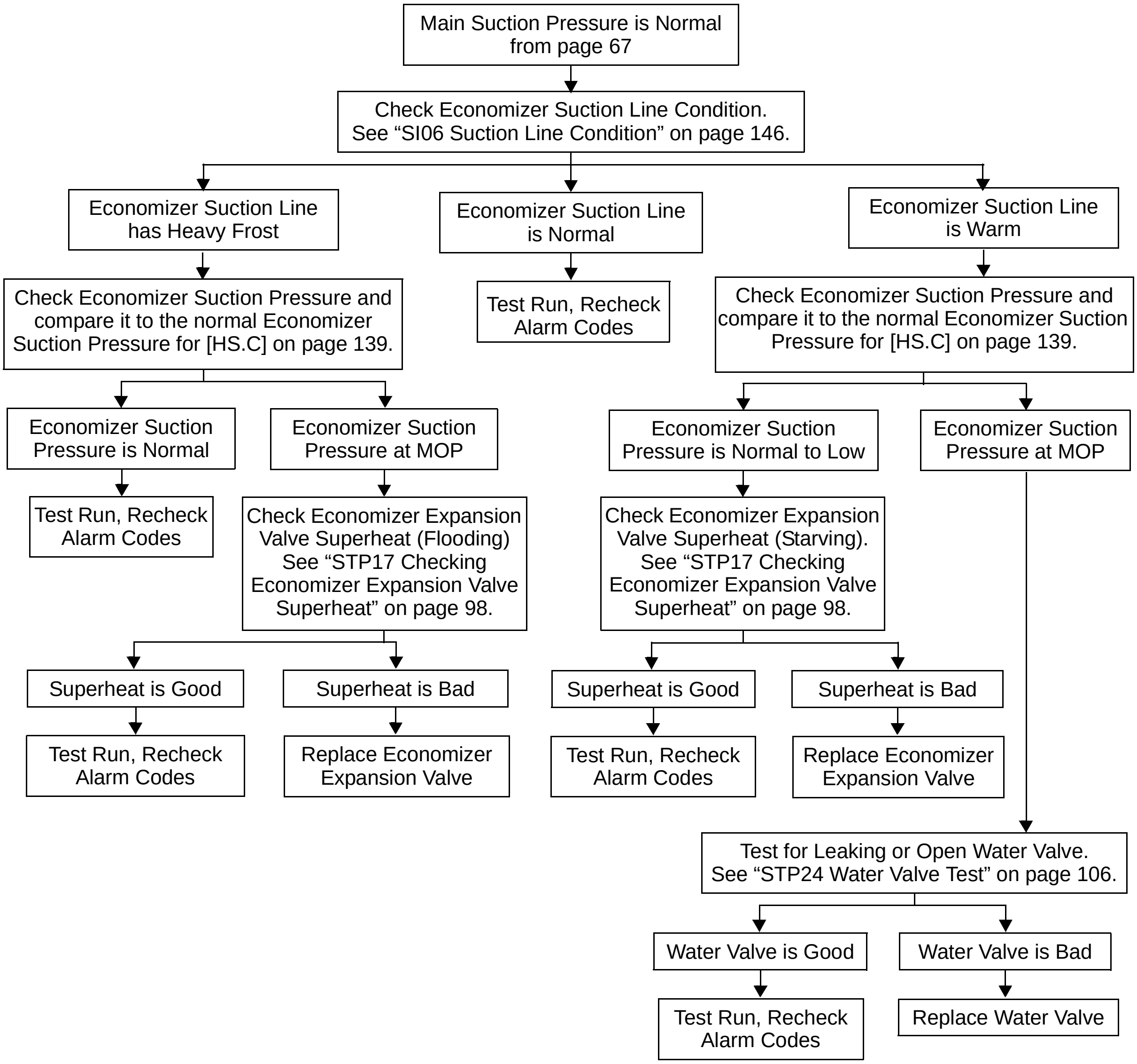
Alarm Codes 21, 23, 26, and 32 — Low Cooling Capacity Flow Chart (continued)



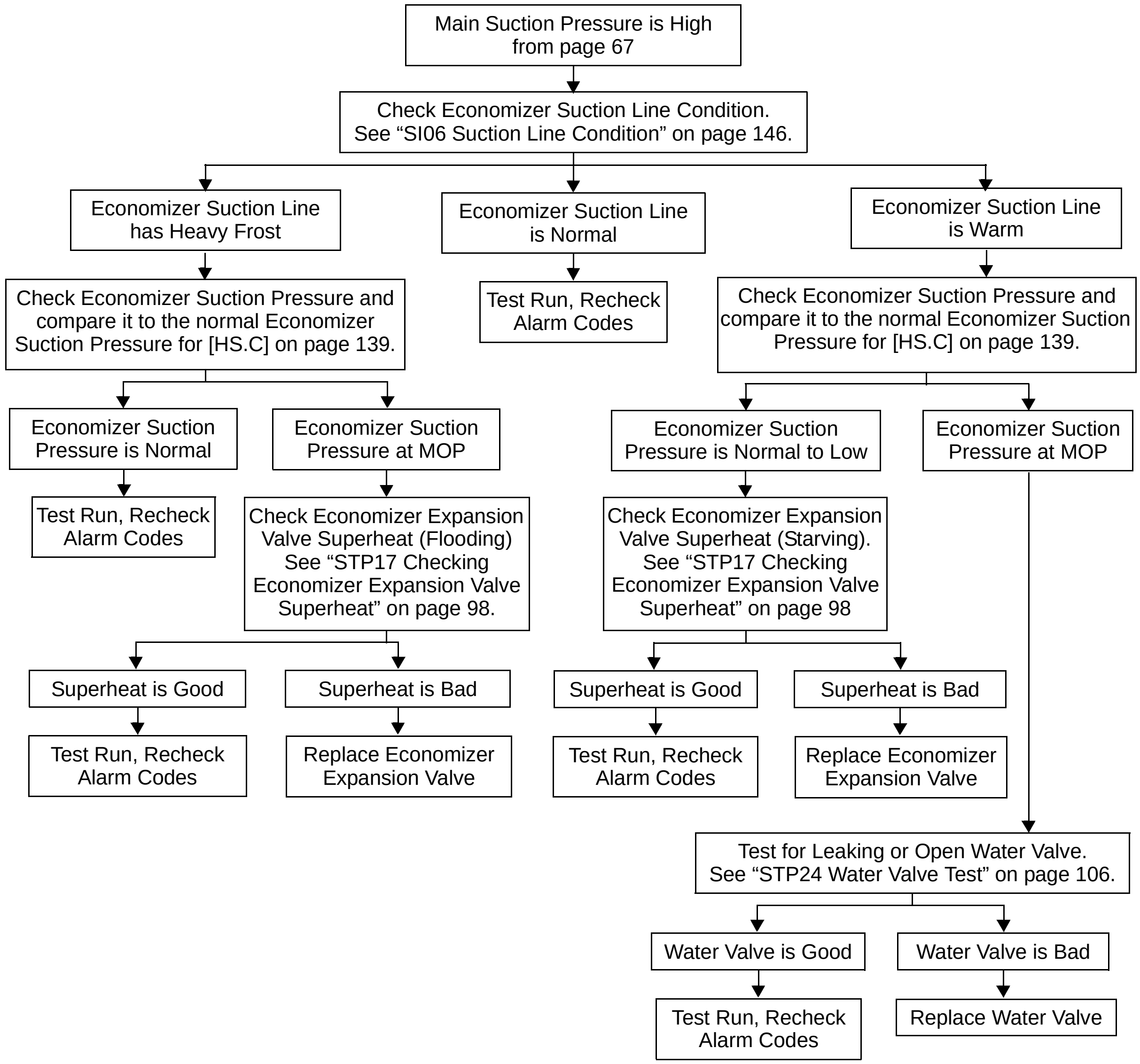
Alarm Codes 21, 23, 26, and 32 — Low Cooling Capacity Flow Chart (continued)



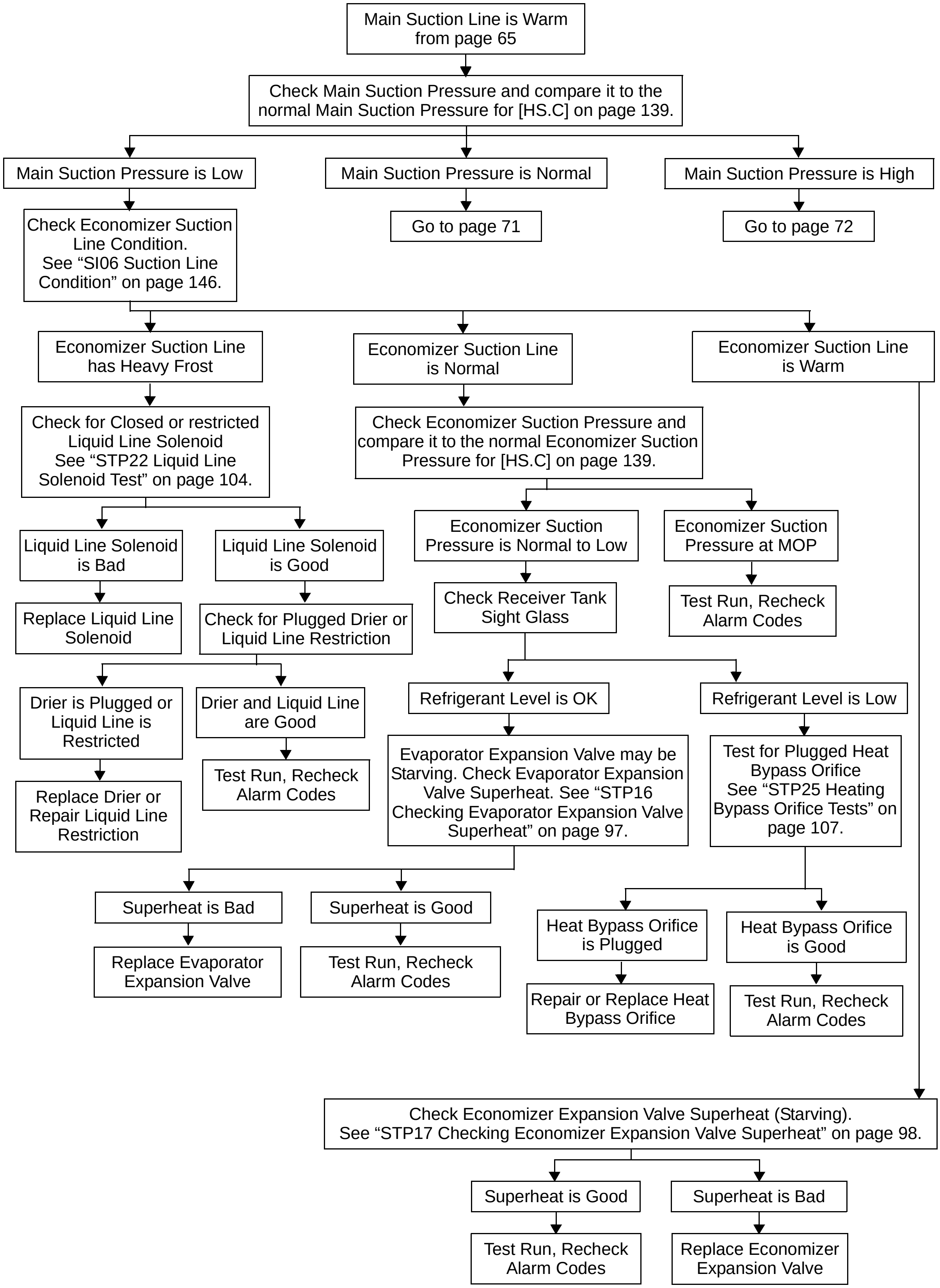
Alarm Codes 21, 23, 26, and 32 — Low Cooling Capacity Flow Chart (continued)



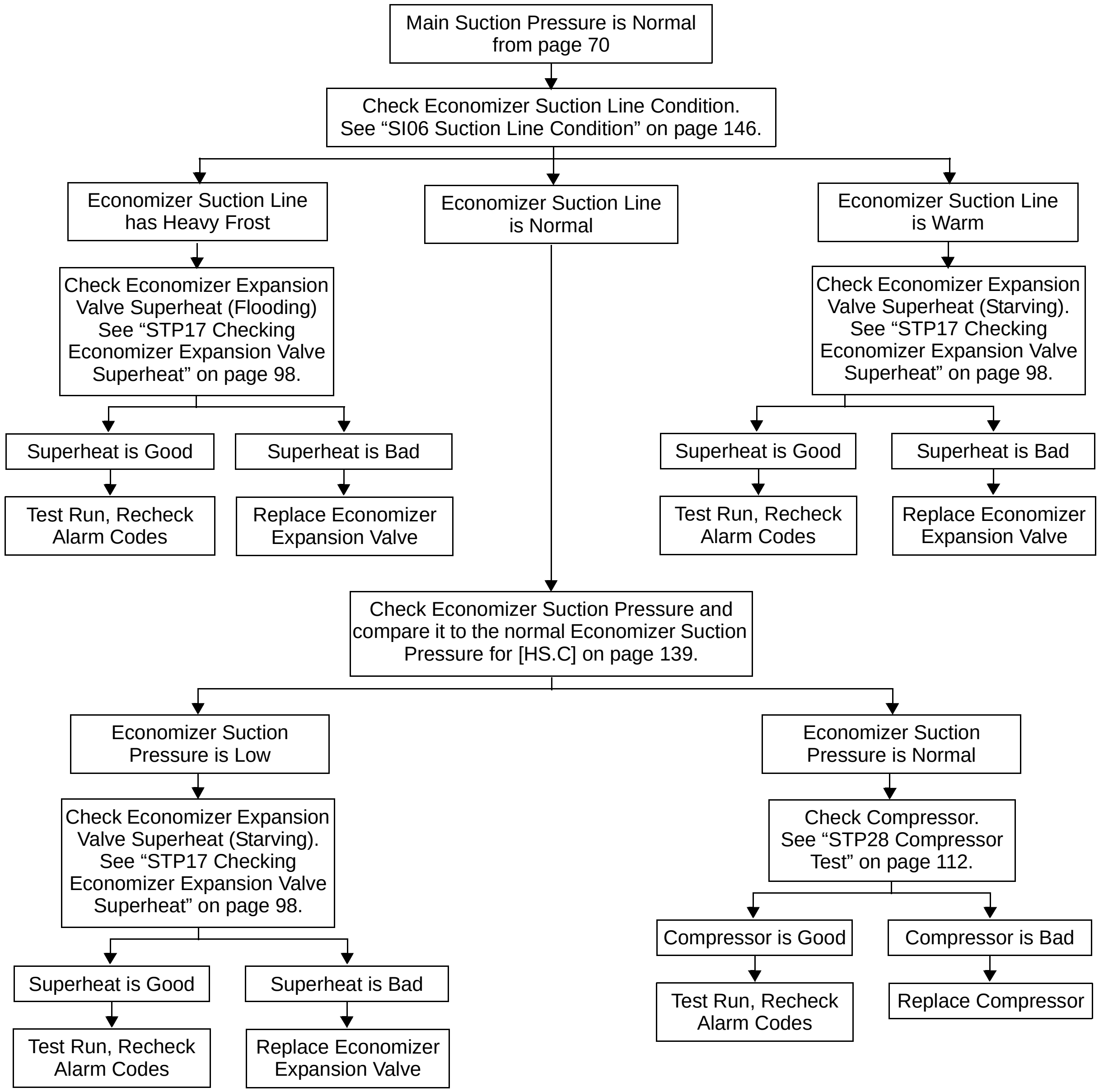
Alarm Codes 21, 23, 26, and 32 — Low Cooling Capacity Flow Chart (continued)



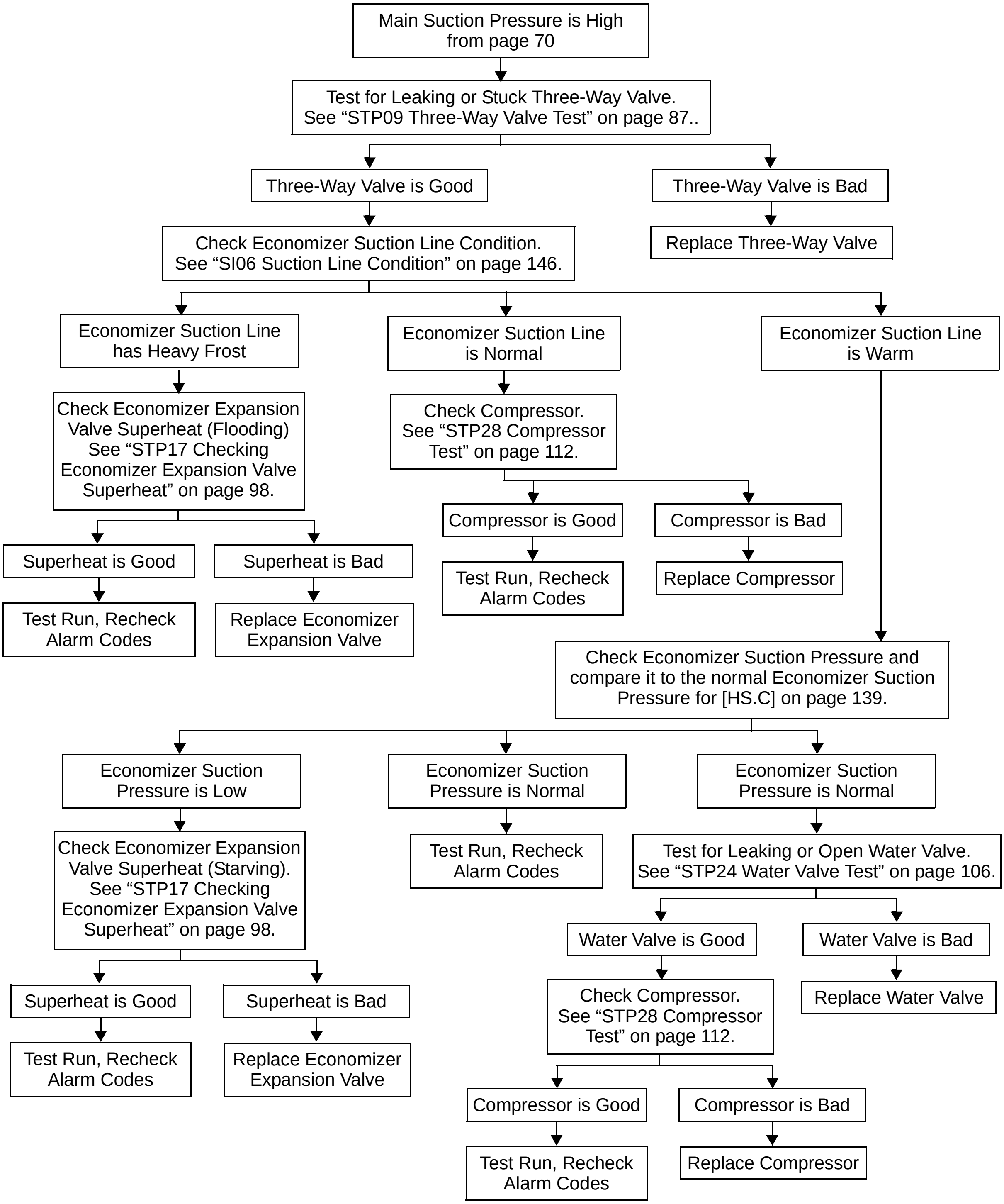
Alarm Codes 21, 23, 26, and 32 — Low Cooling Capacity Flow Chart (continued)



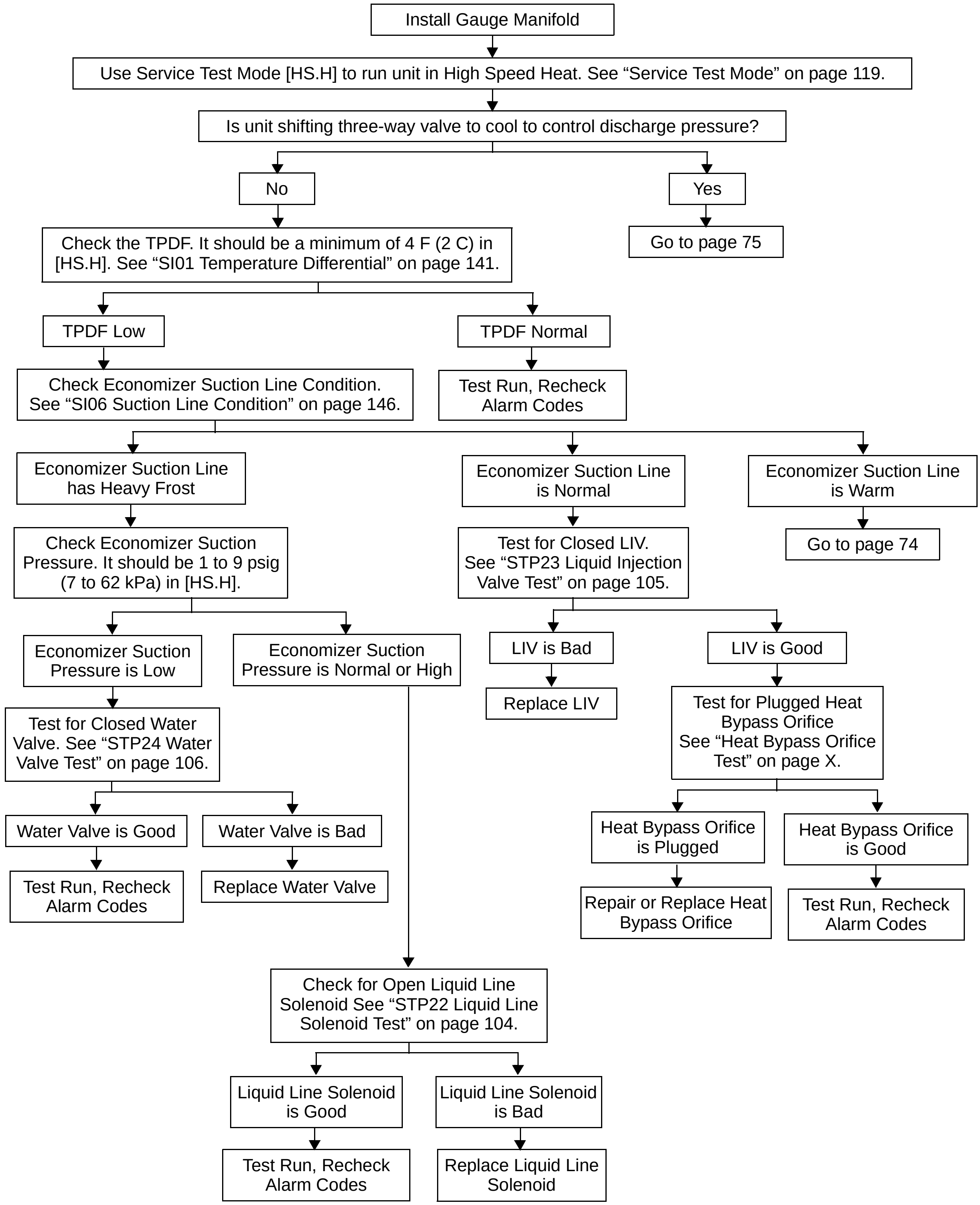
Alarm Codes 21, 23, 26, and 32 — Low Cooling Capacity Flow Chart (continued)



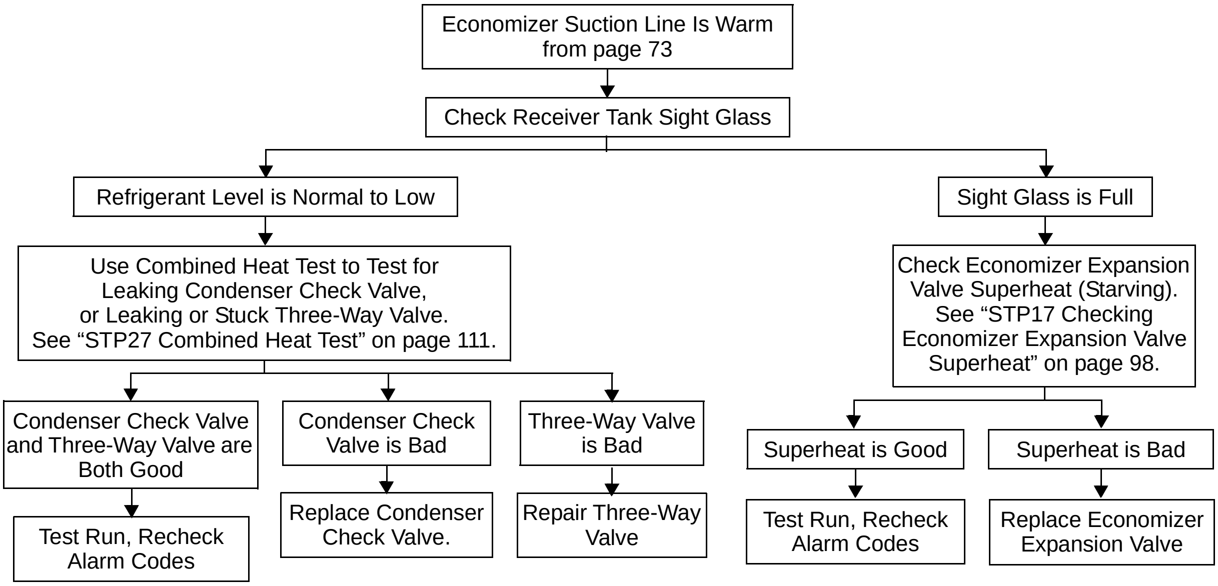
Alarm Codes 21, 23, 26, and 32 — Low Cooling Capacity Flow Chart (continued)



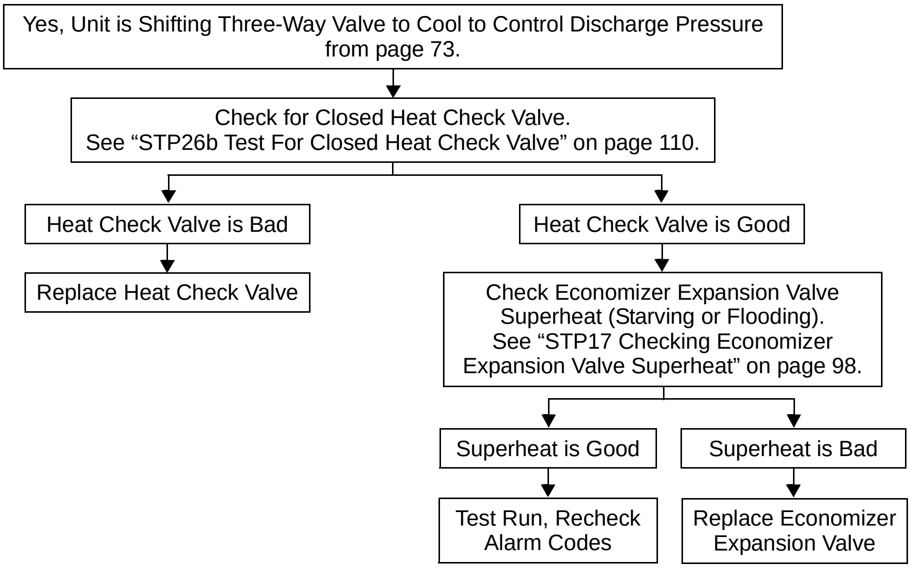
Alarm Codes 22, 24, 26, and 32 — Low Heating Capacity Flow Chart



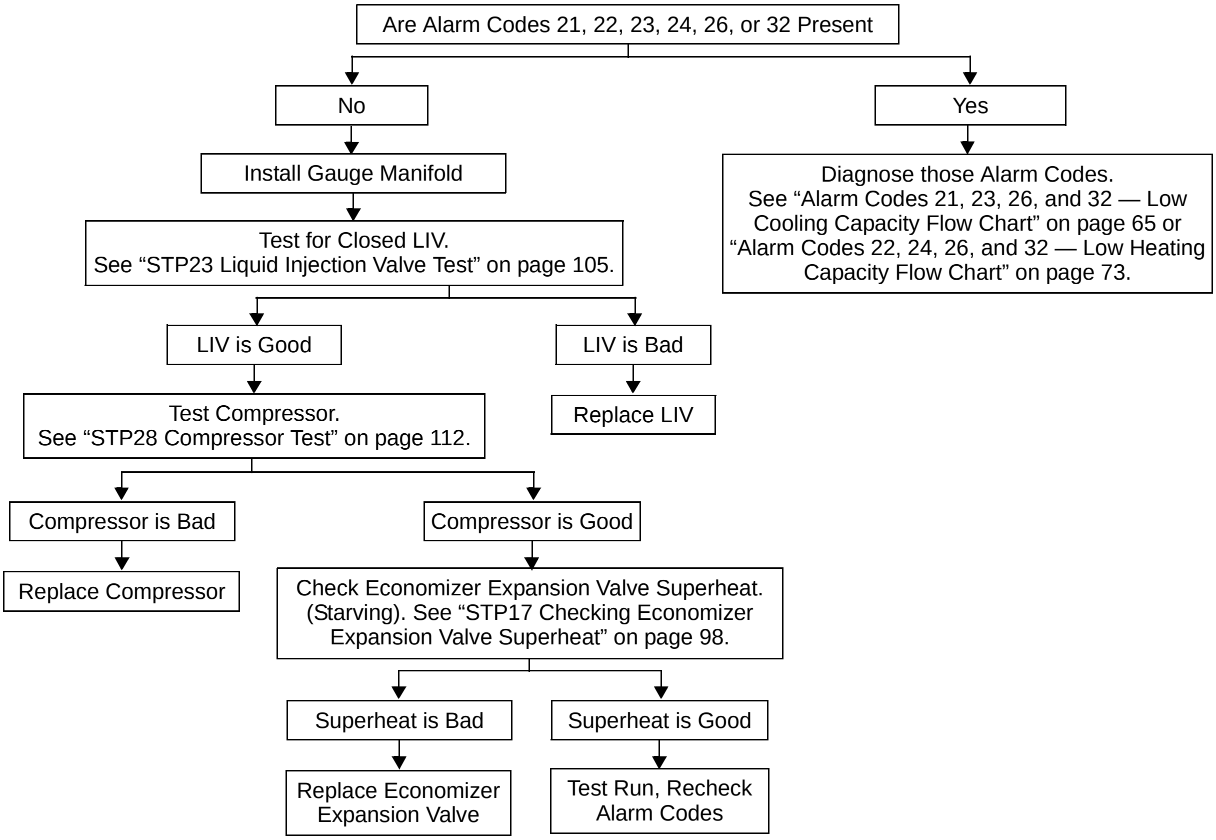
Alarm Codes 22, 24, 26, and 32 — Low Heating Capacity Flow Chart (continued)



Alarm Codes 22, 24, 26, and 32 — Low Heating Capacity Flow Chart (continued)



Alarm Codes 81 and 82 — High Compressor Temperature Flow Chart



Alarm Codes

Alarm Code Overview

This chapter is a troubleshooting aid. It will isolate a problem via Alarm Codes or other symptoms and refer the technician to the appropriate actions and Service Procedures necessary to complete the repair.

The µP-VI microprocessor has been designed to continuously self check its operation. If a problem is found, it will be detected and stored as an Alarm Code. Alarm Codes and the Pretrip Test are the basic troubleshooting tools.

For example, assume a Pretrip Test reports an alarm. The technician reads the alarm code directly from the microprocessor. He or she then looks up the alarm code in this section of the manual. This section will refer the technician to the appropriate actions and Service Procedure(s) required to quickly isolate and correct the problem.

Service Procedures “Green Book”

This chapter has references to Service Procedures in Section 6 of the THERMOGUARD µP-VI Microprocessor for Screw Compressor Applications Diagnostic Manual (TK 51329), which is also called the “Green Book.” These Service Procedures are necessary to successfully accomplish many tasks. They must be followed exactly, for in many cases failure to do so will result in an incomplete or improper repair. They are referenced by Procedure Number (such as A01A or D03A) rather than section and page number to facilitate future updates and additions.

Service Test Procedures—This Manual

This chapter has references to Service Test Procedures in this manual. They are referenced by number, title, and page number (such as “STP01 Gauge Installation” on page 78).

µP-VI Microprocessor Cautions

The following requirements are not readily apparent, but must be followed when working on units equipped with µP-VI microprocessors.

- Never use testers consisting of a battery and a light bulb to test circuits on microprocessor based equipment. Damage to sensitive circuits will almost surely occur!
- Before connecting or disconnecting the battery, the unit On/Off switch must be turned Off.
- Any time a return air or discharge air sensor is changed, it must be calibrated as shown in Service Procedure A15A.
- Any time the Microprocessor is replaced, these Service Procedures must be used:

A02A	Recording Existing Microprocessor Setup
A03A	Microprocessor Removal and Replacement
A04A	Microprocessor Setup
A05A	Setting the Clock/Calendar

- Any time the relay board is replaced, Service Procedure B02A must be followed.
- Any time welding is to be done on the unit or trailer, Service Procedure A26A must be followed.

µP-VI Hardware and Software Revisions

Several revisions of the µP-VI microprocessor hardware and software may become available. Consult the Hardware and Software Table in Section 7 of the “Green Book” THERMOGUARD µP-VI Microprocessor for Screw Compressor Applications Diagnostic Manual (TK 51329) for details before interchanging hardware and software. This table will allow you to correctly identify the existing microprocessor and software and to determine which microprocessors and software revisions may be used as replacements.

Additional Considerations for μP-VI Microprocessors

ESD (Electro Static Discharge)

As with other similar electronic devices, the microprocessor is vulnerable to damage from Electro Static Discharge (ESD). This damage is not always immediately apparent. As a result of ESD, a circuit can be damaged but may continue to operate temporarily only to fail later.

A grounded wrist strap should always be used when handling a microprocessor that is not connected to the unit by its connectors. The microprocessor should always be stored and shipped in the anti-static bag and protective packaging. See Service Procedure A12A for additional information.

μP-VI Diagnostics

The balance of this section is devoted to diagnostic routines designed to help the technician quickly identify a problem and repair it. It is important that the required Service Procedures be followed exactly. Failure to do so may result in an incomplete repair.

The remainder of this section is divided into two tables. The first table suggests corrective actions as a result of alarm codes. The second table suggests corrective actions as a result of symptoms other than alarm codes.

Hints

The following hints will prove helpful when working on μP-VI microprocessors.

- Every effort should be made to perform a Pretrip Test on a unit suspected of having a defect. In almost all cases, the Pretrip Test will result in a alarm code that will lead you directly to the problem. Alarm Codes generated during a Pretrip Test will be preceded by a dash (-).
- If the unit is equipped with a data logger, download and review the most recent trips for additional information.
- Record all alarm codes in sequence for reference.
- Clear all alarms before testing a unit.
- Alarm Codes that can not be cleared normally may clear by first entering Super Guarded Access using Service Procedure A04A and then pressing the Code and Clear keys.
- Be certain all microprocessor connectors are fully seated and connector lock rings are completely locked.
- Be certain all relay board and harness connectors are securely in place.
- Use the Valve Position Displays feature to determine if the unit is operating in an auxiliary mode. See “Identifying Auxiliary Modes” on page 50.
- Be certain all programmable features are restored to the customers specifications before releasing the unit for service.

Alarm Types

Shutdown Alarms

Shutdown alarms will turn the unit off upon detection. With some shutdown alarm codes the unit may wait a timed interval (15 minutes) and then restart to see if the problem still exists. Shutdown alarms are indicated by a flashing alarm symbol and display. If the unit is waiting a timed interval to restart, Alarm Code 84 Restart Null will also be present. Shutdown alarms must be corrected and cleared as soon as possible. It may be possible to temporarily clear a shutdown alarm but the unit will shut down again when the alarm re-occurs.

Check Alarms

Check alarms are a notice to take corrective action before a problem becomes severe. They are indicated by a steady alarm symbol. The unit will run with check alarms but some features and functions may be inhibited. They may be cleared, but will re-occur until corrected.

Stored Alarms

Stored (log) alarms are indicated by a steady alarm symbol which appears on the screen for 30 seconds when the unit power switch is turned on. The alarm symbol will go off after 30 seconds.

These alarms indicate maintenance items which should be addressed as soon as practical. They may be cleared, but will re-occur until corrected. The unit will run with stored (log) alarms.

Alarm Codes Preceded by a Dash

Alarms detected during a pretrip check will be displayed with a dash (-) preceding the alarm code. Alarms detected during normal operation of the unit will not be preceded with a dash (-).

Clearing Alarm Codes from Super Guarded Access

Alarm Codes that can not be cleared normally may clear by first entering Super Guarded Access. See Service Procedure A04A for details.

Alarm Codes, Their Causes and Corrective Actions

<table>
<tr><th>Code</th><th>Name</th><th>Wire</th><th>Operation and Diagnostics</th></tr>
<tr><td>00</td><td>No Alarms exist</td><td>-</td><td>None</td></tr>
<tr><td>01</td><td>Microprocessor Power up</td><td>-</td><td>Not used - data logging purposes only.</td></tr>
<tr><td colspan="4">Sensor Alarms are Check Alarms unless multiple alarms are present.
NOTE: If these alarms are generated during a Full Pretrip Test, they will be preceded by a dash (-).</td></tr>
<tr><td>02

03

04

05

06</td>
<td>Evaporator Coil Sensor

Return Air Sensor
NOTE: This alarm can only be cleared from the Super Guarded Access menu.

Discharge Air Sensor
NOTE: This alarm can only be cleared from the Super Guarded Access menu.

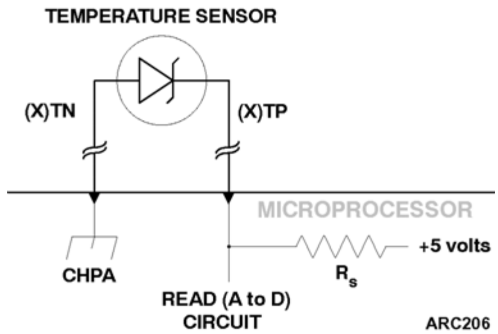
Ambient Air Sensor

Engine Coolant Temp Sensor
The unit will be forced into low speed operation for 2-10 minutes if the engine coolant temperature sensor fails. The time spent in low speed operation is based on the current ambient temperature.</td>
<td>CTP
CTN

RTP
RTN

DTP
DTN

ATP
ATN

WTP
WTN</td>
<td>Operation
The temperature sensor circuits utilize an electronic temperature sensor as shown in the diagram below. Each temperature sensor is an analog input to the microprocessor. The temperature sensors are polarity sensitive electronic devices and can not be checked with an ohmmeter.


In addition to constantly being monitored by the microprocessor, the Sensors are checked during the Full Pretrip Test.
See “Pretrip Test” on page 53 and Service Procedure A17A for additional information on the Full Pretrip Test.
Diagnostics
A defective sensor will usually display as [----]. The sensor or it’s associated circuit may be open, shorted internally or shorted to chassis ground. A direct short to chassis ground on a single sensor may cause multiple sensor codes to appear.
1. Disconnect the sensor and connect a new sensor. Display the sensor on the microprocessor display. If the temperature can now be displayed the original sensor was defective.
2. If the temperature is not displayed by the microprocessor unplug the sensor harness at the microprocessor and check for +5 vdc between (X)TP and (X)TN. If 5 volts is not present check the microprocessor using Service Procedure A01A.
3. If the microprocessor passes the test, use a Fluke meter set for ohms check for shorts to chassis ground on both the (X)TP and (X)TN wires of the suspect sensor. If a short exists examine the wiring harness for chaffed areas and repair as required.
4. If an intermittent problem exists monitor the voltage between (X)TP and (X)TN with the sensor harness connected. The voltage should be approximately 2-4 vdc. If the voltage suddenly increases the sensor is intermittently open. If the voltage suddenly decreases look for an intermittent short or open in the wiring between the microprocessor and the sensor.
See Service Procedures A15A, D01A, D02A, and H01A for additional information.</td></tr>
</table>

<table>
<tr><th>Code</th><th>Name</th><th>Wire</th><th>Operation and Diagnostics</th></tr>
<tr><td>07</td><td>RPM Sensor

This is a Check Alarm</td><td>FS1

FS2</td><td>Operation
The flywheel sensor is a proximity sensor that generates a pulse as each flywheel tooth passes the sensor. The microprocessor counts these pulses and performs the math necessary to convert the pulses into engine rpm. The flywheel sensor FS1 circuit is a digital input to the microprocessor. FS2 is a device ground. The sensor is not polarity sensitive.

NOTE: Unlike earlier flywheel sensor applications the microprocessor can read very small pulses. Adjusting sensor position by checking the voltage at the flywheel sensor is not necessary. It is only necessary to confirm that at least 1.0 vac is present.

Diagnostics
A defective flywheel sensor will usually display as [----]. The sensor or it’s associated circuit may be open, shorted internally or shorted to chassis ground.

1. Disconnect the sensor wires and check the ac voltage at the sensor with the engine running. If a small ac voltage (greater than 1.0 vac) is not present check the sensor adjustment. Shut the unit off and turn the sensor in until it contacts the flywheel. Back the sensor out ½ turn and tighten the lock nut. Recheck the sensor voltage. If voltage is still not present the sensor is defective and must be replaced.

2. If ac voltage is present, disconnect the flywheel harness at the microprocessor and disconnect the flywheel sensor. Using a Fluke meter set for ohms check for shorts to chassis ground on the FS1 wire. If a short exists examine the wiring harness for chaffed areas and repair as required.

3. If no shorts to chassis ground exist connect the FS1 wire to the FS2 wire. Check continuity from FS1 to FS2 at the microprocessor connector. The circuit should measure less than 1 ohm. If the circuit is open, check the harness using the wiring diagram for the unit.</td></tr>
<tr><td>09</td><td>High Evap Temp

This alarm is a Shutdown Alarm. It may be associated with Alarm Code 84 Restart Null. See Alarm Code 84 for details</td><td>CTP

CTN</td><td>Operation
If the evaporator coil temperature sensor analog input remains above approximately 150 F (66 C) for 10 minutes this alarm code is generated.

Diagnostics
Check refrigeration operation, especially in heat and defrost. Check sensor operation as shown in Alarm Code 02.</td></tr>
</table>

<table>
<tr><th>Code</th><th>Name</th><th>Wire</th><th>Operation and Diagnostics</th></tr>
<tr><td>10</td><td>High Discharge Pressure
This is either a Check or Shutdown Alarm. It may be associated with Alarm Code 84 Restart Null. See Alarm Code 84 for details.
The unit will be forced into low speed operation for 30 minutes after a successful Restart Null.
If the unit is switched Off and then back On while in the prevent shutdown state, the Alarm Code becomes a Shutdown Alarm, and the unit will not attempt to restart.</td><td>7K
7EHA
8D</td><td>Operation
This alarm is generated when refrigerant high discharge pressure causes the normally closed high pressure cutout switch (HPCO) to open.
This alarm code will be generated if voltage is present along the 7K wire (digital input signifying Run Relay is energized) and the digital input to the microprocessor is interrupted by the HPCO opening. The digital input from the HPCO travels along the 8D wire which feeds the 7EHA wire of the microprocessor.
The unit will attempt to restart once the HPCO closes, and the restart timer elapses.
Diagnostics
The alarm normally indicates that the high pressure cutout is open. If this is not the case and alarm still exists an open circuit may exist in the 8D or 7EHA circuits to the microprocessor.
1. Check refrigeration system for high discharge pressure and correct as required. See “System Diagnosis” on page 60 and “Alarm Code 10 — High Discharge Pressure Flow Chart” on page 64.
2. If the refrigeration system pressures are normal, check the 8D or 7EHA circuits using Service Procedure H04A and the wiring diagram for the unit.</td></tr>
<tr><td>11</td><td>Unit Controlling on Alternate Sensor
This is a Check Alarm.
Alarm Code 11 will appear along with Alarm Code 03 or 04.</td><td>RTP
RTN
DTP
DTN</td><td>Operation
The µP-VI can be programmed to use discharge air control in modulation. Should the discharge sensor fail the unit will control on the return air sensor. Therefore, this alarm code has been modified to indicate that the primary control sensor (either return or discharge depending on unit settings) has failed and the unit is controlling on the alternate sensor. If the unit is operating with return air sensor control and the return air sensor fails, the unit will control using the discharge air sensor. If the unit is operating with discharge air sensor control and the discharge air sensor fails, the unit will control using the return air sensor.
Diagnostics
Check sensor operation as shown in Alarm Code 03 or 04.</td></tr>
</table>

Code	Name	Wire	Operation and Diagnostics
12	**Sensor Shutdown** This can be a Check Alarm or a Shutdown Alarm. Alarm Code 12 will appear along with Alarm Code 02, 03 and/or 04.	**RTP** **RTN** **DTP** **DTN** **CTP** **CTN**	**Operation** This alarm indicates a critical problem exists with a combination of the return air temperature sensor analog input, discharge air temperature sensor analog input, coil temperature sensor analog input or the associated wiring. If the return air temperature sensor and the discharge air temperature sensor fail with fresh range setpoints, this is a shutdown alarm after the condition has been present for 2 minutes. If the return air temperature sensor and the discharge air temperature sensor fail with frozen range setpoints, this is a check alarm and the unit will continue to run in low speed cool. If the return air temperature sensor, the discharge air temperature sensor, and the coil temperature sensor fail with frozen range setpoints, this is a shutdown alarm after the condition has been present for 2 minutes. **Diagnostics** Check sensor operation as shown in Alarm Code 02, 03, and/or 04. ***NOTE: In rare instances a Alarm Code 12 can be caused by a rapidly fluctuating signal from one of the following digital inputs:*** ***Coolant Level Sensor*** ***Oil Level Switch*** ***Fuel Pressure Switch*** ***Fuel Level Switch*** ***High Pressure Cut In Switch*** ***High Pressure Cutout Switch*** ***Door Switch*** ***Sleep Switch*** ***Low Oil Pressure Switch***
13	**Check Sensor Calibration** This is a Check Alarm.	**RTP** **RTN** **DTP** **DTN** **CTP** **CTN**	**Operation** This alarm indicates the return air temperature sensor, discharge air temperature sensor and coil temperature sensor are not reading within 30 F (17 C) of each other 20 minutes after a defrost cycle is completed. **Diagnostics** 1. Compare the return air, discharge air and coil sensors to determine which sensor is exhibiting an improper or illogical reading. If necessary, use an ice bath to identify the inaccurate sensor. 2. Check sensor operation as shown in Alarm Code 02, 03, and/or 04. 3. Download and review Data Logger report. ***NOTE: Alarm Code 13 also may be caused by the evaporator coil rapidly frosting after a defrost cycle. This can be caused by warm/moist loads or by running the unit with the trailer doors open.***

Code	Name	Wire	Operation and Diagnostics
15	**Glow Plug Check** This is a Check Alarm. ***NOTE: This Alarm Code should not appear on units configured with a TK 486 Yanmar engine (SB-400).***	**PRP** **H**	**Operation - TK486 (Yanmar) Engines** The intake air heater is energized when the PRP output supplies a ground to the preheat relay. When the preheat relay is energized 2AB power is supplied to the intake air heater relay via the H circuit. When the intake air heater relay is energized 2 power is supplied to the intake air heater. ***NOTE: The current drawn by the intake air heater on Yanmar engines is not measured by the ammeter since the amount of current drawn by the heater is quite large (about 80 amperes).*** If Alarm Code 15 occurs on applications with TK 486 (Yanmar) engines check to be sure the unit engine type is configured properly. **Operation - se 2.2 (Isuzu) Engines** The glow plugs are energized when the PRP output supplies a ground to the preheat relay. When the preheat relay is energized 2AB power is supplied to the glow plugs via the H circuit. This alarm code indicates that a glow plugs may be drawing too much or too little current. The glow plug current is checked during Pretrip Tests and whenever the engine is started automatically by the microprocessor. **Diagnostics - se 2.2 Engines** 1. Check the operation of the preheat circuit using Relay Board Test mode. Be sure the Preheat Relay fuse F8 is not blown. 2. If the unit is equipped with glow plugs, check the current draw on the glow plugs with the microprocessor [AMPS] function while pre-heating. 3. Check the voltage at the glow plugs. If the voltage is low check the glow plug circuit for excessive resistance (burned preheat relay contacts, loose or corroded connections). 4. Check the glow plugs for continuity to be sure no plugs are open. 5. Check battery volts when the glow plugs are energized. The voltage should be above 11.2 volts when the unit is not running.

Code	Name	Wire	Operation and Diagnostics
17	**Engine Failed to Crank** This is a Shutdown Alarm. This alarm code may be associated with Alarm Code 84 Restart Null. See Alarm Code 84 for details.	**SRP** **8S**	**Operation** The starter is energized when the SRP output supplies a ground to the starter relay. When the starter relay is energized 2AB power is supplied to the starter solenoid via the 8S circuit. This alarm code indicates that an automatic engine start was attempted but the engine did not crank. This alarm is generated while cranking if the engine speed does not exceed 50 rpm, the engine oil pressure does not rise, and the alternator does not show a positive output. **Diagnostics** 1. Check the operation of the starting circuit using Relay Board Test mode. Be sure the STARTER LED lights. 2. Check the engine starting circuits by removing the battery cable from the starter. Attempt a restart and measure the voltage at the 8S terminal on the starter. If the voltage is less than about 6.5 volts check the 8S and 2 circuits for excessive resistance (burned starter relay contacts, loose or corroded connections). 3. Check the battery cables at both ends for tightness and corrosion. 4. Reattach the battery cable to the starter and check for proper operation.
18	**High Engine Coolant Temperature** This is a Shutdown Alarm. This alarm code may be associated with Alarm Code 41 Engine Coolant Temp Check, Alarm Code 42 Unit Forced to Low Speed, Alarm Code 43 Unit Forced to Low Speed Modulation and Alarm Code 84 Restart Null. See Alarm Code 41, 42, 43 and 84 for additional information.	**WTP** **WTN**	**Operation** This alarm indicates that the engine coolant temperature is excessively high as determined by the coolant temperature sensor input. This alarm occurs if the coolant temperature exceeds 220 F (104 C) and stays above 218 F (103 C) for 25 seconds. The unit will attempt 2 restarts. **Diagnostics** 1. Check the engine coolant temperature by pressing the Gauge key. If above 218 F (103 C) check the engine cooling system to determine the cause of overheating. ***Caution: Do not open radiator when hot.*** 2. Check the engine coolant level. 3. Check the radiator for dirt or restrictions. 4. Check sensor operation as shown in Alarm Code 06.

Code	Name	Wire	Operation and Diagnostics
19	**Low Engine Oil Pressure** This is a Shutdown Alarm.	**20B**	**Operation** This alarm indicates that the engine oil pressure is low as determined by the low oil pressure switch (LOPS). The 20B circuit is a digital input to the microprocessor. If low oil pressure is sensed, the switch will ground the 20B circuit. **Diagnostics** 1. Install an oil pressure test gauge. Start the engine and check the engine oil pressure. 2. Make sure the LOPS is open when the engine is running and closed when the engine is not running. 3. Check the voltage on the 20B circuit. When the engine is running battery voltage should be present. If no voltage is present remove the 20B wire from the oil pressure switch. If battery voltage is present on the 20B wire, the switch is defective. If no voltage is present on the 20B wire when it is disconnected check the 20B circuit for an open circuit or a direct short to chassis ground using Service Procedure H04A and the wiring diagram for the unit.
20	**Engine Failed to Start** This is a Shutdown Alarm. This alarm code may be associated with Alarm Code 84 Restart Null. See Alarm Code 84 for details	**-**	**Operation** This alarm indicates that an engine start was attempted and the engine cranked but did not start. This alarm is generated if the engine speed does not exceed 800 rpm as measured by the rpm sensor digital input and engine oil pressure does not exist. **Diagnostics** 1. Check fuel system for adequate fuel level. 2. Check the fuel solenoid for proper operation by energizing the run relay using Relay Board Test mode. 3. In cold ambient temperatures check the fuel system for gelled fuel. 4. Check for air in the fuel system. 5. Check for restricted air cleaner or air intake system. 6. Check transfer pump operation. 7. Check the intake air heaters on Yanmar engines to be certain they are operating properly.

Code	Name	Wire	Operation and Diagnostics
21	**Cooling Cycle Check** This is a Check Alarm. This alarm code may be associated with Alarm Code 84 Restart Null. See Alarm Code 84 for details ***NOTE: If this alarm is generated during a Pretrip Test, it will be preceded by a dash (-).***	-	**Operation** The unit monitors the reading of the temperature sensors over time. After a period of time the temperature sensor readings indicate that the unit is not cooling properly or may be heating. If an alarm code 21 is generated, the unit will temporarily shutdown. Auto restart will occur after 15 minutes. This alarm code may also be generated during the Cooling Capacity portion of the Pretrip Test. See “Pretrip Test” on page 53 and Service Procedure A17A for additional information on the Full Pretrip Test. See Service Procedure A18A for additional information on the Engine Running Pretrip Test. **Diagnostics** 1. Check temperature differential by displaying the temperature differential [TPDF] or by checking the difference between the return and discharge temperature sensors. A positive temperature differential indicates the unit is heating rather than cooling. 2. Install gauges and check refrigeration system for proper operation. See “System Diagnosis” on page 60 and “Alarm Codes 21, 23, 26, and 32 — Low Cooling Capacity Flow Chart” on page 65.
22	**Heating Cycle Check** This is a Check Alarm. This alarm code may be associated with Alarm Code 84 Restart Null. See Alarm Code 84 for details	-	**Operation** The unit monitors the reading of the temperature sensors over time. After a period of time the temperature sensor readings indicate that the unit is not heating properly or may be cooling. If an alarm code 22 is generated, and the setpoint is in the fresh range, the unit will temporarily shutdown. Auto restart will occur after 15 minutes. **Diagnostics** 1. Check temperature differential by displaying the temperature differential [TPDF] or by checking the difference between the return and discharge temperature sensors. A negative temperature differential indicates the unit is cooling rather than heating. 2. Install gauges and check refrigeration system for proper operation. See “System Diagnosis” on page 60 and “Alarm Codes 22, 24, 26, and 32 — Low Heating Capacity Flow Chart” on page 73.
23	**Cooling Cycle Fault** This alarm is a Shutdown Alarm	-	**Operation** The unit monitors the reading of the temperature sensors over time. After a period of time the temperature sensor readings indicate that the unit is heating when it should be cooling. Alarm code 23 is generated when the problem that caused alarm code 21 was not corrected after the 15 minute shutdown. **Diagnostics** 1. Check temperature differential by displaying the temperature differential [TPDF] or by checking the difference between the return and discharge temperature sensors. A positive temperature differential indicates the unit is heating rather than cooling. 2. Install gauges and check refrigeration system for proper operation. See “System Diagnosis” on page 60 and “Alarm Codes 21, 23, 26, and 32 — Low Cooling Capacity Flow Chart” on page 65

<table>
<tr><th>Code</th><th>Name</th><th>Wire</th><th>Operation and Diagnostics</th></tr>
<tr><td>24</td><td>Heating Cycle Fault

This is a Shutdown Alarm</td><td>-</td><td>Operation
The unit monitors the reading of the temperature sensors over time. After a period of time the temperature sensor readings indicate that the unit is cooling when it should be heating.

Alarm code 24 is generated when the problem that caused alarm code 22 was not corrected after the 15 minute shutdown.

Diagnostics
1. Check temperature differential by displaying the temperature differential [TPDF] or by checking the difference between the return and discharge temperature sensors. A negative temperature differential indicates the unit is cooling rather than heating.

2. Install gauges and check refrigeration system for proper operation. See “System Diagnosis” on page 60 and “Alarm Codes 22, 24, 26, and 32 — Low Heating Capacity Flow Chart” on page 73.</td></tr>
<tr><td>25</td><td>Alternator Check

This is a Check or Shutdown Alarm</td><td>2PA
CHP

8F</td><td>Operation
If the unit has been running for a period of 3 minutes with the battery voltage below 13.0 Vdc and the charging current below -1.0 Amp, a Check alarm will be generated.

If the unit has been running for a period of 3 minutes with the battery voltage above 16.2 Vdc, a Shutdown alarm is generated.

Diagnostics
1. Check alternator operation.

2. Check the [VOLTS] display for proper battery voltage. If this voltage is low compare it to voltage measured at the battery terminals with an accurate voltmeter. If these voltages are noticeably different check the microprocessor by using the microprocessor tester and displaying volts. If this voltage is correct the microprocessor is working properly and the problem lies within the CHP and 2PA or 8F circuits. If any of these circuits are defective the microprocessor will be unable to read voltage accurately.

3. Press the Gauge key to check amps. If the alternator is operational and charging current is still low check the shunt circuits for proper operation as shown under Alarm Code 62.</td></tr>
</table>

Code	Name	Wire	Operation and Diagnostics
26	**Refrigeration Capacity Check** This is a Check Alarm	-	**Operation** The unit monitors the reading of the temperature sensors over time. After a period of time the temperature sensor readings indicate that the unit is not cooling or heating properly. Alarm code 26 indicates the unit is cooling or heating, but the temperature differential is less than expected. The unit still has enough capacity to continue operating. If cooling, one or two defrost cycles will be initiated to correct the problem before an alarm code 26 is generated. If heating, one or two Heat Mode Charge Migration cycles will be initiated to correct the problem before an alarm code 26 is generated. Alarm code 26 will clear automatically if the unit pulls the return air temperature sensor reading to within 5 F (3 C) of the current setpoint. **Diagnostics** 1. Check temperature differential display using the Gauge Menu, or by checking the difference between the return and discharge or coil temperature sensors. 2. Install gauges and check refrigeration system for proper operation. See “System Diagnosis” on page 60, “Alarm Codes 21, 23, 26, and 32 — Low Cooling Capacity Flow Chart” on page 65, and “Alarm Codes 22, 24, 26, and 32 — Low Heating Capacity Flow Chart” on page 73.
-28	**Pretrip Abort** This is a Shutdown Alarm ***NOTE: This alarm is only generated during a Pretrip Test, and will be preceded by a dash (-).***	-	**Operation** This alarm is generated if a shutdown alarm occurs during a Pretrip Test. This alarm also occurs if the unit On/Off switch is set to the Off position while a Pretrip Test is in progress. This alarm is generated during Pretrip Tests only. See “Pretrip Test” on page 53 and Service Procedure A17A for additional information on the Full Pretrip Test. See Service Procedure A18A for additional information on the Engine Running Pretrip Test. **Diagnostics** 1. Check and correct any alarm conditions that exist. Repeat the test.

<table>
<tr><th>Code</th><th>Name</th><th>Wire</th><th>Operation and Diagnostics</th></tr>
<tr><td>-29</td><td>Damper Circuit

This is a Check Alarm

NOTE: This alarm is only generated during a Pretrip Test, and will be preceded by a dash (-).</td><td>29P

29</td><td>Operation
The damper door is closed when the 29P output supplies a ground to the damper door relay. When the damper door relay is energized, 2AB power is supplied to the damper solenoid via the 29 circuit. The unit will not defrost if this alarm is present, resulting in reduced cooling capacity.

For units equipped with a damper solenoid this alarm code indicates that the damper circuit may be drawing too much or too little current. The amperage draw for this output is checked during the amperage draw portion of the Full Pretrip Test.

For units equipped with a damper motor this alarm code indicates that the damper door did not close during the Damper Motor portion of a Pretrip Test.

This alarm is generated during Pretrip Tests only.

See “Pretrip Test” on page 53 and Service Procedure A17A for additional information on the Full Pretrip Test.

See Service Procedure A18A for additional information on the Engine Running Pretrip Test.

Diagnostics
1. Check the operation of the damper circuit using Relay Board Test mode. Be sure the DMPR LED lights and that the damper relay fuses F3 is not blown.

2. Where applicable, check the current drawn by the damper solenoid with the microprocessor [AMPS] function while operating damper door with Relay Board Test mode. The current draw should be 2 to 15 amps.

3. Energize the damper solenoid using relay board test mode and check for power on the 29 circuit. If voltage is low or missing check the 29 circuit for open circuits and loose or corroded connections using Service Procedure H04A and the wiring diagram for the unit.</td></tr>
<tr><td>31</td><td>Oil Pressure Switch

This is a Shutdown Alarm</td><td>20B</td><td>Operation
This alarm indicates that the engine oil pressure switch may be defective. The 20B circuit is a digital input to the microprocessor. The oil pressure switch will ground along the 20B circuit when the engine is not running. The 20B wire should have 0 volts when the engine is not running. The oil pressure switch will open the 20B circuit when the engine is running and the 20B digital input should equal battery voltage. This alarm occurs if the digital input is exhibiting an improper reading

Diagnostics
1. Energize the run relay using Relay Board Test mode and check for voltage on the 20B circuit at the oil pressure switch. No voltage should be present. If voltage is present the switch is defective and must be replaced.

2. Check the voltage on the 20B circuit. When the engine is running, battery voltage should be present. If no voltage is present remove the 20B wire from the oil pressure switch. If battery voltage is present on the 20B wire, the switch is defective and must be replaced. If no voltage is present on the 20B wire, check the 20B circuit for an open circuit or a short to chassis ground using Service Procedure H04A and the unit wiring diagram.</td></tr>
</table>

Code	Name	Wire	Operation and Diagnostics
32	**Refrigeration Capacity Low** This is a Shutdown Alarm ***NOTE: If this alarm is generated during a Pretrip Test, it will be preceded by a dash (-).***	-	**Operation** The unit monitors the reading of the temperature sensors over time. This alarm occurs after a period of time the temperature sensor readings indicate that the unit is not cooling or heating properly. This alarm indicates the unit is cooling or heating, but the temperature differential is too small to continue operation. If cooling, one or two defrost cycles will be initiated to correct the problem before an alarm code 32 is generated. If heating, one or two Heat Mode Charge Migration cycles will be initiated to correct the problem before an alarm code 32 is generated. This alarm must be manually cleared before restarting the unit. Alarm code 32 will occur in Heat mode only with fresh range setpoints. This alarm code can also be generated during the Cooling Capacity portion of the Pretrip Test. See “Pretrip Test” on page 53 and Service Procedure A17A for additional information on the Full Pretrip Test. See Service Procedure A18A for additional information on the Engine Running Pretrip Test. **Diagnostics** 1. Check temperature differential display using the Gauge Menu, or by checking the difference between the return and discharge or coil temperature sensors. 2. Install gauges and check refrigeration system for proper operation. See “System Diagnosis” on page 60, “Alarm Codes 21, 23, 26, and 32 — Low Cooling Capacity Flow Chart” on page 65, and “Alarm Codes 22, 24, 26, and 32 — Low Heating Capacity Flow Chart” on page 73.
-33	**Check Engine RPM** This is a Check Alarm ***NOTE: This alarm is only generated during a Pretrip Test, and will be preceded by a dash (-).***	-	**Operation** The unit monitors the reading of the flywheel sensor over time during the Pretrip Tests. This alarm occurs after a period of time if rpm readings are not in the specified ranges during the pretrip test. This alarm is generated during Pretrip Tests only. See “Pretrip Test” on page 53 and Service Procedure A17A for additional information on the Full Pretrip Test. See Service Procedure A18A for additional information on the Engine Running Pretrip Test. **Diagnostics** 1. Check the [RPM] display for proper engine rpm in high and low speed and adjust engine rpm as necessary. 2. Verify the Super Guarded Access setting for [SBHC] is set properly as shown in Service Procedure A04A. 3. Verify the Super Guarded Access setting for [SBHF] is set properly as shown in Service Procedure A04A.

Code	Name	Wire	Operation and Diagnostics
35	**Run Relay Circuit** This alarm is a Shutdown Alarm. ***NOTE: If this alarm is generated during a Pretrip Test, it will be preceded by a dash (-).***	**RRP** **7K**	**Operation** The run relay circuit is energized when the RRP output supplies a ground to the run relay. When the run relay is energized 8F power is supplied to the 7K circuit. This alarm code indicates that 7K circuit digital input at the microprocessor is not present when the run relay should be energized, or the digital input is present when it should not be. This alarm code may also be generated during the amperage draw portion of the Full Pretrip Test. See “Pretrip Test” on page 53 and Service Procedure A17A for additional information on the Full Pretrip Test. **Diagnostics** 1. Check the operation of the run relay circuit using Relay Board Test mode. Be sure the RUN LED lights on the relay board. 2. With the run relay energized verify that battery voltage is present on the 7K digital input to the microprocessor. If the voltage is low check the circuit for excessive resistance (loose or corroded connections). When the relay de-energized, there should be no voltage on the 7K wire.
37	**Check Engine Coolant Level** This is a Check Alarm	**CLS** **CLP** **CLN**	**Operation** This alarm indicates that the engine coolant level is low. The sensor is located in the radiator expansion tank. The coolant level must be above the sensor location. If the sensor is not submerged in coolant this alarm will be generated after the condition exists for 3 minutes. This alarm will clear automatically if the coolant level rises above the sensor location. The sensor is an optical device. The 3 wire sensor is supplied with +5 vdc and common from the microprocessor. **Diagnostics** ***Caution: Do not open radiator cap when hot.*** 1. Check the engine coolant level and mixture. Be sure coolant is above the sensor when the coolant is cold. The coolant must be a 50% mixture of antifreeze and water. 2. Check that +5 Vdc is present on the red sensor wire from the microprocessor. 3. Check continuity to ground of the black sensor wire. 4. Check the voltage on the white sensor wire. Voltage should be 5 Vdc when the sensor is submerged in coolant and less than 0.5 Vdc when the sensor is not submerged. ***NOTE: In rare instances an Alarm Code 12 and 37 can be caused by borderline low coolant level and road vibration. Check coolant level and add as required***

Code	Name	Wire	Operation and Diagnostics
-39	**Engine Coolant Solenoid Valve Circuit** This is a Check Alarm ***NOTE: This alarm is only generated during a Pretrip Test, and will be preceded by a dash (-).***	**WVP** **8F** **WV**	**Operation** The engine coolant solenoid valve is energized by 8F power when the WVP output supplies a ground to the coolant solenoid valve. This alarm code indicates that the engine coolant valve solenoid may be drawing too much or too little current. The feedback for this output is checked during the amperage draw portion of the Full Pretrip Test. This alarm code may also be generated during the Heat Capacity/EWSV portion of the Pretrip Tests. This alarm is generated during Pretrip Tests only. See “Pretrip Test” on page 53 and Service Procedure A17A for additional information on the Full Pretrip Test. See Service Procedure A18A for additional information on the Engine Running Pretrip Test. **Diagnostics** 1. Check to make sure fuse F30 is not blown. 2. Check the operation of the engine coolant solenoid valve with Relay Board Test mode [WAT.V]. Be sure the WATER VALVE LED lights on the relay board. See Service Procedure A44A for additional information. 3. Check the operation of the engine coolant solenoid valve with “STP24 Water Valve Test” on page 106. 4. Check the voltage between the 8F circuit and the WV circuit. If the voltage is low check the engine coolant solenoid valve circuit for excessive resistance (loose or corroded connections). 5. Check the engine coolant solenoid valve coil for continuity to be sure the coil is not open.

Code	Name	Wire	Operation and Diagnostics
-40	**High Speed Circuit** This is a Check Alarm ***NOTE: This alarm is only generated during a Pretrip Test, and will be preceded by a dash (-).***	**26ED** **7D**	**Operation** The high speed solenoid is energized when the 26ED output supplies a ground to the high speed relay. When the high speed relay is energized 2AB power is supplied to the high speed solenoid via the 7D circuit. This alarm code indicates that the high speed solenoid may be drawing too much or too little current. The high speed solenoid current is checked during the amperage draw portion of Full Pretrip Tests. Operation is also verified during the Engine Running Pretrip Test by energizing the high speed solenoid and checking for an increase in engine rpm. This alarm is generated during Pretrip Tests only. See “Pretrip Test” on page 53 and Service Procedure A17A for additional information on the Full Pretrip Test. See Service Procedure A18A for additional information on the Engine Running Pretrip Test. **Diagnostics** 1. Check the operation of the high speed circuit using Relay Board Test mode. Be sure the HI SPD LED lights and that fuses F18 and F1 are not blown. 2. Check the voltage at the high speed solenoid with the solenoid energized. If the voltage is low check the circuit for excessive resistance (burned high speed relay contacts, loose or corroded connections). 3. Check the high speed solenoid for continuity to be sure the coil is not open.
41	**Engine Coolant Temp Check** This is a Check Alarm. This alarm code may be associated with Alarm Code 42 Unit Forced to Low Speed and Alarm Code 43 Unit Forced to Low Speed Modulation. See Alarm Code 42 and 43 for additional information.	**-**	**Operation** This alarm code is generated if the engine coolant temperature sensor analog input remains above 210 F (99 C) for 30 seconds. This alarm will clear automatically when the coolant temperature falls below 190 F (88 C). **Diagnostics** 1. Check the engine coolant temperature by pressing the Gauge key 2. Check the diesel engine coolant level. 3. Check the drive belts. 4. Check the radiator for blockage and air flow. 5. Check sensor operation as shown in Alarm Code 06.

Code	Name	Wire	Operation and Diagnostics
42	**Unit Forced to Low Speed** This is a Check Alarm This alarm code may be associated with Alarm Code 18 High Engine Coolant Temperature, Alarm Code 41 Engine Coolant Temp Check, and Alarm Code 43 Unit Forced to Low Speed Modulation. See Alarm Code 18, 41, and 43 for additional information. This alarm clears automatically when coolant or ambient temperatures return to normal.	**-**	**Operation** This alarm indicates that the unit has been forced to low speed operation due to high engine coolant temperature or ambient temperatures over 140 F (60 C). The engine rpm is set to low speed and the compressor is unloaded (LV1 and LV2 are de-energized with fresh range setpoints, only LV1 is de-energized with frozen range setpoints) to help reduce system load and engine coolant temperature. ***NOTE: Alarm codes 42 and 43 represent progressive states of system unloading (reducing the system load reduces engine coolant temperature).*** **Diagnostics** 1. Check the engine coolant temperature via the Gauge Menu. 2. Check the engine coolant level. 3. Check the drive belts. 4. Check the radiator for blockage and air flow. 5. Check sensor operation as shown in Alarm Code 06.
43	**Unit Forced to Low Speed Modulation** This is a Check Alarm This alarm code may be associated with Alarm Code 41 Engine Coolant Temp Check and Alarm Code 42 Unit Forced to Low Speed. See Alarm Code 41 and 42 for additional information. This alarm clears automatically when coolant temperature returns to normal	**-**	**Operation** This alarm indicates that the unit has been forced to low speed operation with full modulation due to high engine coolant temperature. If the engine coolant temperature remains too high after the engine rpm is set to low speed and the compressor has been unloaded (see alarm code 42) the refrigerant flow is decreased to further help reduce system load and engine coolant temperature. With fresh range setpoints the ETV is closed to step 100, and with frozen range setpoints the ETV is closed to step 200. ***NOTE: Alarm codes 42 and 43 represent progressive states of system unloading (reducing the system load reduces engine coolant temperature).*** **Diagnostics** 1. Check the engine coolant temperature by via the Gauge Menu. 2. Check the diesel engine coolant level. 3. Check the drive belts. 4. Check the radiator for blockage and air flow. 5. Check sensor operation as shown in Alarm Code 06.

Code	Name	Wire	Operation and Diagnostics
44	**Fuel System** This is a Shutdown Alarm	**FP** **FS1** **FS2**	**Operation - TK486 (Yanmar) Engines** This alarm indicates the optional fuel pressure switch is sensing low fuel pressure. **Operation - se 2.2 (Isuzu) Engines** This alarm indicates that the microprocessor is sensing erratic engine rpm when operating in diesel mode. This is typically caused by unit running out of fuel. **Diagnostics** 1. Check the fuel level. 2. Check the FP circuit on units with TK486 (Yanmar) engines for an open circuit or a short to chassis ground using Service Procedure H04A and the unit wiring diagram. 3. Check for loose fuel lines and/or air in the fuel lines. 4. Check for gelled diesel fuel when operating in extremely cold conditions.
46	**Air Flow Check** This is a Stored Alarm during startup, and a Check Alarm during unit operation.	**-**	**Operation** This alarm indicates that microprocessor is sensing a problem with air flow in the trailer. If the sensor temperatures change rapidly, the unit may be short cycling due to blocked air flow. This alarm is generated shortly after initial startup if the return air temperature, the discharge air temperature, or both the return and discharge air temperatures drop rapidly. Under these conditions, Alarm Code 46 is a Stored Alarm. ***NOTE: This alarm may occur under conditions of high box temperature coupled with very high box humidity. Clear the alarm as required. (This feature may be turned off if necessary, see Service Procedure A04A [AFDT] setting).***
50	**Reset Clock** This is a Check Alarm ***NOTE: Alarm Code 50 may appear briefly when the unit is first powered up but this code will clear automatically when the DAS sets the microprocessor clock.***	**-**	**Operation** The microprocessor clock is automatically set by DAS when the unit is turned on. If the DAS time or date is incorrect it must be changed using a remote computer and Thermo King Wintrac software. This alarm indicates that an interruption has occurred between the microprocessor and the DAS time and date signal. **Diagnostics** 1. Restart the unit and wait 15 seconds for microprocessor and DAS to establish communications. 2. Check wiring between microprocessor and DAS.

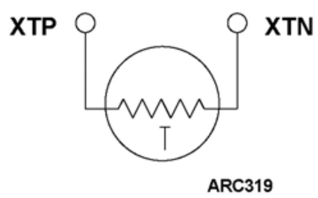
Code	Name	Wire	Operation and Diagnostics
-52	**Heat Circuit** This is a Check Alarm ***NOTE: This alarm is only generated during a Pretrip Test, and will be preceded by a dash (-).***	**14P** **26G** **26P**	**Operation** The pilot solenoid is energized by 8F power when the heat output 14P supplies a ground to the solenoid. This alarm code indicates that the pilot solenoid may be drawing too much or too little current. The feedback for this output is checked during the amperage draw portion of the Full Pretrip Test. This alarm code may also be generated during the Heat Capacity/EWSV portion of the Pretrip Tests. This alarm is generated during Pretrip Tests only. See "Pretrip Test" on page 53 and Service Procedure A17A for additional information on the Full Pretrip Test. See Service Procedure A18A for additional information on the Engine Running Pretrip Test. Diagnostics 1. Make sure that fuses F6 and F27 are not blown. 2. Check the operation of the pilot solenoid with Relay Board Test mode [HEAT]. Be sure the HEAT LED lights on the relay board. See Service Procedure A44A for additional information. 3. Check the operation of the pilot solenoid with "STP11 Pilot Solenoid Valve Test" on page 91. 4. Check the voltage for the pilot solenoid at the 14P circuit on the relay board. With the solenoid de-energized 12 volts should be present. If the voltage is low check the circuit for excessive resistance (loose or corroded connections). With the solenoid energized the voltage at this point should be less than 1 Vdc which indicates that the output has supplied a ground to the solenoid. 5. Check the pilot solenoid coil for continuity to be sure the coil is not open.
54	**Test Mode Timeout** This is a Shutdown Alarm	**-**	**Operation** This alarm indicates that the unit was placed in a Service Test mode or Relay Board Test mode function and no other test mode function was selected for 15 minutes. **Diagnostics** While in Service Test mode or Relay Board Test mode, if no other function is selected within 15 minutes the unit will shut down and record Alarm Code 54. Clear the alarm and re-enter Service Test mode if necessary to complete the diagnosis or repair.

Code	Name	Wire	Operation and Diagnostics
55	**Check Engine Speeds** This is a Check Alarm	-	**Operation** The unit monitors the reading of the flywheel sensor over time. This alarm occurs after a period of time if the unit should be in low speed but the engine rpm indicates the engine is running in high speed. **Diagnostics** 1. Check the [RPM] display for proper engine rpm in high and low speed and adjust the engine rpm as necessary. 2. Check for binding or sticky throttle linkage.
61	**Low Battery Volts** This is a Check or Shutdown Alarm ***NOTE: If this alarm is generated during a Full Pretrip Test, it will be preceded by a dash (-).***	**2PA** **CHP**	**Operation** A check alarm is generated during the Full Pretrip Test if the battery voltage is low. See “Pretrip Test” on page 53 and Service Procedure A17A for additional information on the Full Pretrip Test. A shutdown alarm is generated any time if the battery voltage is low for several minutes while the engine was not running. The battery voltage is sensed through the 2PA and CHP circuit. ***NOTE: If all the Sensor Codes (02, 03, 04, 05 & 06) and Code 61 are present, the battery may be extremely low or the microprocessor may be defective.*** ***NOTE: This Alarm Code may occur if the unit is rapidly switched Off and back On. Allow a several second pause after switching the unit Off before turning it back On.*** **Diagnostics** 1. Check for discharged (run down) battery. 2. Check the battery terminals at both ends for tightness and corrosion. 3. Start the unit and check the charging rate using the [AMPS] and [BATV] displays of the Gauge menu. 4. Check the 2PA pin and CHP pin on the connector at the microprocessor for a pushed pin. Refer to Service Procedure H04A and unit wiring diagrams for details. 5. Load test the 2PA and CHP circuits at the microprocessor connector.
62	**Ammeter Out of Calibration Range** This is a Shutdown Alarm	**VHP** **VHN**	**Operation** This alarm indicates that the ammeter can not be properly calibrated and that it’s readings may be erroneous. **Diagnostics** 1. Check the VHP and VHN circuits for continuity. 2. Test the microprocessor per Service Procedure A01A.

Code	Name	Wire	Operation and Diagnostics
63	**Engine Stopped - Reason Unknown** This alarm is a Shutdown Alarm. This alarm code may be associated with Alarm Code 84 Restart Null. See Alarm Code 84 for details. The unit will be forced into low speed operation for 30 minutes after a successful Restart Null.	**-**	**Operation** This alarm indicates that the unit was running and still should be but has stopped for an unknown reason. **Diagnostics** 1. Check and correct any existing Alarm Codes. 2. Check the fuel level and fuel system. 3. Check refrigeration system for high discharge pressure or seized compressor. 4. Check blowers, idlers, motors and belts for seizure or overload. 5. Check the air cleaner and intake hose for obstructions. 6. Check for proper operation of the RPM sensor. 7. Check the oil level and coolant level. Be sure engine is not seized. 8. Perform a Full Pretrip per Service Procedure A17A to determine cause for shutdown. 9. Download data logger and check for any conditions that may have caused engine to stop.
64	**Pretrip Reminder** This is a Stored Alarm This alarm clears automatically when the Pretrip Test is performed	**-**	**Operation** This alarm occurs if the pretrip reminder feature is activated. It serves as a reminder to perform a Pretrip Test. This programmable function is enabled by setting hourmeter 4, 5 or 6 to Type 15. **Diagnostics** Perform a Pretrip test. Alarm Code 64 is automatically cleared and the pretrip reminder timer is reset to zero when a Pretrip test is performed.
66	**Low Engine Oil Level** This is a Shutdown Alarm	**2AAL** **OLS**	**Operation** This alarm occurs when the engine oil level is low for period of time. The oil level switch applies 12 volts to the OLS input to the microprocessor when the oil level is low. When the engine is full of oil no voltage is present on the OLS circuit. **Diagnostics** 1. Check the engine oil level. 2. Check for voltage on the OLS input at the microprocessor. No voltage should be present when engine is full of oil. 12 Vdc should be present when oil level is low. 3. If this alarm does not occur when the oil level is low check the 2AAL circuit and fuse F28.

Code	Name	Wire	Operation and Diagnostics
-67	**Liquid Line Solenoid Circuit** This is a Check Alarm ***NOTE: This alarm is only generated during a Pretrip Test, and will be preceded by a dash (-).***	**LLSPP** **LLSP** **LLS** **8F**	**Operation** The liquid line solenoid is energized by 8F power when the LLSP output supplies a ground to the liquid line solenoid. This alarm code indicates that the liquid line solenoid may be drawing too much or too little current. The feedback for this output is checked during the amperage draw portion of the Full Pretrip Test. This alarm code may also be generated during the Liquid Line Solenoid portion of the Pretrip Tests. This alarm is generated during Pretrip Tests only. See “Pretrip Test” on page 53 and Service Procedure A17A for additional information on the Full Pretrip Test. See Service Procedure A18A for additional information on the Engine Running Pretrip Test. **Diagnostics** 1. Be sure the associated fuses F26 and F27 are not blown. 2. Check the operation of the liquid line solenoid circuit using Relay Board Test mode [LLS]. Be sure the LIQ LINE LED lights on the relay board. See Service Procedure A44A for additional information. 3. Check the operation of the liquid line solenoid with “STP22 Liquid Line Solenoid Test” on page 104. 4. Check the voltage between the 8F circuit and the LLS circuit. If the voltage is low check the liquid line solenoid circuit for excessive resistance (loose or corroded connections). 5. Check the liquid line solenoid coil for continuity to be sure the coil is not open. ***NOTE: A flooding economizer expansion valve or a leak between the compressor main suction port and the economizer suction port can cause a false -67 alarm code.***
70	**Hourmeter Failure** This is a Stored Alarm This alarm can only be cleared from Guarded Access mode.	**-**	**Operation** This alarm indicates that the hourmeter exceeds 99999 hours or that a problem occurred when the microprocessor attempted to write to the hourmeter memory. **Diagnostics** 1. Check Hourmeters 1, 2 and 3. If the reading is normal, perform a Cold Start per Service Procedure A07A. Be sure and record the micro-processor settings using Service Procedure A02A before performing the Cold Start. If the code can be cleared, proceed with microprocessor setup using Service Procedure A04A. 2. If Alarm Code 70 will not clear from Guarded Access mode, attempt to clear it from Super Guarded Access mode.

Code	Name	Wire	Operation and Diagnostics
71 72 73	**Hourmeter 4 Exceeds Set Limit** **Hourmeter 5 Exceeds Set Limit** **Hourmeter 6 Exceeds Set Limit** These are Stored Alarms. This alarm can only be cleared from Guarded Access mode.	-	**Operation** This alarm indicates that the indicated hourmeter has exceeded the programmed time limit. **Diagnostics** 1. Perform required maintenance, reset the hour meter and clear the alarm using Service Procedure A10A.
74	**µP Reverted to Default Settings** This is a Check Alarm. This alarm can only be cleared from Super Guarded Access.	**2PA** **CHPA** **CSP**	**Operation** This alarm indicates that all programmable values have been reset to the default values. This occurs as a result of performing a Cold Start or changing the microprocessor software. This may also occur as the result of intermittent power when a battery is connected with the micro-processor power switch On. **Diagnostics** 1. Check the 2PA and CHPA circuits for intermittent operation. 2. Be sure the Cold Start jumper on the relay board is in the correct position (from pin TP-1 to the center pin). 3. Complete the microprocessor setup using Service Procedures A04A, A05A and A20A. Alarm code 74 will be cleared during the microprocessor setup using Service Procedure A04A. ***NOTE: Failure to perform the above setup procedures after a Code 74 alarm may result in the unit failing to perform to customer specifications.***
75 76 77 78	**µP Ram** **µP EPROM** **µP EPROM Checksum** **Data Log EPROM** These are Factory Alarms	-	**Operation** The microprocessor continuously checks and verifies it's internal operations. If a problem occurs one of these factory alarms will generated. **Diagnostics** 1. Perform a Cold Start using Service Procedure A07A. If the code is cleared, complete the microprocessor setup using Services Procedures A04A, A05A and A20A. 2. If the code *can not* be cleared with a Cold Start, replace the microprocessor using Service Procedure A03A. Complete the microprocessor setup using Service Procedures A04A, A05A and A20A. ***NOTE: Alarm Code 77 may clear if the software chip is replaced.***
79	**Data Log Overflow** This is a Check Alarm	-	**Operation** This alarm may occur during a data logger download with the unit running. If an event occurs during a download (such as the unit switching from Cycle Sentry run to Cycle Sentry null) it may not be recorded by the data logger. Alarm Code 79 will be generated to inform the operator that an event occurred that was not recorded. **Diagnostics** No corrective action is possible. This serves only as an indication that an event occurred that was not recorded by the data logger.

<table>
<tr><th>Code</th><th>Name</th><th>Wire</th><th>Operation and Diagnostics</th></tr>
<tr><td>80</td><td>Compressor Temp Sensor
This is a Check Alarm</td><td>CSTP
CSTN</td><td>Operation
The compressor temperature circuit utilizes a resistance thermal detector (RTD) sensor as shown in the diagram below. Each temperature sensor is an analog input to the microprocessor. The temperature sensors are polarity sensitive electronic devices and can not be checked with an ohmmeter.


NOTE: Beginning with revision 4310 software, if this alarm code is present, the discharge superheat control is disabled, and the microprocessor uses discharge pressure to control the liquid injection valve (LIV) during heat mode operation (like revision 4300 and 4301 software).
Diagnostics
A defective sensor will usually display as [----]. The sensor or it’s associated circuit may be open, shorted internally or shorted to chassis ground. A direct short to chassis ground on a single sensor may cause multiple sensor codes to appear.
1. Disconnected the sensor and temporarily connect a new sensor. Display the sensor on the microprocessor display. If the temperature can now be displayed the original sensor was defective.
2. If the temperature is not displayed by the microprocessor unplug the sensor and check for +5 vdc between CSTP and CSTN. If 5 volts is not present check the microprocessor using Service Procedure A01A.
3. If the microprocessor passes the test, disconnect the sensor harness from the microprocessor and disconnect the suspected bad sensor. Using a Fluke meter set for ohms check for shorts to chassis ground on both the CSTP and CSTN wires of the suspect sensor. If a short exists examine the wiring harness for chaffed areas and repair as required.
4. If no shorts exist connect a jumper across the sensor connector. Check continuity from CSTP to CSTN at the microprocessor connector. The circuit resistance should be less than 1 ohm. If not, check the harness and all associated connectors using the wiring diagram for the unit.
5. If an intermittent problem exists monitor the voltage between CSTP and CSTN at the sensor plug with the sensor connected. The voltage should be approximately 2-4 vdc. If the voltage suddenly increases the sensor is intermittently open. If the voltage suddenly decreases look for an intermittent short or open in the wiring between the microprocessor and the sensor.</td></tr>
</table>

Code	Name	Wire	Operation and Diagnostics
81	**High Compressor Temp** This is a Check Alarm	-	**Operation** This alarm indicates the compressor temperature exceeded 290 F (143 C) for 1minute while the unit was running. **Diagnostics** 1. Check the refrigerant level. 2. Check for air in the system. 3. Check refrigeration system for proper operation. See “System Diagnosis” on page 60 and “Alarm Codes 81 and 82 — High Compressor Temperature Flow Chart” on page 76.
82	**High Compressor Temp** This is a Shutdown Alarm This alarm code may be associated with Alarm Code 84 Restart Null. See Alarm Code 84 for details.	-	**Operation** This alarm indicates the compressor temperature sensor is working properly, and readings have exceeded 295 F (146 C) continuously for 15 minutes, or exceeded 310 F (154 C) continuously for 1 minute while the unit was running. **Diagnostics** 1. Check the refrigerant level. 2. Check for air in the system. 3. Check refrigeration system for proper operation. See “System Diagnosis” on page 60 and “Alarm Codes 81 and 82 — High Compressor Temperature Flow Chart” on page 76.
83	**Low Engine Coolant Temp** This is a Check Alarm ***NOTE: If this alarm is generated during a Pretrip Test, it will be preceded by a dash (-).***	-	**Operation** This alarm indicates the engine coolant temperature was below 120 F (49 C) continuously for 30 minutes while the unit was running in heat or defrost mode. It can also indicate bucking heat mode operation failed to warm the engine coolant to the minimum engine coolant temperature. ***NOTE: The minimum engine coolant temperature is 140 F (60 C) for units running revision 4310 software, and 120 F (49 C) for units running revisions 4300 and 4301 software.*** This alarm code may also be generated during the Heat Capacity/EWSV portion of the Pretrip Tests. See “Pretrip Test” on page 53 and Service Procedure A17A for additional information on the Full Pretrip Test. See Service Procedure A18A for additional information on the Engine Running Pretrip Test. **Diagnostics** Check coolant system thermostat for proper operation.

Code	Name	Wire	Operation and Diagnostics
84	**Restart Null** This is a Check Alarm This alarm clears automatically if the original condition does not re-occur.	-	**Operation** This alarm indicates that the microprocessor is attempting to take corrective action due to the occurrence of Shutdown Alarm Codes 9, 10, 17, 18, 20, 21, 22, 44, 63, 82, 93, or 99. The microprocessor will take corrective actions as a result of one or more of these codes and then attempt a restart in order to keep the unit running. Many of these actions include a “waiting period” of 15 minutes (to allow the engine to cool down, a high pressure condition to subside, etc.). The Alarm Code that caused the condition and Alarm Code 84 may be present to indicate that the microprocessor is taking a corrective action and that a restart will be attempted when conditions permit. If the corrective action is successful the original alarm code as well as Alarm Code 84 are cleared automatically. If the original alarm condition continues to occur and the corrective actions taken by the microprocessor are not successful the original alarm code remains, Alarm Code 84 is automatically cleared and the unit will shut down. Conditions that are automatically cleared are logged on units equipped with Data Loggers. **Diagnostics** 1. Alarm Code 84 indicates that the microprocessor is actively taking corrective action even though the unit may appear to be shut down. If Alarm Code 84 is present the microprocessor should be allowed time to complete its corrective actions. The display will not flash when Alarm Code 84 is present. 2. Record all alarm codes that appear along with Alarm Code 84. 3. If Alarm Code 84 disappears and the other alarm code or codes are still present, proceed with corrective actions for those alarm codes.
85	**Forced Unit Operation** This is a Check Alarm This alarm clears automatically if the condition that caused forced unit operation returns to normal	-	**Operation** This alarm indicates that the unit was forced out of Bucking Heat mode and into Heat mode in an effort to prevent a condition from shutting down the unit. **Diagnostics** Check for other alarm codes and correct them as suggested in this section.

Code	Name	Wire	Operation and Diagnostics
87	**Suction Pressure Transducer** This is a Check Alarm	**SPI** **HSPP** **HSPN**	**Operation** This alarm indicates that the suction pressure transducer has failed or its readings have gone above the design range. It may also occur if the electronic throttling valve does not open (Alarm Code 89). This alarm will be generated if the suction pressure reading is above 200 psig (1378 kPa) continuously for 15 seconds at anytime the unit is running. ***NOTE: This Alarm Code may occur during Evacuation Mode. This is normal.*** **Diagnostics** 1. Check the suction pressure display using the Gauge Menu. 2. If the suction pressure is not displayed by the microprocessor unplug the transducer and check for +5 Vdc between HSPP and HSPN. See Service Procedure D03A for additional information. If 5 volts is not present check the microprocessor using Service Procedure A01A. 3. Check the harness wires HSPP, HSPN and SPI for continuity using an ohmmeter. 4. Connect refrigeration gauges to verify that transducer is displaying the correct pressure. Replace the transducer as required.

Code	Name	Wire	Operation and Diagnostics
89	**Electronic Throttling Valve Test** This can be a Check or Shutdown Alarm	**8EV** **EVA** **EVB** **EVC** **EVD**	**Operation** This alarm code indicates that refrigeration system pressures did not respond as expected during unit startup. This may be caused by a malfunction in the electronic throttling valve circuits or a refrigeration system problem such as low refrigerant level or severe suction side restriction. This test is always performed during the first few minutes of operation after the unit is started. However, the test results are ignored if the box temperature or ambient temperature is below 15 F (-9 C). For a complete description of the ETV test, see Service Procedure G03A. The Electronic Throttling Valve has two internal coils. The microprocessor operates the valve is by energizing the coils with a variable frequency ac signal. The sequence in which the microprocessor energizes the coils determines the direction of travel and the frequency of the signal determines the speed of valve motion. Wires EVA and EVB energize one coil and wires EVC and EVD energize the other coil. Power to the ETV circuit is supplied from fuse F14 via the 8EV wire. Field experience indicates that if the correct signals are present that the valve will operate. **Diagnostics** 1. Install a gauge set and compare gauge readings to suction and discharge pressure transducers with unit not running to determine if transducers are reading properly and if refrigerant charge is adequate. 2. Start the unit and compare gauge readings to suction and discharge pressure transducers to determine if transducers are reading properly and pressures appear to be normal. 3. Check electrical operation of electronic throttling valve circuit using Service Procedure G03A. 4. If the electronic throttling valve appears to function electrically check the refrigeration system for low refrigerant, frozen expansion valve or a severe restriction in the suction side of the system.

Code	Name	Wire	Operation and Diagnostics
93	**Low Compressor Suction Pressure** This is a Shutdown Alarm. This alarm code may be associated with Alarm Code 84 Restart Null. See Alarm Code 84 for details.	-	**Operation** This alarm indicates the compressor suction pressure transducer reading has dropped below -9 psig (-62 kPa) continuously for 1 minute while the unit was running. The unit will attempt to restart once the 15 minute restart timer has elapsed. **Diagnostics** 1. Check refrigerant level. 2. Perform a Full Running Pretrip to determine cause for shutdown, and correct any alarm codes generated. 3. Check #1 and #2 loading solenoid valve operation. Loading valves may be plugged or stuck closed. 4. Check suction pressure transducer for correct operation. See Service Procedure D03A for additional information. If alarm code is generated while unit is in Heat mode: 1. Check the engine coolant temperature display using the Gauge Menu. This alarm code can be generated it the engine thermostat fails during low ambient operation. 2. Economizer expansion valve restricted “starving”. Also check sensing bulb, it may have lost its charge. 3. Check refrigeration system for proper operation. See “System Diagnosis” on page 60 and “Alarm Codes 22, 24, 26, and 32 — Low Heating Capacity Flow Chart” on page 73. If alarm code is generated while unit is in Cool mode: 1. Check for low evaporator air flow. Look for an iced evaporator coil, dirt or debris on the evaporator coil, or a loose or broken evaporator blower drive belt. 2. Evaporator expansion valve restricted “starving”. Also check sensing bulb, it may have lost its charge. 3. Check damper door operation to make sure damper door is not stuck closed. 4. Check refrigeration system for proper operation. See “System Diagnosis” on page 60 and “Alarm Codes 21, 23, 26, and 32 — Low Cooling Capacity Flow Chart” on page 65.

Code	Name	Wire	Operation and Diagnostics
94	**#1 Loading Solenoid Valve** This is a Check Alarm. ***NOTE: If this alarm is generated during a Pretrip Test, it will be preceded by a dash (-).***	**8F** **EBVP** **LV1P** **LV1**	**Operation** The #1 loading valve solenoid is energized by 8F power when the economizer output EBVP supplies a ground to the solenoid. This alarm is generated if the suction pressure decreases by less than 3 psig (21 kPa) when the #1 loading solenoid valve (LV1) is energized during the unit startup sequence. The startup pressure check is not performed if the ambient temperature is less than 15 F (-9 C). This alarm can also be generated if the #1 loading solenoid is drawing too much or too little current. The solenoid amperage draw is measured prior to startup and during the amperage draw portion of the Full Pretrip Test. See “Pretrip Test” on page 53 and Service Procedure A17A for additional information on the Full Pretrip Test. **Diagnostics** 1. Make sure that fuses F32 is not blown. 2. Check the operation of the #1 loading valve solenoid with Relay Board Test mode [LV1]. Be sure the ECON LED lights on the relay board. See Service Procedure A44A for additional information. 3. Check the operation of the #1 loading valve with “STP21 Loading Valve Test” on page 103. 4. Check the voltage for the #1 loading valve solenoid at the EBVP circuit on the relay board. With the solenoid de-energized 12 volts should be present. If the voltage is low check the circuit for excessive resistance (loose or corroded connections). With the solenoid energized the voltage at this point should be less than 1 Vdc which indicates that the output has supplied a ground to the solenoid. 5. Check the #1 loading valve solenoid coil for continuity to be sure the coil is not open.

Code	Name	Wire	Operation and Diagnostics
95	**#2 Loading Solenoid Valve** This is a Check Alarm. ***NOTE: If this alarm is generated during a Pretrip Test, it will be preceded by a dash (-).***	**8F** **ULP** **LV2P** **LV2**	**Operation** The #2 loading valve solenoid is energized by 8F power when the loading output ULP supplies a ground to the solenoid. This alarm is generated if the suction pressure decreases by less than 3 psig (21 kPa) when the #2 loading solenoid valve (LV2) is energized during the unit startup sequence. The startup pressure check is not performed if the ambient temperature is less than 15 F (-9 C). This alarm can also be generated if the #2 loading solenoid is drawing too much or too little current. The solenoid amperage draw is measured prior to startup and during the amperage draw portion of the Full Pretrip Test. See “Pretrip Test” on page 53 and Service Procedure A17A for additional information on the Full Pretrip Test. **Diagnostics** 1. Make sure that fuses F29 is not blown. 2. Check the operation of the #2 loading valve solenoid with Relay Board Test mode [LV2]. Be sure the UNLOADER LED lights on the relay board. See Service Procedure A44A for additional information. 3. Check the operation of the #2 loading valve with “STP21 Loading Valve Test” on page 103. 4. Check the voltage for the #2 loading valve solenoid at the ULP circuit on the relay board. With the solenoid de-energized 12 volts should be present. If the voltage is low check the circuit for excessive resistance (loose or corroded connections). With the solenoid energized the voltage at this point should be less than 1 Vdc which indicates that the output has supplied a ground to the solenoid. 5. Check the #2 loading valve solenoid coil for continuity to be sure the coil is not open.

Code	Name	Wire	Operation and Diagnostics
99	**High Compressor Pressure Ratio** This is a Shutdown Alarm. This alarm code may be associated with Alarm Code 84 Restart Null. See Alarm Code 84 for details.	-	**Operation** This alarm is generated when the microprocessor calculates a compressor compression ratio of 25:1 or higher for a period of 3 minutes. The unit will attempt to restart once the 15 minute restart timer has elapsed. **Diagnostics** 1. Check refrigerant level. 2. Perform a Full Running Pretrip to determine cause for shutdown, and correct any alarm codes generated. 3. Check #1 and #2 loading solenoid valve operation. Loading valves may be plugged or stuck closed. 4. Check suction pressure and discharge pressure transducers for correct operation. See Service Procedure D03A for additional information. If alarm code is generated while unit is in Heat mode: 1. Economizer expansion valve restricted “starving”. Also check sensing bulb, it may have lost its charge. 2. Check refrigeration system for proper operation. See “System Diagnosis” on page 60 and “Alarm Codes 22, 24, 26, and 32 — Low Heating Capacity Flow Chart” on page 73. If alarm code is generated while unit is in Cool mode: 1. Check for low evaporator air flow. Look for an iced evaporator coil, dirt or debris on the evaporator coil, or a loose or broken evaporator blower drive belt. 2. Check damper door operation to make sure damper door is not stuck closed. 3. Check refrigeration system for proper operation. See “System Diagnosis” on page 60 and “Alarm Codes 21, 23, 26, and 32 — Low Cooling Capacity Flow Chart” on page 65.

Code	Name	Wire	Operation and Diagnostics
109	**Discharge Pressure Transducer** This is a Check Alarm	**DPI** **HSPP** **HSPN**	**Operation** This alarm indicates that discharge pressure transducer has failed or its readings have gone above or below the design range. This alarm will be generated if the discharge pressure reading is above 500 psig (3447 kPa) continuously for 15 seconds at anytime the microprocessor is On. This alarm will also be generated if the discharge pressure reading is below 25 psig (172 kPa) continuously for 15 seconds at anytime the unit is running and the ambient temperature is above 0 F (-18 C). ***NOTE: If this alarm code is present, the microprocessor uses the high pressure cut-in switch (HPCI) as a backup to monitor the discharge pressure during heat mode operation.*** **Diagnostics** 1. Check the discharge pressure display using the Gauge Menu. 2. If the discharge pressure is not displayed by the microprocessor unplug the sensor and check for +5 Vdc between HSPP and HSPN. See Service Procedure D03A for additional information. If 5 volts is not present check the microprocessor using Service Procedure A01A. 3. Check the harness wires HSPP, HSPN and DPI for continuity using an ohmmeter. 4. Connect refrigeration gauges to verify that transducer is displaying the correct pressure. Replace the transducer as required.

Code	Name	Wire	Operation and Diagnostics
-121	**Liquid Injection Solenoid Valve** This is a Check Alarm ***NOTE: This alarm is only generated during a Pretrip Test, and will be preceded by a dash (-).***	**8F** **LQ1PP** **LQ1P** **LQ1**	**Operation** The liquid injection valve solenoid is energized by 8F power when the liquid injection output LQIP supplies a ground to the solenoid. This alarm code indicates that the liquid injection valve solenoid may be drawing too much or too little current. The feedback for this output is checked during the amperage draw portion of the Full Pretrip Test. This alarm code may also be generated during the liquid injection solenoid valve (LIV) portion of the Pretrip tests. This alarm is generated during Pretrip Tests only. See “Pretrip Test” on page 53 and Service Procedure A17A for additional information on the Full Pretrip Test. See Service Procedure A18A for additional information on the Engine Running Pretrip Test. **Diagnostics** 1. Make sure that fuses F25 is not blown. 2. Check the operation of the liquid injection valve solenoid with Relay Board Test mode [LIV]. Be sure the LIQ INJ LED lights on the relay board. See Service Procedure A44A for additional information. 3. Check the operation of the liquid injection valve with “STP23 Liquid Injection Valve Test” on page 105. 4. Check the voltage for the liquid injection valve solenoid at the LQIP circuit on the relay board. With the solenoid de-energized 12 volts should be present. If the voltage is low check the circuit for excessive resistance (loose or corroded connections). With the solenoid energized the voltage at this point should be less than 1 Vdc which indicates that the output has supplied a ground to the solenoid. 5. Check the liquid injection valve solenoid coil for continuity to be sure the coil is not open. ***NOTE: A flooding main expansion valve or a flooding economizer expansion valve can generate a false -121 alarm code.***

Service Test Procedures

NOTE: The following procedures involve servicing the refrigeration system. Some of these service procedures are regulated by Federal, and in some cases, by State and Local laws.

In the USA all regulated refrigeration service procedures must be performed by an EPA certified technician, using approved equipment and complying with all Federal, State and Local laws.

The following are the Service Test Procedures covered in this chapter:

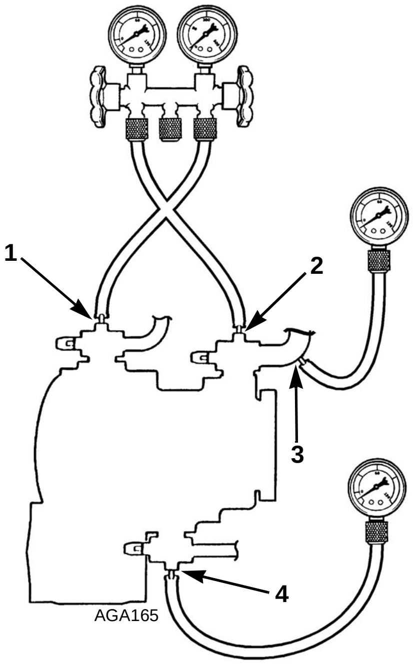
STP01 Gauge Installation

NOTE: All gauges should be calibrated to 0 at atmospheric pressure to ensure accuracy.

The S391 screw compressor has two suction service valves and one discharge service valve. The main suction service valve is on top of the compressor. The economizer suction service valve is on the side of the compressor.

When installing a gauge manifold:

1. Connect the compound gauge line to the main suction service valve port.



1.	Discharge—High Side Gauge
2.	Main Suction—Low Side Gauge
3.	Suction Access Port—Low Side Gauge
4.	Economizer Suction—Low Side Gauge

Figure 1: Gauge Installation

2. Connect the high pressure gauge line to the discharge service valve port.

3. For some tests it is necessary to connect a second compound gauge to the economizer suction service valve port.

4. The unit is equipped with an additional access port called the suction pressure access port. It is used to monitor the pressure on the low side of the system when the main suction service valve is closed. The suction pressure access port is located on the tube that connects the suction vibrasorber to the suction service valve.

STP02 Checking Refrigerant Charge

CAUTION: The S391 screw compressor refrigeration system is sensitive to an overcharge of refrigerant. It is also easy to mistake a full charge for a low charge. Do not add refrigerant unless you are certain the unit is low on refrigerant. If there is any doubt about the refrigerant charge, recover the refrigerant, evacuate the system, and recharge the system by weight.

STP02a Testing The Refrigerant Charge With An Empty Trailer

If the unit has an insufficient charge of refrigerant, the evaporator will be "starved" and the box temperatures will rise even though the unit is operating. The suction pressure will drop as the refrigerant charge decreases. Check the refrigerant charge by looking in the receiver tank sight glass with the following conditions established:

1. Place a test box over the evaporator.
2. Install a gauge manifold on the compressor (see "STP01 Gauge Installation" on page 78).
3. Use Service Test Mode [HS.C] to run the unit in High Speed Cool. See "Service Test Mode" on page 119 for specific information about the Service Test Mode.
4. Use the microprocessor to monitor the return air temperature.
5. Run the unit on high speed cool until the air in the box is at 0 F (–18 C). By allowing the box to leak a small amount, you will be able to maintain 0 F (–18 C).
6. Cover the condenser grille with a piece of cardboard to raise the discharge pressure. The discharge pressure must be between 300 to 400 psig (2068 to 2756 kPa) and rising.
7. Under these conditions, the ball should be floating in the receiver tank sight glass. If refrigerant is not visible in the receiver tank sight glass, the unit is low on refrigerant.

STP02b Testing The Refrigerant Charge With A Loaded Trailer

1. Install a gauge manifold (see "STP01 Gauge Installation" on page 78).
2. Use Service Test Mode [HS.C] to run the unit in High Speed Cool. See "Service Test Mode" on page 119 for specific information about the Service Test Mode.
3. Cool the compartment to lowest temperature required.
4. Cover the condenser grille with a piece of cardboard to raise the discharge pressure. The discharge pressure must be between 300 to 400 psig (2068 to 2756 kPa) and rising.
5. Under these conditions, the ball should be floating in the receiver tank sight glass. If refrigerant is not visible in the receiver tank sight glass, the unit is low on refrigerant.

   NOTE: If the ball floats, there is sufficient refrigerant in the unit for that load at that particular temperature. This test does not determine if the unit contains a full charge of refrigerant.

STP02c Testing for an Overcharge

If the unit has an overcharge of refrigerant, it may exhibit the following symptoms:

- High discharge pressure
- High CTMP
- Alarm Code 10 on defrost
- Operating in auxiliary modes

Use the following procedure to identify a unit with an excessive refrigerant charge:

1. Install a gauge manifold on the compressor (see "STP01 Gauge Installation" on page 78).
2. Use Service Test Mode [HS.C] to run the unit in High Speed Cool. See "Service Test Mode" on page 119 for specific information about the Service Test Mode.
3. Operate the unit in high speed cool long enough to stabilize system pressures and reduce the box temperature to approximately 60 F (16 C) or colder.

4. Observe discharge pressure and cover the condenser to increase the discharge pressure approximately 50 psig (345 kPa) above the observed pressure. Do not allow the discharge pressure to go above 350 psig (2413 kPa).

   NOTE: If the ball and liquid level in the receiver sight glass drops during step 4, the unit is not overcharged and it is not necessary to complete the procedure.

5. Remove the condenser cover to rapidly reduce discharge pressure.
6. Observe the receiver tank sight glass and the unit discharge pressure.
7. By the time the discharge pressure drops approximately 50 psig (345 kPa), the ball in the receiver tank sight glass should begin to move and the liquid level should drop.
   a. When discharge pressure stabilizes, the ball and liquid level will rise.
   b. If the ball will not begin to move or the liquid level will not drop, the unit most likely has an overcharge of refrigerant. The refrigerant level should be adjusted.

To adjust the refrigerant level:

1. Stop the unit and remove some refrigerant with an approved refrigerant recovery device.
2. Perform a refrigerant level check and repeat the overcharge test.
3. If the liquid level is low, add refrigerant as follows:
   a. Connect a refrigerant tank to the gauge manifold service line and purge the line.
   b. Mid seat the main suction service valve.
   c. Set the refrigerant tank for liquid removal and open the hand valve.
   d. Operate the unit in high speed cool.
   e. Observe the suction pressure and slowly open the gauge manifold low pressure hand valve to allow liquid refrigerant to flow into the main suction service valve.
   f. Control the liquid flow so the suction pressure increases approximately 20 psig (138 kPa).
   g. Maintain a discharge pressure of at least 275 psig (1896 kPa) while adding refrigerant.
   h. Close the hand valve on the refrigerant tank when liquid appears in the receiver sight glass.
4. Repeat the overcharge test.
5. Remove the gauge manifold set and cap all service ports and valve stems when the refrigerant level is correct.

STP03 Checking Compressor Oil

The compressor oil should be checked when there is evidence of oil loss (oil leaks) or when components in the refrigeration system have been removed for service or replacement.

NOTE: Too much oil in the compressor can cause low refrigeration capacity.

Note the following items:

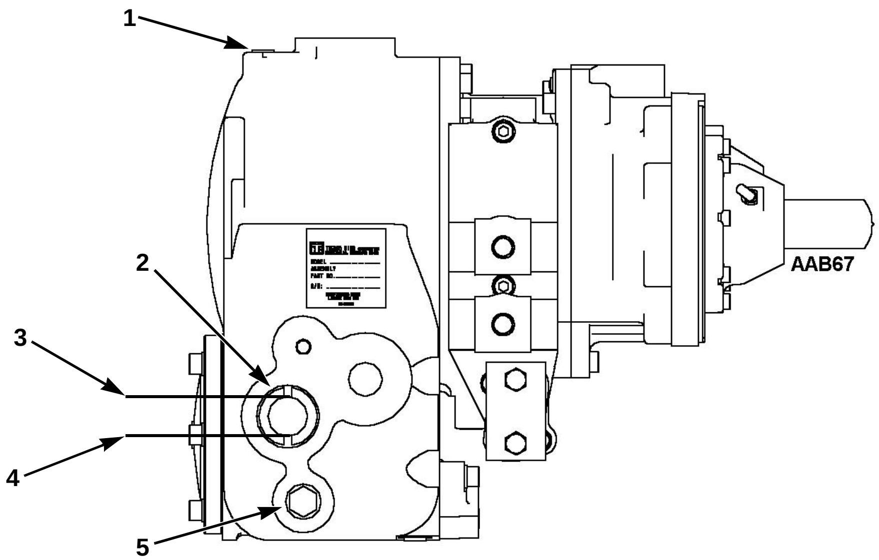
- The unit must be running in high speed cool when checking the compressor oil level. Use Service Test Mode [HS.C] to run the unit in High Speed Cool. See "Service Test Mode" on page 119 for specific information about the Service Test Mode.
- The oil level should be visible in the sight glass.
- DO NOT operate the unit if the compressor oil level is below the bottom of the sight glass.

  NOTE: The oil level in the compressor sump depends on the operating conditions. The oil should be visible in the sight glass. The compressor can handle losing up to about 0.6 qt (0.6 liters) of oil. The "Oil Level Chart" on page 82 shows the relative compressor oil levels with a total oil charge of 2.8 qt (2.7 liters).
- If the oil level is above the top of the sight glass, remove some oil from the compressor to bring the oil level down to the middle of the sight glass.
  a. Close the main suction service valve, the economizer suction service valve, and the discharge service valve to isolate the compressor from the system.
  b. Recover the refrigerant remaining in the compressor.
  c. Carefully loosen the drain plug (see Figure 19 on page 82) and allow oil to slowly drain from the compressor until the oil level is at the middle of the sight glass.
  d. Tighten the drain plug.
  e. Backseat the service valves.
  f. Check the refrigerant charge and the oil level. Adjust as necessary.

STP04 Adding Compressor Oil

NOTE: Use only Ester base refrigeration compressor oil P/N 203-515.

1. Close the main suction service valve, the economizer suction service valve, and the discharge service valve to isolate the compressor from the system.
2. Recover the refrigerant remaining in the compressor.
3. Remove the discharge service valve, or the small plug near the discharge service valve, from the top of the compressor.
4. Pour the required amount of compressor oil into the compressor. Use oil from a capped contained. DO NOT use oil from an open container.
5. Install the service valve, or the plug, with a new O-ring.
6. Pressurize the compressor and test for leaks. If no leaks are found, evacuate the compressor.
7. Backseat the service valves.
8. Check the refrigerant charge and the oil level. Adjust as necessary.



1.	Add Oil Through Discharge Port or Small Plug on Top of Sump
2.	Sight Glass
3.	1.4 Quarts (1.3 Liters) Level
4.	0.9 Quarts (0.8 Liters) Level
5.	Drain Plug

Figure 2: Checking Compressor Oil Level

Oil Level Chart

Box Temp. F (C)	Ambient Temp. F (C)	Oil In System qts (liters)	Oil In Compressor Not in Sump qts (liters)	Oil in Compressor Sump qts (liters)	Oil Level Viewed Through Compressor Sight Glass
–20 to 70 (–29 to 21)	Above 50 (10)	0.1 to 1.1 (0.1 to 1.0	0.3 (0.3)	1.4 to 2.4 (1.3 to 2.3)	At or above the top of the sight glass
–20 to 70 (–29 to 21)	Below 50 (10)	1.1 to 1.4 (1.0 to 1.3)	0.3 (0.3)	1.1 to 1.4 (1.0 to 1.3)	From the middle of the sight glass to the top of the sight glass

STP05 Compressor Pump Down

NOTE: Never run the unit if the compressor oil is not visible in the sight glass. The compressor will not function properly if the compressor oil level is low.

NOTE: Do not run the compressor in a vacuum for more than 2 minutes.

1. Install a gauge manifold on the compressor (see “STP01 Gauge Installation” on page 78). Attach the low side gauge to the service port on the main suction service valve. Attach the high side gauge to the service port on the discharge service valve. Attach an additional low side gauge to the service port on the economizer suction service valve.
2. Use Service Test Mode [HS.C] to run the unit in High Speed Cool. See “Service Test Mode” on page 119 for specific information about the Service Test Mode.
3. Close the economizer suction service valve and the main suction service valve while the unit is running. The compressor should pump down to a 25 in. Hg vacuum (–85 kPa) within 30 seconds. If the compressor does not pump down and has the proper oil level, the compressor is defective. The compressor should pull a 25 in. Hg vacuum (–85 kPa) within 30 seconds.

   NOTE: If the pressure at the economizer suction service valve is not equal to the pressure at the main suction service valve while the compressor pumps down, one of the suction service valves may be leaking.
4. Shut the unit off. The pressures in the compressor should equalize.
5. To isolate the compressor for service:
   a. Close the discharge service valve.

   NOTE: Never close (front seat) the discharge service valve while the unit is running.

   b. Recover the refrigerant in the compressor.
   c. Compressor service may now be performed. (This includes repair or replacement of the compressor.)
6. To return the unit to service:
   a. Evacuate the compressor.
   b. Open the discharge, main suction, and economizer suction service valves.

   NOTE: Never close (front seat) the discharge service valve while the unit is running.

   c. Recharge the unit with the refrigerant recovered in step 5, and verify proper refrigerant charge level in the unit.
   d. Remove the service gauges from the unit.

STP06 Low Side Pump Down

NOTE: Never run the unit if the compressor oil is not visible in the sight glass. The compressor will not function properly if the compressor oil level is low.

NOTE: Do not run the compressor in a vacuum for more than 2 minutes.

1. Install a gauge manifold on the compressor (see “STP01 Gauge Installation” on page 78). Attach the low side gauge to the service port on the main suction service valve. Attach the high side gauge to the service port on the discharge service valve. Attach an additional low side gauge to the suction access port, which is located on the suction tube near the main suction service valve.
2. Use Service Test Mode [HS.C] to run the unit in High Speed Cool. See “Service Test Mode” on page 119 for specific information about the Service Test Mode.
3. Close the receiver tank outlet valve. The compressor should pump the low side down to a 25 in. Hg vacuum (–85 kPa).
4. To isolate the low side:
    a. Close the economizer suction service valve and the main suction service valve while the unit is running.
    b. Shut the unit Off. The pressures in the compressor should equalize. The suction access port gauge should remain near the vacuum level obtained in step 3.
5. If the suction access port gauge was unable to obtain an approximate 25 in. Hg vacuum (–85 kPa) in step 3, but the compressor does pump down in step 4, at least one of the following components is probably leaking or defective:
    - Three-Way Valve (Evaporator Side)
    - Pilot Solenoid Valve
    - Heat Check Valve
    - Receiver Tank Outlet Valve
    - External leak to the atmosphere

    A gradual rise of the suction access port gauge reading after the unit is shut down indicates a small leak in one or more of the above mentioned components.
6. To perform service functions on low side components:
    a. Equalize the pressure in the low side to slightly positive.
    b. Perform necessary repairs to low side component(s).
    c. Evacuate the low side through the suction access port. Evacuate the entire system if the refrigerant was recovered because of an external leak.
    d. Open the receiver tank outlet valve, main suction, and economizer suction service valves.
    e. Verify the proper refrigerant charge level in the unit.
    f. Remove the service gauges from the unit.

    NOTE: To return the unit to service without performing service functions on low side components, open the receiver tank outlet valve, main suction, and economizer suction service valves.

STP07 High Pressure Cut In Switch (HPCI) Test

The high pressure cut in switch (HPCI) is located in the compressor discharge service valve. This switch is used as backup for a failed discharge pressure transducer. It is connected to the HPCI and CH wires in the main wire harness. The microprocessor only uses the input from the HPCI to protect the compressor from high discharge pressures when the discharge pressure transducer fails. If the discharge pressure rises above 425 psig (2930 kPa), the HPCI closes. This signals the microprocessor that the discharge pressure is high. The microprocessor may use this information to place the unit in an auxiliary mode. Once closed, the HPCI opens when the discharge pressure drops below 325 psig (2241 kPa). This signals the microprocessor that the discharge pressure has dropped. The microprocessor may use this information to discontinue an auxiliary mode.

Use the following procedure to test the HPCI:

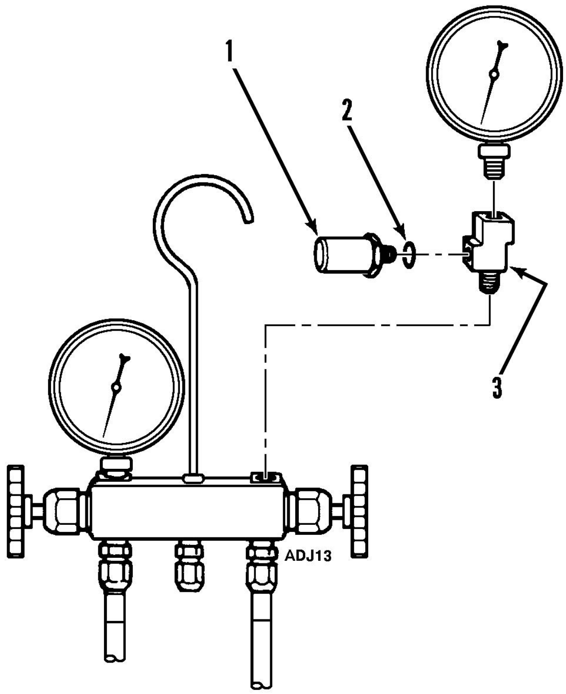
1. Install a gauge manifold on the compressor (see “STP01 Gauge Installation” on page 78).
2. Disconnect the HPCI switch from the HPCI and CH wires in the main wire harness.
3. Check the HPCI for continuity. It should be open when the unit is not running.
4. Use Service Test Mode [HS.C] to run the unit in High Speed Cool. See “Service Test Mode” on page 119 for specific information about the Service Test Mode.
5. Cover the condenser to raise the discharge pressure.
6. Monitor the discharge and suction pressures. When the discharge pressure reaches 425 ± 10 psig (2930 ± 69 kPa), the HPCI should close.
7. Uncover the condenser to lower the discharge pressure.
8. Monitor the discharge and suction pressures. When the discharge pressure reaches 325 ± 10 psig (2241 ± 69 kPa), the HPCI should open.
9. Replace the HPCI if it does not function properly.
10. Reconnect the HPCI to the main wire harness and remove the gauge manifold.

STP08 High Pressure Cutout Switch (HPCO) Test

The high pressure cutout switch (HPCO) is located in the compressor discharge service valve. It is connected to the 8PA and 8D wires in the main wire harness. If the discharge pressure rises above 450 psig (3102 kPa), the HPCO opens. This opens the 8PA-8D circuit, which de-energizes the fuel solenoid and shuts down the unit. The microprocessor then records Alarm Code 10. Test the HPCO for the following symptoms:

- The unit shuts down and records Alarm Code 10 in heat or cool without first running in an auxiliary mode.
- The high pressure relief valve vents refrigerant while the unit is running.

To test the HPCO rework a gauge manifold as shown in the “High Pressure Cutout Manifold” illustration (below) and use the following procedure:



1.	Relief Valve (66-6543)
2.	O-Ring (33-1015)
3.	Adapter Tee Weather Head (No. 552X3)

Figure 3: High Pressure Cutout Manifold

1. Connect the gauge manifold to the compressor discharge service valve with a heavy duty, black jacketed thick wall #HCA 144 hose with a 900 psig (6204 kPa) working pressure rating.
2. Use Service Test Mode [HS.C] to run the unit in High Speed Cool. See “Service Test Mode” on page 119 for specific information about the Service Test Mode.
3. Raise the discharge pressure of the compressor first by blocking the condenser coil air flow by covering the roadside condenser grille with a piece of cardboard. If this does not raise the discharge pressure to the cutout level of the HPCO, increase the engine speed by overriding the throttle solenoid, but do not exceed 2400 rpm. (This will cause Alarm Code 33 Check Engine RPM.) This should increase the discharge pressure enough to cause the HPCO to cut out. The cut out pressure should be 450 ± 7 psig (3102 ± 48 kPa).

CAUTION: If the discharge pressure reaches 477 psig (3289 kPa), shut the unit off immediately. Do not allow the discharge pressure to exceed 457 psig (3151 kPa).

4. If the HPCO does not open to de-energize the fuel solenoid and stop the engine, it must be replaced.

STP09 Three-Way Valve Test

If the three-way valve is leaking (or stuck in the middle) when the unit is in cool, the TPDF will be low, both suction lines will be warm, the main suction pressure will be high, the economizer suction pressure will be at or above the MOP, and the discharge pressure will be high.

If the three-way valve is leaking (or stuck in the middle) when the unit is in heat, the TPDF will be low, the economizer suction line will be warm, the economizer suction pressure will be low, and the discharge pressure will be low.

To check the operation of the three-way valve:

Part 1 of the test checks to see if the three-way valve shifts reliably.

1. Install a gauge manifold on the compressor (see "STP01 Gauge Installation" on page 78). Attach the low side gauge to the service port on the main suction service valve. Attach the high side gauge to the service port on the discharge service valve. Attach an additional low side gauge to the suction access port, which is located on the suction tube near the main suction service valve.
2. Place the three-way valve in the cool position by using Service Test Mode [HS.C] to run the unit in High Speed Cool. See "Service Test Mode" on page 119 for specific information about the Service Test Mode.
3. Now, shift the three-way valve to the heat position by using Service Test Mode [HS.H] to place the unit in High Speed Heat. You should hear the three way valve shift and the discharge pressure should drop. If the three-way valve does not shift, test the pilot solenoid. See "STP11 Pilot Solenoid Valve Test" on page 91. If the pilot solenoid is functioning properly and the three-way valve does not shift, repair the three-way valve.
4. Shift shift the three-way valve back to the cool position by using Service Test Mode [HS.C] to place the unit in High Speed Cool. You should hear the three way valve shift and see the discharge pressure change.
5. Repeat step 3 and step 4 a few times to make sure the three-way valve is shifting reliably. If not, repair the three-way valve.

Part 2 of the test checks to see if the three-way valve leaks to the evaporator side.

6. Front seat the three-way valve condenser pressure bypass check valve. See "STP10 Condenser Pressure Bypass Check Valve" on page 89.
7. Close the receiver tank outlet valve and pump down the low side to 20 in. Hg (-68 kPa) of vacuum.
8. Isolate the low side by closing the economizer suction service valve and the main suction service valve while the unit is running.
9. Stop the unit. The pressures in the compressor should equalize. The discharge pressure and the pressure at the suction access port should then remain stable, indicating no leaks.
10. Check the reading on the gauge attached to the suction pressure access port. If the suction pressure is rising, the three-way valve is probably leaking to the evaporator side.

    NOTE: If the heat check valve leaks, the reading on the gauge attached to the suction pressure access port will also rise. However the suction line will probably be frosty. Perform "STP26a Test for Leaking Heat Check Valve" on page 109 to verify the heat check valve is leaking.

Part 3 of the test checks to see if the three-way valve leaks to the condenser side, and checks the operation of the condenser pressure bypass check valve.

11. Without starting the unit, shift the three-way valve to the heat position by using Service Test Mode [LS.H] to place the unit in Low Speed Heat. The pressure at the suction access port should raise and the discharge pressure will drop as these pressures equalize. If these pressures rise after equalizing, the three-way

valve or the condenser pressure bypass check valve is probably leaking and the three-way valve should be repaired.

12. Back seat the condenser pressure bypass check valve stem against snap ring. The pressure at the suction access port and the discharge pressure should both rise indicating the condenser pressure bypass check valve is properly releasing condenser pressure into the discharge tube and heat circuit.

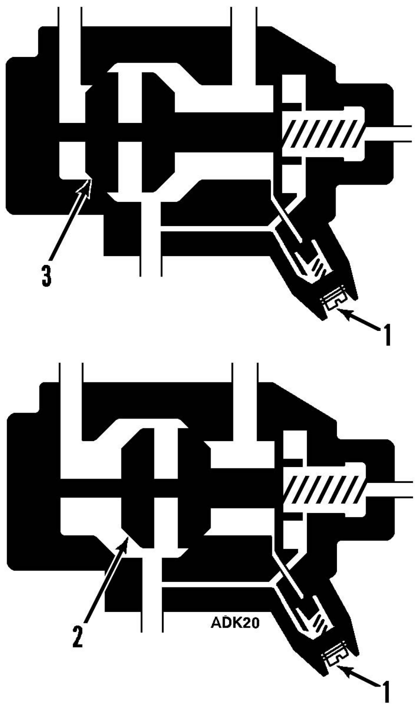
STP10 Condenser Pressure Bypass Check Valve

A three-way valve condenser pressure bypass check valve is used in this unit. This check valve controls the bypass flow of refrigerant gas between the condenser inlet line and the compressor discharge line.

The check valve is closed when the unit is running on cool, or whenever the discharge pressure is higher than the condenser pressure.

When the unit is running on defrost or heat, if the condenser pressure is higher than the discharge pressure, the check valve opens and the condenser pressure is bled off until it drops to the level of the discharge pressure. The purpose of the valve is to improve the three-way valve response time when shifting from heat to cool.

If a three-way valve does not shift back to cool immediately after the pilot solenoid closes, and finally shifts to cool when the temperature rise puts the unit into high speed, the three-way valve end cap should be checked. See “End Cap Checks” in the SB-400 Maintenance Manual TK 51113, and Service Bulletin T&T 260.



1.	Condenser Pressure Bypass Check Valve
2.	Heat/Defrost Position
3.	Cool Position

Figure 4: Condenser Pressure Bypass Check Valve

To check the operation of the condenser pressure bypass check valve:

1. Remove the condenser pressure bypass check valve cap from the three-way valve.
2. Using a screwdriver, gently turn the check valve stem in until the valve is front seated.
3. Install a gauge manifold on the compressor (see “STP01 Gauge Installation” on page 78). Attach the low side gauge to the service port on the main suction service valve. Attach the high side gauge to the service port on the discharge service valve. Attach an additional low side gauge to the suction access port, which is located on the suction tube near the main suction service valve.
4. Use Service Test Mode [HS.C] to run the unit in High Speed Cool. See “Service Test Mode” on page 119 for specific information about the Service Test Mode.
5. Close the receiver tank outlet valve and pump down the low side to 20 in. Hg (–68 kPa) of vacuum.
6. Isolate the low side by closing the economizer suction service valve and the main suction service valve while the unit is running.
7. Stop the unit. The pressures in the compressor should equalize. The discharge pressure and the pressure at the suction access port should then remain stable, indicating no leaks.
8. Without starting the unit, shift the three-way valve to the heat position using Service Test Mode [LS.H] to place the unit in Low Speed Heat. The pressure at the suction access port will raise slightly and the discharge pressure will drop to approximately zero as these pressures equalize.

9. These pressures will remain at approximately zero if the three-way valve seals properly toward the condenser and the condenser pressure bypass check valve seals properly.

10. Back seat condenser pressure bypass check valve stem against snap ring. The pressure at the suction access port and the discharge pressure should both rise indicating the condenser pressure bypass check valve is properly releasing condenser pressure into the discharge tube and heat circuit.

11. Replace the cap on the condenser pressure bypass check valve.

    NOTE: Valve stem MUST be back seated during normal unit operation.

12. Open the receiver tank outlet valve, the economizer suction service valve, the main suction service valve, remove the gauges and return the unit to normal operation.

STP11 Pilot Solenoid Valve Test

If the pilot solenoid sticks closed, the three-way valve will not shift from cool to heat. If the pilot solenoid sticks open or leaks, the three-way valve will not shift from heat to cool.

To check the operation of the pilot solenoid:

1. Use Service Test Mode [HS.C] to run the unit in High Speed Cool. See “Service Test Mode” on page 119 for specific information about the Service Test Mode.
2. Carefully check the temperature of the copper tube that goes from the pilot solenoid to the main suction line by touching it. The tube should be at about the ambient temperature. If the tube is cold, the pilot solenoid in probably leaking. If the tube is warm or hot, the pilot solenoid may be stuck open.
3. Shift the three-way valve to the heat position by using Service Test Mode [HS.H] to place the unit in High Speed Heat. You should hear the three way valve shift.
4. If the three-way valve does not shift, carefully check the temperature of the copper tube that goes from the pilot solenoid to the main suction line. The copper tube should be warming up as hot gas flows through it to the suction line.
   a. If the copper tube was warm or hot before placing the unit is High Speed Heat and is still warm or hot, the pilot solenoid is stuck open and should be replaced.
   b. If the copper tube is stays at about the ambient temperature after placing the unit is High Speed Heat, the pilot solenoid is not opening.
5. If the pilot solenoid is not opening:
   a. Check the fuses F6 and F27, and the 8F/26G and LLSPP/26P circuits to the pilot solenoid for an open circuit.
   b. If the fuses F6 and F27, and the 8F/26G and LLSPP/26P circuits are intact, check the resistance of the pilot solenoid coil. It should be approximately 17 ohms. If the coil is defective, replace it.
   c. If the pilot solenoid coil is not defective, replace the pilot solenoid valve.

STP12 Condenser Check Valve Test

If the condenser check valve sticks closed, the low side will pump down when the unit is in cool and the receiver tank sight glass will be empty because the condenser will fill up with liquid refrigerant. The unit may shut down with alarm code 93 (Low Compressor Suction Pressure) or alarm code 99 (High Compressor Pressure Ratio). The unit may shut down with alarm code 10 (High Discharge Pressure) if the ambient temperature is high.

If condenser check valve leaks or sticks open, the unit will have low TPDF in heat and the receiver tank sight glass will be empty.

The condenser check valve can also be tested with the Combined Heat Test. See “STP27 Combined Heat Test” on page 111.

To test the condenser check valve:

1. Install a gauge manifold on the compressor (see “STP01 Gauge Installation” on page 78). Attach additional low side gauge to the service port on the economizer suction service valve.
2. Use Service Test Mode [HS.C] to run the unit in High Speed Cool. See “Service Test Mode” on page 119 for specific information about the Service Test Mode.
3. Check the suction pressures and the receiver tank sight glass. If the suction pressures go into a vacuum and the receiver tank sight glass is empty, the condenser check valve is probably stuck closed. If not, go to step 4.
4. Cover the condenser to raise the discharge pressure.
5. Front seat the receiver tank outlet valve to pump down the low side.
6. Front seat the economizer suction service valve when the economizer suction pressure goes into a vacuum.
7. Remove the condenser cover.
8. Front seat the main suction service valve.
9. Turn the unit off to stop the unit.
10. Check the reading on the gauge attached to the discharge service valve. If it is rising, the condenser check valve is probably leaking.

STP13 Checking Condenser Airflow

Correct airflow through the condenser coil is critical to maintaining temperature control and preventing high discharge pressures.

If the unit has high discharge pressure check the following:

- Check for broken or loose fan belts.
- Check for debris on the condenser coil.
- Check for a dirty or plugged condenser coil.
- Check the condenser blower and its alignment.

Refer to the SB-400 Maintenance Manual TK 51113 for information about cleaning the coil, adjusting or replacing the fan belts, and the fan blower position and alignment.

STP14 Checking Evaporator Airflow

Correct airflow through the evaporator coil is critical to maintaining temperature control and proper unit operation. Reduced airflow through the evaporator coil can cause a low TPDF.

Indications of reduced airflow:

- frost or ice on evaporator coil
- low evaporator coil temperature [COIL]
- frost or ice on suction line
- unit short cycles
- unit cannot maintain temperature.

Check the following:

- trailer load shifted and is blocking the evaporator outlet or return air inlet
- debris (e.g., plastic wrap, cardboard or paper) blocking the evaporator outlet or return air inlet
- defrost damper stuck closed
- damaged or plugged ceiling ducts or chutes
- dirty evaporator coil
- damaged evaporator coil
- loose or broken fan belts
- fan blower positioned incorrectly in orifice.

Refer to the SB-400 Maintenance Manual TK 51113 for information about cleaning the coil, adjusting or replacing the fan belts, and the fan blower position and alignment.

STP15 Checking Discharge Superheat

The discharge superheat is used as a quick check, it should not be used as a definitive test. If the discharge superheat is out of the normal range, the individual components should be tested.

In Cool Mode

Normal discharge superheat in high speed cool (compressor fully loaded) is 60 to 100 F (33 to 56 C) with a box temperature of –20 to 0 F (–29 to –18 C) and an ambient temperature of 80 to 100 F (27 to 38 C).

A high discharge superheat indicates the evaporator expansion valve may be starving, the compressor may be partially or fully unloaded, or the refrigerant charge may be low.

NOTE: It is not unusual to see the discharge superheat above 150 F (83 C) in modulated cool in the fresh range when the compressor is fully unloaded.

A low discharge superheat indicates flooding that is usually caused by the following:

- Leaking or open Liquid Injection Valve
- Leaking or open Heat Check Valve
- Flooding Evaporator Expansion Valve
- Flooding Economizer Expansion Valve (only at box temperatures below 0 F (–18 C).

In Heat Mode

Normal discharge superheat in high speed heat (compressor partially loaded) is 60 to 100 F (33 to 56 C). This is not true with Software Revision 4310 if the Heat Mode Discharge Superheat Control is active. That happens when the ambient temperature is below 32 F (0 C) or the TPDF is below 7.2 F (4.0 C).

A high discharge superheat indicates the economizer expansion valve may be starving, the compressor may be fully unloaded, or the refrigerant charge may be low.

A low discharge superheat indicates flooding that may be caused by a leaking or open liquid injection valve, or a flooding economizer expansion valve.

NOTE: During normal heat modes the microprocessor energizes the liquid injection valve as necessary to maintain a consistently high heating capacity. In Software Revision 4300 and 4301 the microprocessor monitors the discharge pressure to control liquid injection. In Software Revision 4310 the microprocessor uses Heat Mode Discharge Superheat Control for liquid injection. See "Low Speed Heat" on page 34 and "Heat Mode Discharge Superheat Control" on page 48.

Procedure

1. Use the Service Test Mode [HS.C] to run the unit in high speed cool or use [HS.H] to run the unit in high speed heat. See "Service Test Mode" on page 119 for specific information about the Service Test Mode.
2. Let the unit run for at least 5 minutes to allow the pressures and temperatures to stabilize.
3. Use the **GAUGES** key on the microprocessor to check and record the compressor temperature [CTM.P] and the discharge pressure [DIS.P].
4. Calculate the superheat as follows or use the "Discharge Superheat Calculation Table" on page 96:
   a. Convert the discharge pressure to a temperature using a pressure/temperature chart for R-404A.
   b. Subtract the converted temperature from the compressor temperature. See the following example.

Example:

Discharge Pressure =	390 psig (2689 kPa)
Convert to Temperature =	390 psig = 138 F (2689 kPa = 59 C)
Converted Temperature =	138 F (59 C)
Compressor Temperature =	206 F (97 C)
Superheat =	206 F – 138 F = 68 F (97 C – 59 C = 38 C)

Discharge Superheat Calculation Table

Discharge Pressure (psig) versus Compressor Temperature (CTMP Degrees F)
= Discharge Superheat (Degrees F)

	Compressor Temperature (CTMP Degrees F)										
Discharge Pressure (psig)	**50**	**75**	**100**	**125**	**150**	**175**	**200**	**225**	**250**	**275**	**300**
50	24.8	49.8	74.8	99.8	124.8	149.8	174.8	199.8	224.8	249.8	274.8
75	12.5	37.5	62.5	87.5	112.5	137.5	162.5	187.5	212.5	237.5	262.5
100	0.9	25.9	50.9	75.9	100.9	125.9	150.9	175.9	200.9	225.9	250.9
125		15.0	40.0	65.0	90.0	115.0	140.0	165.0	190.0	215.0	240.0
150		4.7	29.7	54.7	79.7	104.7	129.7	154.7	179.7	204.7	229.7
175			20.1	45.1	70.1	95.1	120.1	145.1	170.1	195.1	220.1
200			11.2	36.2	61.2	86.2	111.2	136.2	161.2	186.2	211.2
225			3.0	28.0	53.0	78.0	103.0	128.0	153.0	178.0	203.0
250				20.4	45.4	70.4	95.4	120.4	145.4	170.4	195.4
275				13.6	38.6	63.6	88.6	113.6	138.6	163.6	188.6
300				7.4	32.4	57.4	82.4	107.4	132.4	157.4	182.4
325				1.8	26.8	51.8	76.8	101.8	126.8	151.8	176.8
350					22.0	47.0	72.0	97.0	122.0	147.0	172.0
375					17.8	42.8	67.8	92.8	117.8	142.8	167.8
400					14.3	39.3	64.3	89.3	114.3	139.3	164.3
425					11.5	36.5	61.5	86.5	111.5	136.5	161.5
450					9.3	34.3	59.3	84.3	109.3	134.3	159.3
475					7.8	32.8	57.8	82.8	107.8	132.8	157.8

(dark shading)	= LIV On
(light shading)	= LIV Pulsing On and Off
(no shading)	= LIV Off

NOTE: The shaded cells indicate where liquid injection can be active during Heat Mode Discharge Superheat Control in Software Revision 4310.

STP16 Checking Evaporator Expansion Valve Superheat

Before checking the superheat, perform the following items and repair as necessary to make sure the system is performing acceptably.

- Check the refrigerant charge.
- Check the compressor oil level.
- Check the engine speeds.
- Pump down the low side to check for leaks.
- Check the loading valves. LV1 (economizer bypass solenoid) and LV2 must be opening and closing properly.
- Inspect the evaporator and condenser coils to make sure they are clean and have good airflow.
- Check the evaporator expansion valve feeler bulb to see that it position properly, is making good contact with the suction line, and is covered with insulating tape. See “SI07 Evaporator Expansion Valve Feeler Bulb Location” on page 147.

Procedure

1. Install a gauge manifold on the compressor (see “STP01 Gauge Installation” on page 78). Attach the low side gauge (must be accurate) to the service port on the main suction service valve. Attach the high side gauge to the service port on the discharge service valve.
2. Install an accurate thermometer sensor on the suction line beside the expansion valve feeler bulb. Secure and insulate thermometer sensor.
3. Adjust the setpoint to –20 F (–29 C) and run the unit until the return air temperature displayed on the microprocessor approaches –20 F (–29 C).
4. Defrost the evaporator and allow the return air temperature to stabilize near –20 F (–29 C).
5. Use the Service Test Mode [HS.C] to run the unit in high speed cool. See “Service Test Mode” on page 119 for specific information about the Service Test Mode.
6. Cover the condenser as needed to maintain a discharge pressure of 275 to 300 psig (1896 to 2068 kPa).
7. Check and record the suction pressure and the suction line temperature simultaneously. Take four readings at 2 minute intervals.
8. Calculate the superheat for each of the four readings as follows:
   a. Convert the suction pressure to a temperature using a pressure/temperature chart.
   b. Subtract the converted temperature from the suction line temperature.

Example:

Suction Pressure =	5 psig (34 kPa)
Convert to Temperature =	5 psig = –39 F (34 kPa = –39.4 C)
Suction Line Temperature =	–30 F (–34.4 C)
Converted Temperature =	–39 F (–39.4 C)
Superheat =	–30 F – (–39 F) = 9 F (–34.4 C – [–39.4 C] = 5 C)

9. Average the four superheat values by adding them together and dividing the sum by four.
10. The average superheat value should be 3 to 9 F (1.7 to 5 C) at a return air temperature of approximately –20 F (–29 C).

STP17 Checking Economizer Expansion Valve Superheat

Before checking the superheat, perform the following items and repair as necessary to make sure the system is performing acceptably.

- Check the refrigerant charge.
- Check the compressor oil level.
- Check the engine speeds.
- Pump down the low side to check for leaks.
- Check the loading valves. LV1 (economizer bypass solenoid) and LV2 must be opening and closing properly.
- Inspect the evaporator and condenser coils to make sure they are clean and have good airflow.
- Check the economized expansion valve feeler bulb to see that it position properly, is making good contact with the suction line, and is covered with insulating tape. See “SI08 Economizer Expansion Valve Feeler Bulb Location” on page 148.

NOTE: It is normal for the economizer expansion valve to have a high superheat when the economizer suction pressure is above the MOP of 50 psig (345 kPa). The economizer suction pressure must be well below the MOP to accurately check the economizer expansion valve superheat.

Procedure

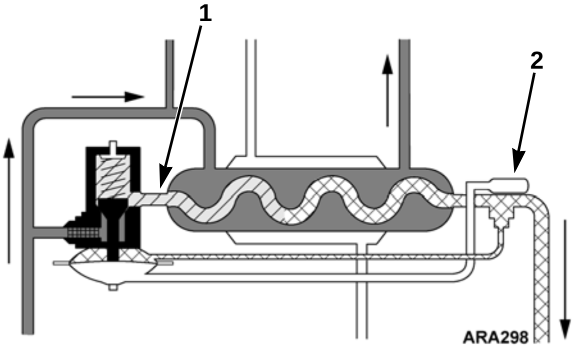
1. Install a gauge manifold on the compressor (see “STP01 Gauge Installation” on page 78). Attach the low side gauge to the service port on the main suction service valve. Attach the high side gauge to the service port on the discharge service valve.
2. Attach an additional, accurate compound gauge to the economizer suction service valve.
3. Install an accurate thermometer sensor on the suction line beside the economizer expansion valve feeler bulb. Install another accurate thermometer sensor on the tube between the economizer expansion valve and the economizer. Secure and insulate thermometer sensors.
4. Use the Service Test Mode [HS.H] to run the unit in high speed heat. See “Service Test Mode” on page 119 for specific information about the Service Test Mode.
5. Run the unit in [HS.H] high speed heat until the system pressures stabilize and the engine coolant temperature is above 140 F (60 C) (120 F [49 C] in Software Revision 4300 and 4301). The ambient temperature must be below 100 F (38 C).
6. Check and record the economizer suction service valve pressure and the suction line temperature simultaneously. Take four readings at 2 minute intervals.
7. Calculate the superheat for each of the four readings.
   a. Convert the economizer suction service valve pressure to a temperature using a pressure/temperature chart.
   b. Subtract the converted economizer suction service valve temperature from the suction line feeler bulb temperature.

Example:

Economizer Suction Service Valve Pressure =	6 psig (41 kPa)
Convert to Temperature =	6 psig = –37 F (41 kPa = –38.3 C)
Feeler Bulb Temperature =	–28 F (–33.3 C)
Converted Temperature =	–37 F (–38.3 C)
Superheat =	–28 F – (–37 F) = 9 F (–33.3 C – [–38.3 C] = 5 C)

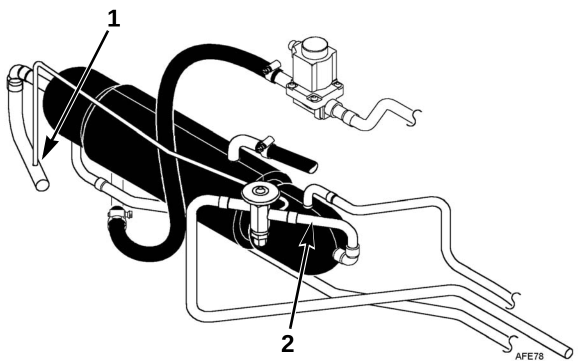
8. Average the four superheat values by adding them together and dividing the sum by four.
9. The average superheat value should be 7 to 12 F (3.9 to 6.7 C).

NOTE: The temperature at the tube between the economizer expansion valve and the economizer should be at least 10 F (5.6 C) above the feeler bulb temperature. If the temperatures are nearly the same, the expansion valve is flooding. If the temperature at the tube between the expansion valve and the economizer is 10 F (5.6 C) below the temperature at the feeler bulb, the expansion valve is starving.



1.	Tube Between Economizer Expansion Valve and Economizer
2.	Feeler Bulb

Figure 5: Economizer



1.	Feeler Bulb Location
2.	Tube Between Economizer Expansion Valve and Economizer

Figure 6: Economizer

STP18 Checking Economizer Liquid Line Temperature Differential

One of the functions of the economizer is to cool the warm liquid refrigerant that is traveling from the receiver tank to the evaporator expansion valve in the cool mode. The liquid line temperature differential is the difference between the temperature of the liquid entering the economizer and the liquid leaving the economizer. See “Economizer Liquid Line Temperature Differential Versus Box Temperature” on page 140.

Under certain conditions you can use liquid line temperature differential as a quick check of the economizer expansion valve. The liquid line temperature differential is normally –50 to –70 F (–28 to –39 C) at a box temperature of 0 to –20 F (–18 to –29 C) and an ambient temperature of 100 F (38 C). If the liquid line temperature differential is not in this range under these conditions, check the economizer expansion valve superheat (see “STP17 Checking Economizer Expansion Valve Superheat” on page 98).

A high liquid line temperature differential (–80 F [–44 C or higher) might be caused by a restriction in the low side such as a plugged evaporator expansion valve or the ETV stuck closed.

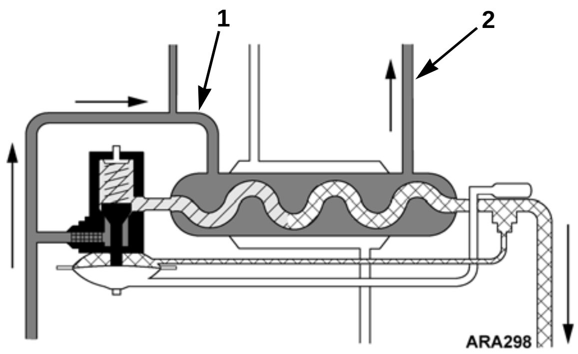
A low liquid line temperature differential (–20 F [–11 C or higher) might be caused by the water valve being stuck open in cool.

NOTE: The flow of refrigerant through the economizer expansion valve starts to decrease as economizer suction pressure approaches the MOP (50 psig [345 kPa]) of the economizer expansion valve. Therefore, the economizer suction pressure must be well below the MOP when checking the liquid line temperature differential.

To calculate the economizer liquid line temperature differential, subtract the temperature of the liquid line entering the economizer from the temperature of the liquid line leaving the economizer.

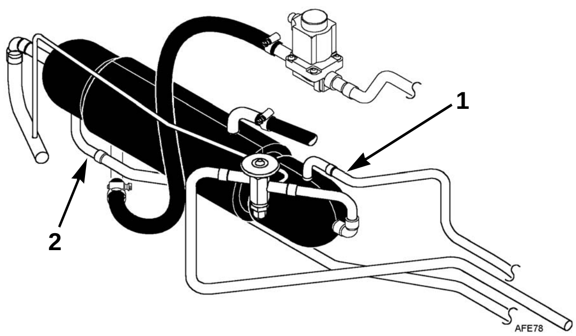
Example:

Temperature of Liquid Line Leaving Economizer	65 F (18 C)
Temperature of Liquid Line Entering Economizer	120 F (49 C)
Liquid Line Temperature Differential	65 F – 120 F = –55 F (18 C – 49 C = –31 C)



1.	Liquid Line Entering Economizer
2.	Liquid Line Leaving Economizer

Figure 7: Economizer



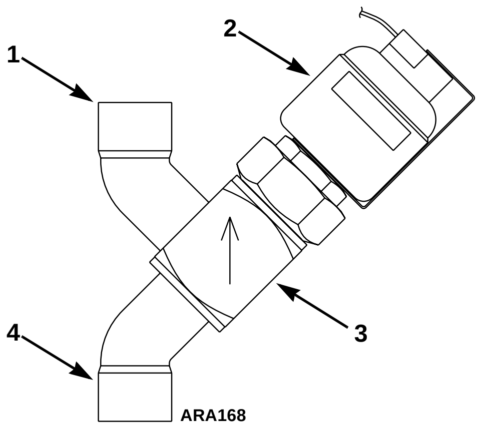
1.	Liquid Line Entering Economizer
2.	Liquid Line Leaving Economizer

Figure 8: Economizer

STP19 Checking Electronic Throttling Valve (ETV)

The ETV is located in the suction line near the evaporator outlet. The ETV has two internal coils. The microprocessor operates the valve by energizing the coils with a variable frequency ac signal. The valve position can be monitored with the GAUGE key [ETV.P]. Zero (0) indicates the valve is fully closed and 800 indicates the valve is fully open.

The microprocessor tests the ETV every time the unit is started. Alarm Code 89 indicates the refrigeration system pressures did not respond as expected during the test. This may be caused by a malfunction of the ETV or by a refrigeration system problem such as low refrigerant level, a frozen expansion valve, or a restriction in suction line. The microprocessor ignores the test results if the box temperature or the ambient temperature is below 10 F (–12 C). The ETV test can also be performed using Service Test Mode [ETV] ETV Check. See “Service Test Mode” on page 119 for specific information about the Service Test Mode.



1.	Outlet
2.	Stepper Motor
3.	Valve Body
4.	Inlet

Figure 9: Electronic Throttling Valve

Use the GAUGE key to check the operation of the ETV during the ETV test. The valve position [ETV.P] should be 0 at the start of the test when the valve is fully closed, and should go to a higher value when the valve is opened. The suction pressure [SUC.P] should decrease while the valve is fully closed, and should begin to increase when the valve is opened.

Refer to Service Procedure G03A, the Electronic Throttling Valve (ETV) Test, in the THERMOGUARD µP-VI Microprocessor for Screw Compressor Applications Diagnostic Manual TK 51329, and Alarm Code 89 for more information about the testing and operation of the ETV.

STP20 Checking Pressure Transducers

The discharge pressure transducer and the suction pressure transducer supply pressure information to the microprocessor. These pressures can be monitored with the GAUGE key. [SUC.P] is the suction pressure. [DIS.P] is the discharge pressure. The readings can be checked by comparing them to the readings on a calibrated gauge manifold set attached to the compressor.

- The suction pressure transducer reading should within 7 psig (48 kPa) of the low side gauge reading.
- The discharge pressure transducer reading should within 17.5 psig (121 kPa) of the high side gauge reading.
- The the suction and discharge pressure transducer readings should be within 5 psig (34 kPa) when the suction and discharge pressures have been equalized.

Refer to Service Procedure D03A, the Pressure Sensor Test, in the THERMOGUARD µP-VI Microprocessor for Screw Compressor Applications Diagnostic Manual (TK 51329), and Alarm Codes 87 and 109 for more information about the testing and operation of the pressure transducers.

STP21 Loading Valve Test

Use the following procedure to test LV1 (economizer bypass solenoid) and LV2. The procedure first tests LV1 and then tests LV2. LV2 cannot be tested properly unless LV1 is functioning correctly.

NOTE: If you decide to replace a solenoid valve, check the openings in the valve holder to make sure that a plugged opening is not causing the valve to malfunction. Repeat the Loading Valve Test after replacing a solenoid valve. If the loading valve still malfunctions, its piston may be sticking in the discharge housing and should be inspected.

Before testing the loading valves, check the loading valve coils to make sure they are in the correct position and snapped on tightly. LV2 should be on top. It has a square 4-pin connector. LV1 should be on the bottom and has a triangular 3-pin connector.

1. Install a gauge manifold on the compressor (see “STP01 Gauge Installation” on page 78). Attach the low side gauge to the service port on the main suction service valve. Attach the high side gauge to the service port on the discharge service valve.
2. Connect an extra compound gauge to the economizer suction service valve.
3. Use Service Test Mode [LS.C] to run the unit in Low Speed Cool. See “Service Test Mode” on page 119 for specific information about the Service Test Mode.
4. Monitor the discharge and suction pressures. Let the unit run until the pressures stabilize and note the pressures.
5. Use Service Test Mode [LSC.P] to place the unit in Low Cool Partial Load. This opens LV1 (economizer bypass solenoid). The main suction pressure should rise and the economizer suction pressure should fall. The main suction pressure should stabilize a minimum of 5 psig (34 kPa) below the economizer suction pressure.

   If the pressures do not change acceptably, LV1 is not opening.

   a. Check the 8F/EVBPP and EBV circuits to LV1 for an open circuit.

   b. If the 8F/EVBPP and EBV circuits are intact, check the current draw of the LV1 coil. It should be approximately 1.5 amps. If the coil is defective, replace it.

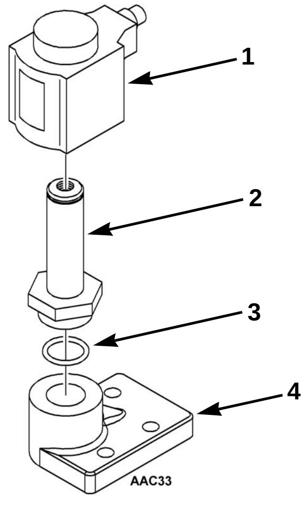
   c. If the LV1 coil is not defective, replace the solenoid valve.
6. Use Service Test Mode [LSC.U] to place the unit in Low Cool Unloaded. This opens LV2. The main suction pressure and the economizer suction pressure should both rise, and the discharge pressure should fall. The main suction pressure should stabilize a minimum of 5 psig (34 kPa) below the economizer suction pressure.

   If the pressures do not change acceptably, LV2 is not opening.

   a. Check the 8F/ULPP and UL circuits to LV2 for an open circuit.

   b. If the 8F/ULPP and UL circuits are intact, check the current draw of the LV2 coil. It should be approximately 1.5 amps. If the coil is defective, replace it.

   c. If the LV2 coil is not defective, replace the solenoid valve.



1.	Coil	3.	O-Ring
2.	Armature Tube	4.	Body

Figure 10: Exploded View of LV1 and LV2

STP22 Liquid Line Solenoid Test

Use the following procedure to test the LLSV (Liquid Line Solenoid).

1. Install a gauge manifold on the compressor (see “STP01 Gauge Installation” on page 78). Attach the low side gauge to the service port on the main suction service valve. Attach the high side gauge to the service port on the discharge service valve.
2. Start the unit.
3. Use Service Test Mode [LLS.T] to run the Liquid Line Solenoid Valve Service Test. See “Service Test Mode” on page 119 for specific information about the Service Test Mode.

   NOTE: If alarm codes 87 or 89 are active, [LLS.T] will not appear when scrolling through the Service Test Mode screens.
4. Approximately 30 seconds after the test starts, the microprocessor will check the suction pressure.
   a. If the suction pressure is above –3 psig (–21 kPa) (–5 psig [–34 kPa] in Software Revision 4300 and 4301), the test will continue. See step 5.
   b. If the suction pressure is below –3 psig (–21 kPa) (–5 psig [–34 kPa] in Software Revision 4300 and 4301), the engine will stop running and LO SP (Low Suction Pressure) will appear in the upper display. This indicates the main suction pressure is lower than expected and the LLSV may be stuck closed. Check the LLS circuit for a short to ground, and check for other causes of low main suction pressure. If the LLS circuit is not shorted to ground, and there are no other causes of low main suction pressure, replace the LLSV.
5. The microprocessor will then energize (close) the LLSV.
6. Approximately 2 minutes after the LLSV is energized, the microprocessor will check the suction pressure.
   a. If the suction pressure is below –3 psig (–21 kPa) (–5 psig [–34 kPa] in Software Revision 4300 and 4301), the engine will stop running and PASS will appear in the upper display. This indicates the LLSV is functioning properly.
   b. If the suction pressure is above –3 psig (–21 kPa) (–5 psig [–34 kPa] in Software Revision 4300 and 4301), the engine will stop running and FAIL will appear in the upper display. This indicates the main suction pressure is higher than expected and the LLSV may not be closing.
      - Check the LLS and LLSPP circuits for open circuits.
      - If the LLS and LLSPP circuits are intact, check the current draw of the LLSV coil. It should be approximately 1.5 amps. If the coil is defective, replace it.
      - If the LLSV coil is not defective, check for other causes of high main suction pressure. If there are no other causes of high main suction pressure, replace the LLSV.

STP23 Liquid Injection Valve Test

Use the following procedure to test the LIV (Liquid Injection Valve).

1. Install a gauge manifold on the compressor (see “STP01 Gauge Installation” on page 78). Attach the low side gauge to the service port on the main suction service valve. Attach the high side gauge to the service port on the discharge service valve.
2. Use Service Test Mode [LS.C] to run the unit in Low Speed Cool. See “Service Test Mode” on page 119 for specific information about the Service Test Mode.
3. Monitor the discharge and suction pressures and let the unit run until the pressures stabilize.
4. Use Service Test Mode [LIV] to place the unit in Liquid Injection Mode. This opens and closes the LIV at 3 seconds intervals. The main suction pressure should rise when LIV opens, and fall when LIV closes. Use the Valve Position Displays to see when the valve opens and closes (see “SI02 Valve Position Displays” on page 142).

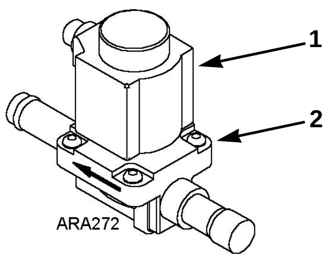
   If the main suction pressure does not rise and fall at 3 seconds intervals, LIV is not opening and closing.

   a. Check the LQI and LQIPP circuits to LIV for open or short circuits.
   b. If the LQI and LQIPP circuits are intact, check the current draw of the LIV coil when energized. It should be approximately 1.5 amps. If the LIV coil is defective, replace it.
   c. If the LIV coil is not defective, replace the solenoid valve.

STP24 Water Valve Test

The water valve (EWSV) is a normally closed valve. It is located on the bulkhead above the engine. The water valve is opened (after a 90 second delay) during heat and defrost. This supplies hot engine coolant to the economizer, where the heat is transferred to the refrigerant to increase the heating capacity. Test the water valve for the following symptoms:

- The unit records Alarm Code 39 (Water Valve) and the water valve circuits are not faulty.
- The unit records Alarm Code 26 (Check Refrigeration Capacity) and either the heating capacity or the cooling capacity is low.



1.	Coil
2.	Body

Figure 11: Water Valve

To test the water valve use the following procedure:

1. Use Service Test Mode [HS.C] to run the unit in High Speed Cool. See “Service Test Mode” on page 119 for specific information about the Service Test Mode.
2. Use the microprocessor to monitor the engine coolant temperature.
3. Let the unit run until the engine coolant temperature rises above 140 F (60 C).
4. Carefully check the temperature of the hose and the copper tube attached to the water valve by touching them. Do not grab a hose. It may be hot enough to burn you.
5. The hoses and copper tube may be warm, but they should not be hot. If the hoses are hot, the water valve is probably stuck open. That would reduce the cooling capacity of the unit.
6. Use Service Test Mode [HS.H] to place the unit in High Speed Heat.
7. The water valve should open after a 90 second delay.
8. Use the Valve Position Displays (see “SI02 Valve Position Displays” on page 142) to see when the EWSV opens and use the **GAUGES** key to check the engine coolant temperature. If the EWSV is functioning properly, the engine coolant temperature should momentarily drop 5 to 7 F (3 to 4 C) when the EWSV opens.
9. Carefully check the temperature of the hoses attached to the water valve by touching them. Do not grab a hose. It may be hot enough to burn you.
10. The hoses should be warming up and soon get almost as hot as the engine coolant.
    a. If the hoses do not get hot, the water valve is probably not opening. That would reduce the heating capacity of the unit. Check the current draw of the water valve coil. It should be approximately 1.5 amps. If the water valve coil is defective, replace it. If the water valve coil is not defective, replace the whole water valve.
    b. If the hoses were already hot in step 5, and did not get much hotter in step 9, the water valve is probably stuck open. Replace it.

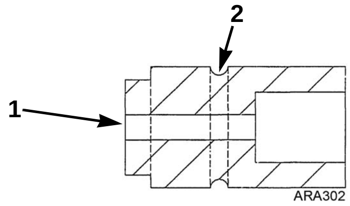
STP25 Heating Bypass Orifice Tests

STP25a Checking for Oversized Heating Bypass Orifice

NOTE: The heating bypass orifice and some related components were changed in the first quarter of 2004. An oversized heating bypass orifice should not be a problem with the late style heating bypass orifice because its size is consistent. See "SI09 Heating Bypass Orifice Identification" on page 149 for more information.

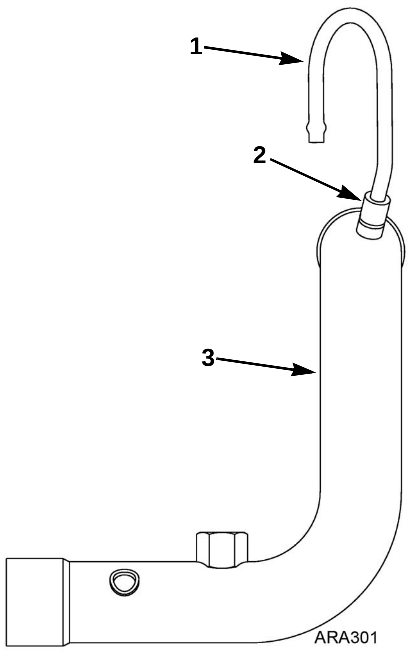
An oversized heating bypass orifice can cause high compressor temperatures when the unit is running in heat or defrost.

The correct early style heating bypass orifice has an inside diameter of 0.09 in. (2.29 mm) and a groove around the outside to identify it. A unit with an oversized heating bypass orifice can have a high compressor temperature when running in heat or defrost, may run in compressor temperature control auxiliary mode, and might record alarm codes 81 and 82. If you have a unit that runs high compressor temperatures in heat and defrost, but not in cool, check the heating bypass orifice to make sure it has a groove around it.



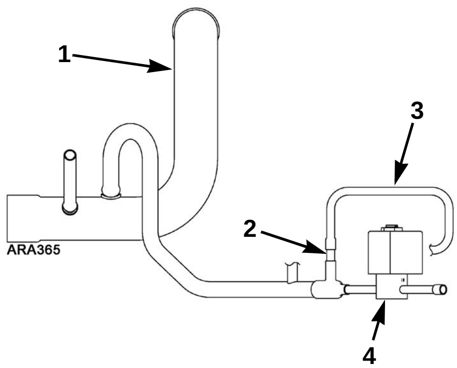
1.	Inside Diameter of 0.09 in. (2.29 mm)
2.	Groove (for Identification)

Figure 13: Cross Section of Early Style Heating Bypass Orifice



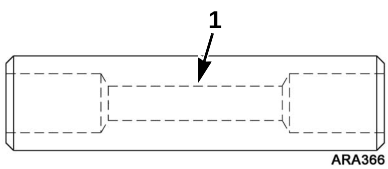
1.	Tube from Hot Gas Line
2.	Heating Bypass Orifice
3.	Main Suction Line

Figure 12: Early Style Heating Bypass Orifice Location on Condenser Side of Bulkhead



1.	Main Suction Line
2.	Heating Bypass Orifice
3.	Tube from Hot Gas Line
4.	Pilot Solenoid

Figure 14: Late Style Heating Bypass Orifice Location on Condenser Side of Bulkhead



1.	Inside Diameter of 0.09 in. (2.29 mm)

Figure 15: Late Style Heating Bypass Orifice

STP25b Test for Plugged Heating Bypass Orifice

Use the following procedures to test for a plugged heating bypass orifice. A plugged heat bypass orifice can make it look like the unit is low on refrigerant and cause low TPDFs in cool.

1. Use Service Test Mode [OFC.T] to run the Heat Orifice Flow Check Test. See “Service Test Mode” on page 119 for specific information about the Service Test Mode.
2. Use the **GAUGES** key on the microprocessor to check the suction pressure [SUC.P].
3. If suction pressure pumps down into a vacuum, the heat bypass orifice is plugged.

STP26 Heat Check Valve Tests

STP26a Test for Leaking Heat Check Valve

The heat check valve prevents refrigerant from entering the heat circuit when the unit is in cool. If the heat check valve fails, it may leak so much that a temperature difference across the valve is not noticeable. This fills the heat circuit with liquid. The liquid evaporates as it passes through the heating bypass orifice between the hot gas line and the suction line. This causes heavy frost accumulation on the main suction line between the heating bypass orifice and the compressor. A leaking heat check valve may cause the following symptoms:

- The unit records Alarm Code 26 (Check Refrigeration Capacity) and the cooling capacity is low.
- The unit shuts down and records Alarm Code 32 (Refrigeration Capacity Low).
- Heavy frost accumulation on the main suction line to the compressor while the unit is in cool.
- The low side will not pump down into a deep vacuum, but the compressor will.
- The compressor oil looks milky.

There is no absolute test for the heat check valve. Instead, look for a pattern of symptoms using the following procedure. The "STP27 Combined Heat Test" on page 111 can also be used to test the heat check valve.

1. Install a gauge manifold on the compressor (see "STP01 Gauge Installation" on page 78). Attach the low side gauge to the service port on the main suction service valve. Attach the high side gauge to the service port on the discharge service valve.
2. Use Service Test Mode [HS.C] to run the unit in High Speed Cool. See "Service Test Mode" on page 119 for specific information about the Service Test Mode.
3. Check for a temperature difference across the heat check valve by feeling the tubes on both sides of the valve. A temperature difference indicates a small leak. A faulty heat check valve may leak so much that a temperature difference across the valve is not noticeable.
4. Check the refrigerant charge. A leaking heat check valve allows liquid refrigerant to accumulate in the heat circuit. This causes the refrigerant charge to appear low.
5. Close the receiver tank outlet valve to pump down the low side. A leaking heat check valve will usually prevent the low side from pumping down into a vacuum.
6. Open the receiver tank outlet valve and run the unit in high speed cool.
7. Check the main suction line to the compressor. A leaking heat check valve may cause a heavy accumulation of frost on the main suction line between the heating bypass orifice and the compressor.
8. Remove the lower evaporator access panel and check the suction line from the evaporator to the bulkhead for frost. If the heat check valve is leaking, this part of the suction line should be free of frost. There may be a little frost on the suction line right where it enters the bulkhead. If so, it is from liquid passing through the heating bypass orifice on the other side of the bulkhead.
9. Assume the heat check valve is leaking if the following symptoms were confirmed during the test procedure:
   - Low refrigerant charge.
   - Low side will not pump down into a vacuum.
   - Heavy frost on the main suction line between the heating bypass orifice and the compressor, but not between the evaporator and the heating bypass orifice.

STP26b Test For Closed Heat Check Valve

If the heat check valve is stuck closed, it will not affect the operation of the unit in cool. However, in heat, a heat check valve that is stuck closed will cause high discharge pressures and the unit will go into the High Discharge Pressure Control auxiliary mode. Use the following procedure to test for a heat check valve that is stuck closed.

1. Install a gauge manifold on the compressor (see “STP01 Gauge Installation” on page 78). Attach the low side gauge to the service port on the main suction service valve. Attach the high side gauge to the service port on the discharge service valve. Attach an additional high side gauge to the service port on the receiver tank outlet valve.
2. Use Service Test Mode [HS.H] to run the unit in High Speed Heat. See “Service Test Mode” on page 119 for specific information about the Service Test Mode.
3. If the heat check valve that is stuck closed you will see the discharge pressure rise quickly, but the receiver tank pressure will not rise. If the receiver tank pressure rises with the discharge pressure, the heat check valve is not stuck closed, but there is probably a restriction in the liquid line. At a discharge pressure of approximately 415 psig (2861 kPa) the unit will shift the three-way valve to the cool position to lower the discharge pressure. The discharge pressure will then start to drop. When the discharge pressure drops enough, the unit will shift the three-way valve back to the heat position. The discharge pressure will rise and the cycle will be repeated with the three-way valve shifting back and forth between heat and cool. The unit may shut down on for Alarm Code 10 High Discharge Pressure.

STP27 Combined Heat Test

The Combined Heat Test is a Service Test Mode used to check a unit with low heating capacity. The Combined Heat Test will check the condenser check valve and condenser side of the three-way valve for leaks that will affect unit heating capacity. See “Service Test Mode” on page 119 for specific information about the Service Test Mode.

1. Install a gauge manifold on the compressor (see “STP01 Gauge Installation” on page 78). Attach additional low side gauges to the service port on the economizer suction service valve and the suction pressure access port. Attach an additional high side gauge to the service port on the receiver tank outlet valve.
2. Front seat the three-way valve condenser pressure bypass check valve. See “STP10 Condenser Pressure Bypass Check Valve” on page 89. If you do not close this valve, the unit will fail the CHT.D part of this test.
3. Start the unit and wait for the unit to finish the ETV/Loading Valve Check.
4. Enter the Service Test Mode. See “Operating the Service Test Mode” on page 121.
5. Repeatedly press the **UP ARROW** key until CHT.A appears on the display.
6. Press the **ENTER** key to place the unit in the Combined Heat Test. CHT.A will remain on the display. The unit should be running in high speed cool.
7. Cover the condenser to raise and maintain the discharge pressure at 300 to 350 psig (2068 to 2413 kPa).
8. Front seat the receiver tank outlet valve to pump down the low side to 0 psig (0 kPa).
9. Remove the condenser cover to reduce the discharge pressure.
10. Press the **UP ARROW** key. CHT.B will appear on the display and the unit should shift to low speed, and LLSV, LV1, and LV2 should close.
11. Front seat the economizer suction service valve when the economizer suction pressure goes into a vacuum.
12. Front seat the main suction service valve.
13. When the discharge pressure has dropped approximately 100 psig (689 kPa), press the **UP ARROW** key. CHT.C will appear on the display and the engine should stop running.
14. Check the reading on the gauge attached to the discharge service valve. A pressure increase indicates a leaking condenser check valve.
15. Press the **UP ARROW** key. CHT.D will appear on the display, the pilot solenoid should energize and the three-way valve should shift to heat.
16. The pressure at the suction access port should rise and the discharge pressure should drop as these pressures equalize. If these pressures rise after equalizing, the condenser side of the three-way valve, or the condenser pressure bypass check valve is probably leaking.
17. Back seat the condenser pressure bypass check valve stem against the snap ring. The pressure at the suction access port and the discharge pressure should both rise indicating the condenser pressure bypass check valve is properly releasing condenser pressure into the discharge tube and heat circuit.
18. Place the unit On/Off switch in the Off position to stop the Combined Heat Test.

STP28 Compressor Test

The following symptoms often occur when the compressor is failing and its capacity is low:

- The unit records Alarm Code 26 (Check Refrigeration Capacity) and the heating capacity and/or the cooling capacity is low.
- The unit shuts down and records Alarm Code 32 (Refrigeration Capacity Low).
- The unit records Alarm Code 81 (High Compressor Temperature Check).
- The unit shuts down and records Alarm Code 82 (High Compressor Temperature Shutdown).
- The unit shuts down and records Alarm Code 63 (Engine Stopped - Reason Unknown). This occurs if the compressor locks up.
- The unit records Alarm Code -67 (Liquid Line Solenoid Circuit) and the Liquid Line Solenoid is functioning properly.

Use the following procedure, and to the Compressor Test Flowchart on pages 115 and 116, to test the compressor:

1. Download the Data Logger and check for the following items. They are often associated with a defective compressor and may indicate a defective compressor if the rest of the system is in good condition.
   a. Alarm Codes 26, 32, 63, 67, 81, and 82.
   b. An evaporator temperature differential (TPDF) less than –10 F (–6 C) while the unit is running in high speed cool with a box temperature of 35 F (2 C) and an ambient temperature of 90 F (32 C).

   NOTE: The TPDF should be negative when the unit is running in cool. A temperature differential less than –10 F (–6 C) means less negative. For example, a TPDF of –9 F (–5 C) is less than a TPDF of –10 F (–6 C).

   c. Compressor temperatures (CTMP) above 250 F (121 C) while the unit is running in high speed cool with a box temperature of 35 F (2 C) and an ambient temperature of 90 F (32 C).
2. Install a gauge manifold on the compressor (see “STP01 Gauge Installation” on page 78) and connect an extra compound gauge to the economizer suction service valve. Make sure the gauge attached to the economizer suction service valve is calibrated correctly.
3. Use the Service Test Mode [HS.C] to run the unit in high speed cool. See “Service Test Mode” on page 119 for specific information about the Service Test Mode.
4. Check the compressor oil level and condition.
   a. If compressor oil level is below the bottom of the sight glass, add oil and recheck the oil level and condition.
   b. Light brown compressor oil indicates slight acidity. Dark brown compressor oil indicates acidity, copper plating, and possible high compressor temperatures. If the compressor oil is clear to dark brown, go to step 5.
   c. Gray compressor oil indicates metal contamination. The compressor is probably defective if the oil is gray. Go to step 17.
5. Check the refrigerant charge.
   a. If the refrigerant charge is low or high, repair and recharge the unit, then go to step 6.
   b. If the refrigerant charge is correct, go to step 6.

   NOTE: For steps 6 through 9 the trailer temperature must be warm enough to develop over 17 psig (117 kPa) of suction pressure at the main suction service valve.
6. Use Service Test Mode [HS.C] to run the unit in high speed cool.

7. Cover the condenser to raise the discharge pressure to 400 psig (2758 kPa).

8. Close the main suction service valve slowly to reduce the main suction pressure to 16 psig (110 kPa).

   NOTE: If you cannot raise the discharge pressure to 400 psig (2758 kPa), make sure you have at least 16 psig (110 kPa) of main suction pressure. If not, the trailer is still too cool or the system is causing the capacity loss. Check for another problem that causes low main suction pressure. If you cannot raise the discharge pressure to 400 psig (2758 kPa) with a main suction pressure of 16 psig (110 kPa) or higher, the compressor is probably defective.

9. With the discharge pressure at 400 psig (2758 kPa) and the main suction pressure at 16 psig (110 kPa), close (front seat) the economizer suction service valve. When the economizer suction service valve is closed, the gauge attached to it is reading the pressure inside the compressor, not the economizer suction pressure.

   a. A pressure of 20 psig (138 kPa) or less indicates the compressor is good and you can stop the test.

   b. A pressure of 20 to 23 psig (138 to 159 kPa) indicates the compressor is probably good, but you should continue the test. Go to step 10.

   c. A pressure above 23 psig (159 kPa) indicates the compressor is probably defective. The higher the pressure, the less capacity the compressor has.

10. Open the main suction service valve back up to the port position.

11. Make sure the discharge pressure is still approximately 400 psig (2758 kPa).

12. Check and record the CTMP with the unit in high speed cool and the box temperature as close as possible to 20 F (–7 C).

13. Use Service Test Mode [LS.C] to run the unit in low speed cool.

14. If necessary, adjust the cover on the condenser to obtain a discharge pressure of approximately 400 psig (2758 kPa).

15. Check and record the CTMP after about 15 minutes with the unit in low speed cool and the box temperature as close as possible to 20 F (–7 C).

16. Compare the CTMP obtained in step 12 (high speed cool) to the CTMP obtained in step 15 (low speed cool).

    a. If the difference between the CTMPs is more than 60 F (16 C), the compressor is probably defective.

    b. If the difference between the CTMPs is 60 F (16 C) or less, the compressor is probably not defective.

17. If you think the compressor is defective, remove the compressor sump and check for metal shavings.

    a. Shut the unit off.

    b. Close the main suction service valve, the economizer suction service valve, and the discharge service valve to isolate the compressor from the system.

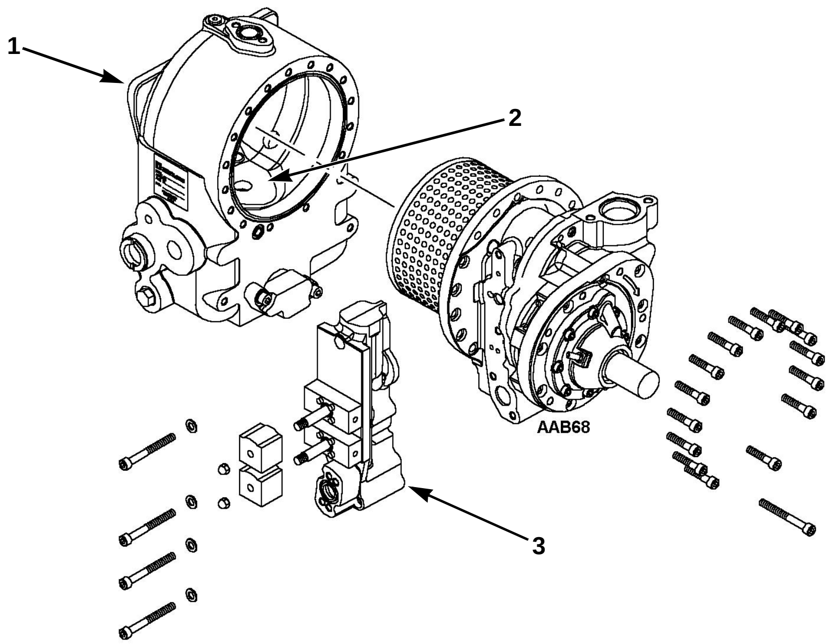
    c. Recover the refrigerant from the compressor.

    d. Disconnect the service valves from the compressor and remove the compressor from the unit.

    e. Remove the valve holder from the compressor.

    f. Remove the sixteen Allen screws that attach the sump to the compressor. Fifteen 8 X 1.25 X 35 mm screws are located in the flange on the rotor housing. One 8 X 1.25 X 70 mm screw is located at the bottom of the rotor housing.

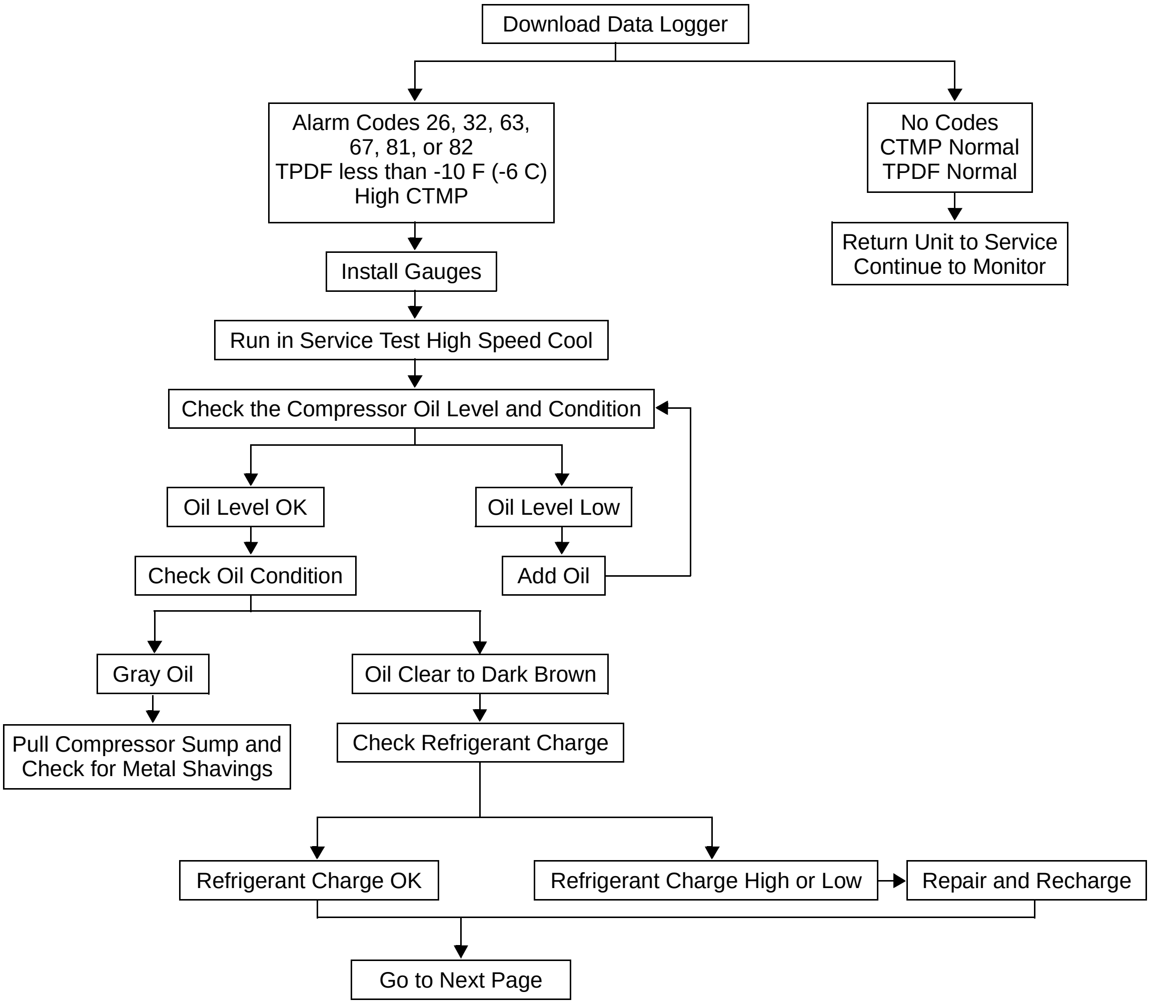
g. Remove the sump and check it for metal shavings. Shavings tend to accumulate on the shelf in the lower part of the sump between the oil separator and the oil filter. Some shavings are usually present. If there are enough shavings to cover a finger size magnet passed around the shelf, the compressor is defective. Repair or replace the compressor.



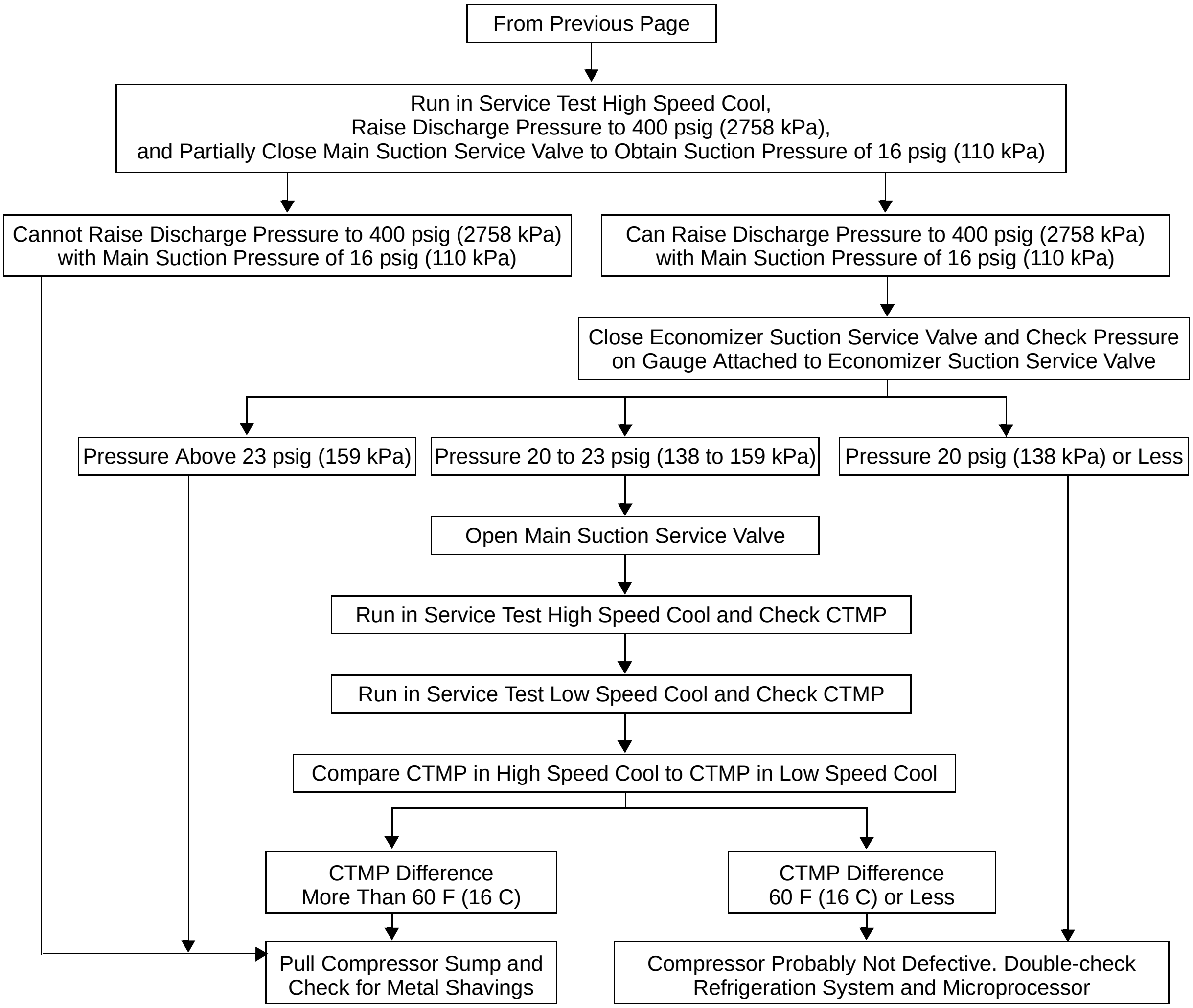
1.	Sump
2.	Check Shelf for Metal Shavings
3.	Valve Holder

Remove Sump

Compressor Test Flow Chart



Compressor Test Flow Chart (Continued)



STP29 Diagnosing Moisture in the Refrigeration System

When a refrigeration system becomes saturated with moisture and the drier has absorbed as much as it can, the moisture starts to condense at the expansion valve seat because it is cold. If the unit is running at a low enough box temperature, the moisture eventually freezes and completely closes off the expansion valve. Previous units would then pump into a deep vacuum, but the SB-400 will go into the suction pressure control auxiliary mode or the compression ratio control auxiliary mode in an attempt to raise the suction pressure or lower the compression ratio. If the SB-400 cannot keep the suction pressure above a 12 inch vacuum [–6 psig (–41 kPa)], it will shutdown on alarm code 93 (Low Compressor Suction Pressure). If the SB-400 cannot keep the compression ratio below 25:1, it will shutdown on alarm code 99 (High Compressor Pressure Ratio).

An SB-400 unit that runs in suction pressure control or compression ratio control (and possibly records alarm code 93 or 99) at low box temperatures, but not at higher box temperatures, the unit may have moisture in the system.

With a reciprocating compressor, it was easily diagnosed by shutting the unit off and watching the vacuum. If it stayed down, it was probably moisture. If it rose, it probably was some type of low side obstruction or a failed expansion valve. The final check was to let the unit set for a while, or use warm wet rags on the valve. The ice would melt, and the vacuum would rise.

This is not the case in a screw compressor unit. If a screw compressor unit is in a deep vacuum and you turn it off, even if the expansion valve is completely blocked with ice, the vacuum will rise because the high side will slowly bleed back through the compressor into the main suction line, and the economizer expansion valve will feed backwards through the compressor into the main suction line. Either way, the vacuum quickly disappears, so the last thing you would suspect is a frozen expansion valve.

Another factor involved in a moisture diagnosis of a screw compressor unit is the liquid line solenoid. The solenoid is designed to fail in an open position, but if for some reason it should stick closed, it would look like a frozen expansion valve. On a SB-400 unit, a liquid line solenoid that is stuck closed should record alarm code –67 (Liquid Line Solenoid Circuit) during a pretrip test.

To check a screw compressor system for a frozen expansion valve use the following procedure:

1. Check the dry-eye that surrounds the receiver tank sight glass. If it is a full yellow color, there is probably moisture in the system. If it is a yellow/green mix, there may be moisture, but probably not enough to cause a frozen expansion valve.
2. If the unit runs in suction pressure control or compression ratio control, or has recorded alarm codes 93 or 99, use Service Test Mode [DE.F] to run the unit in defrost. Unlike a standard unit, the screw compressor unit will heat very well with a frozen expansion valve. Switch the unit back to [HS.C] high speed cool occasionally to see if the ice has melted in the valve and the suction pressure has returned to normal. If the suction pressure does not rise before the unit times out of Service Test Mode, the problem is something other than moisture. If the suction pressure does rise and the unit resumes normal cooling the problem is moisture in the refrigerant.

To thoroughly dry a known wet refrigeration system unit use the following triple evacuation procedure:

1. Follow the instructions given in Service Bulletin T&T 061 (Oct. 9, 1992) on setting up and testing the evacuation equipment. Use the three-point evacuation process described in the bulletin.

2. Do not recharge the unit as required by Step 13 under Unit Evacuation. Instead, break the vacuum with dry nitrogen up to 0 psig (0 kPa) pressure. Let the nitrogen remain in the system for at least five minutes. The dry nitrogen will absorb part of the water vapor in the system.
3. Re-evacuate the system down to at least 1500 microns. Hold 1500 microns or below for at least fifteen minutes.
4. Break the vacuum to 0 psig (0 kPa) with nitrogen again. Leave the nitrogen in for at least five minutes. The first charge of nitrogen can only pick up half of the water vapor so this charge will pick up half of the remaining half.
5. Re-evacuate to 1500 microns for fifteen minutes. Break the vacuum to 0 psig (0 kPa) with dry nitrogen again. This charge picks up half of the remaining water vapor again. By now, almost 90% of the water vapor has been removed.
6. Do a final evacuation to 1500 microns and charge the unit by weight following the steps given in the Unit Charging section of T&T 061.

NOTE: The refrigerant you removed is contaminated with moisture. You must use the drying function of your recycling machine to dry the refrigerant or you should use fresh, dry, refrigerant.

7. Run the unit for at least thirty minutes, then pump down the low side and install a new drier.

Service Information

SI01 Temperature Differential

Definition

The temperature differential (TPDF) is the difference in temperature between the air entering the evaporator coil and the air leaving the evaporator coil. It is also called the temperature difference, Delta T, TD, and can be written as “ΔT.” You will most often see the term TPDF or TD.

Determining Temperature Differential

The temperature differential is measured as the difference between discharge air temperature (DAT) and return air temperature (RAT). It is calculated by subtracting the RAT from the DAT. If the unit is in Cool mode, the differential should be a negative number. If the unit is in Heat mode, the differential should be a positive number.

Example 1. If a unit is operating in Cool mode with a DAT of 40 F (5 C) and a RAT or 50 F (10 C), the TPDF is:

DAT – RAT = TPDF

or,

40 F (5 C) – 50 F (10 C) = –10 F (–5 C) TPDF.

Example 2. If a unit is operating in Heat mode with a DAT of 40 F (5 C) and an RAT of 36 F(2 C), the TPDF is:

DAT – RAT = TPDF

or,

40 F (5 C) – 36 F (2 C) = 4 F (3 C) TPDF.

Uses of Temperature Differential

Temperature differential is a measure of refrigeration performance. Box temperature influences the TPDF, with higher values found with higher box temperatures in Cool mode. Time is also a factor, because the unit must have run in a mode long enough to stabilize the system pressures and coil temperature.

For example, in both examples above, the TPDFs indicate normal performance at those box temperatures, assuming the unit has run long enough to stabilize.

However, if the unit is operating in Cool mode with a DAT of 48 F (9 C) and an RAT of 50 F (10 C) after enough time has lapsed for the unit to stabilize, the –2 F (–1 C) TPDF could indicate a problem. TPDF is used by Thermo King microprocessor-based controllers to determine performance characteristics and generate alarm codes when indicated.

SI02 Valve Position Displays

The following gauge screens are called the Valve Position Displays and are also called "Embedded Gauges."

These screens show the state of some of the solenoid valves in the unit. [On] means the solenoid is energized. [OFF] means the solenoid is de-energized. To access this group of gauge screens, press and hold the **TK LOGO** key for about 3 seconds while any gauge screen is displayed. Release the **TK LOGO** key the [LV1 screen appears and press the **GAUGES** key to scroll through the following screens. The unit must be turned on to display these screens. The unit can be running, and you will see the valve positions change if the mode changes.

[LV1]: Loading Valve #1

[LV2]: Loading Valve #2

[LIV]: Liquid Injection Valve

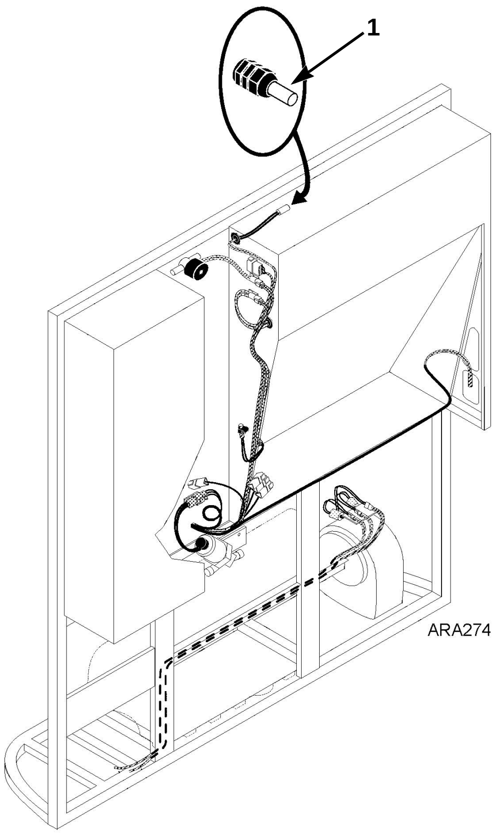
[LLS]: Liquid Line Solenoid Valve

[EWS]: Engine Water Solenoid Valve

[PSV]: Pilot Solenoid Valve

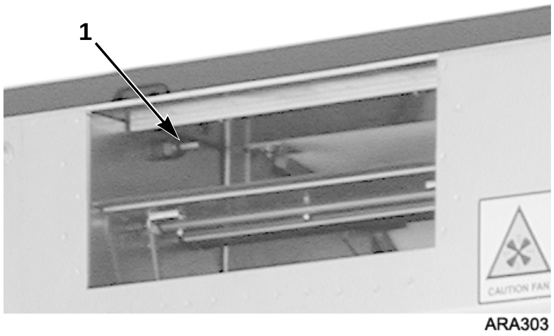
SI03 Discharge Air Sensor Position

The discharge sensor should protrude a minimum of 1.0 in. (25.4 mm) from its clamp. An incorrectly positioned Discharge Air Sensor can cause an incorrect Temperature Differential reading. The discharge air sensor is located above the defrost damper in the evaporator air outlet.



1.	Protrudes a Minimum of 1.0 in. (25.4 mm)

Figure 1: Discharge Air Sensor Position



1.	Discharge Air Sensor

Figure 2: Discharge Air Sensor Location

SI04 Suction Pressures

The unit is equipped with two different expansion valves. The expansion valve used for the evaporator coil is similar to the expansion valve used on a reciprocating compressor system. The expansion valve used for the economizer is a Maximum Operating Pressure (MOP) expansion valve. The MOP is set at 50 psig (345 kPa). The flow through the economizer expansion valve is limited by the MOP. The flow through the economizer expansion valve starts to decrease as economizer suction pressure approaches the MOP, and then more or less stops when the economizer suction pressure is above the MOP.

The unit is also equipped with an electronic throttling valve. It is located in the suction line near outlet from the evaporator coil.

When LV1 (economizer bypass solenoid) is closed:

- The suction pressure at the main suction service valve will vary according to box and ambient conditions.
- The economizer suction pressure will always be higher than the main suction pressure, but the flow through the economizer expansion valve is limited by its MOP.

When LV1 (economizer bypass solenoid) is open:

- The economizer suction pressure will always be higher than the main suction pressure.
- The economizer suction pressure may be lower when LV1 is open than when LV1 is closed.
- The suction pressure at the main suction service valve will normally be approximately 5 to 10 psig (34 to 69 kPa) lower than the economizer suction pressure.

SI05 Heat/Defrost Economizer MOP Ceiling Syndrome

The following situation can happen when the unit is in heat/defrost if the economizer expansion valve superheat setting is too high (low MOP).

When the economizer suction pressure reaches the MOP the economizer expansion valve will stop the flow of refrigerant through the economizer inner coiled tube to the compressor. When this flow is stopped, the economizer will not cool the liquid refrigerant in the jacket around the inner coiled tube. The liquid refrigerant in the jacket is then heated by the hot engine coolant and the pressure in the liquid line rises quickly. This also causes the discharge pressure to rise quickly, and Discharge Pressure Control will shift the three-way valve to the cool position to reduce the discharge pressure. Once the discharge pressure drops, the three-way valve will shift back to the heat position. This will happen again if the economizer suction pressure rises to the MOP of the economizer expansion valve.

If it is happening you can usually hear the three-way valve shifting back and forth, and the TPDF will be very low. You can also use Valve Position Displays to watch the pilot solenoid go on and off.

If you see this happening, check the economizer expansion valve superheat setting. See “STP17 Checking Economizer Expansion Valve Superheat” on page 134.

SI06 Suction Line Condition

The condition of the main suction line and the economizer suction line are an important indication of the unit's operation.

The main suction line should be:

- cool at high box temperatures in cool
- cold or frosted at lower box temperatures in cool
- extremely frosted at –20 F box temperatures in cool.

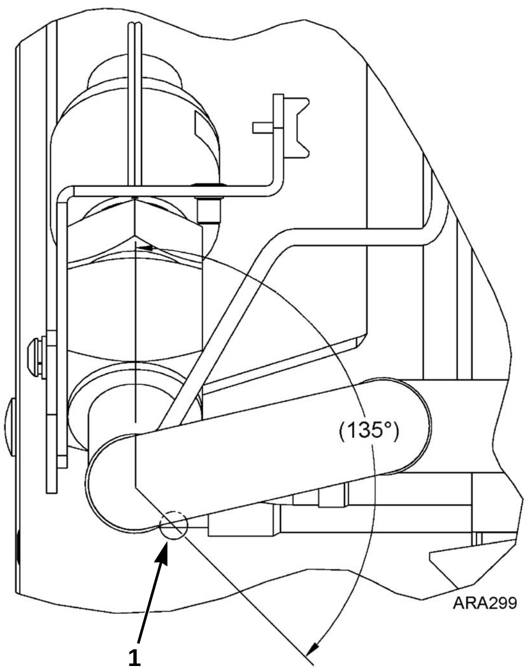
The economizer suction line should be:

- cold or slightly frosted under most conditions in cool
- frosted to the compressor in heat and defrost (except when the main suction pressure is high).

NOTE: Ambient temperatures and humidity can effect the visual appearance of the lines.

SI07 Evaporator Expansion Valve Feeler Bulb Location

The following drawing shows the proper location of the evaporator expansion valve feeler bulb. It must be positioned properly, be making good contact with the suction line, and be covered with insulating tape for the evaporator expansion valve to function properly.

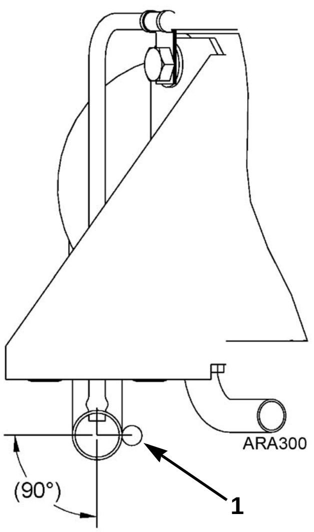


1.	Evaporator Expansion Valve Feeler Bulb

Figure 3: Evaporator Expansion Valve Feeler Bulb Location

SI08 Economizer Expansion Valve Feeler Bulb Location

- The following drawing shows the proper location of the economizer expansion valve feeler bulb. It must be positioned properly, be making good contact with the suction line, and be covered with insulating tape for the economizer expansion valve to function properly.



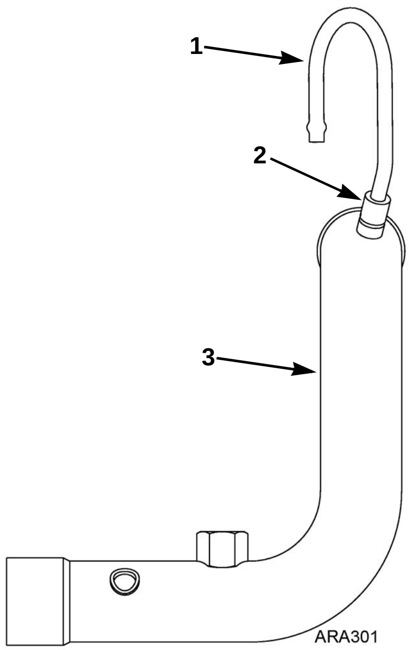
1.	Economizer Expansion Valve Feeler Bulb

Figure 4: Economizer Expansion Valve Feeler Bulb Location

SI09 Heating Bypass Orifice Identification

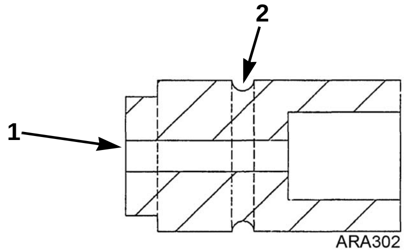
NOTE: The heating bypass orifice and some related components were changed in the first quarter of 2004.

The correct early style heating bypass orifice has an inside diameter of 0.09 in. (2.29 mm) and a groove around the outside to identify it. A unit with an oversized heating bypass orifice can have a high compressor temperature when running in heat or defrost, may run in compressor temperature control auxiliary mode, and might record alarm codes 81 and 82. If you have a unit that runs high compressor temperatures in heat and defrost, but not in cool, check the heating bypass orifice to make sure it has a groove around it. An oversized heating bypass orifice should not be a problem with the late style heating bypass orifice.



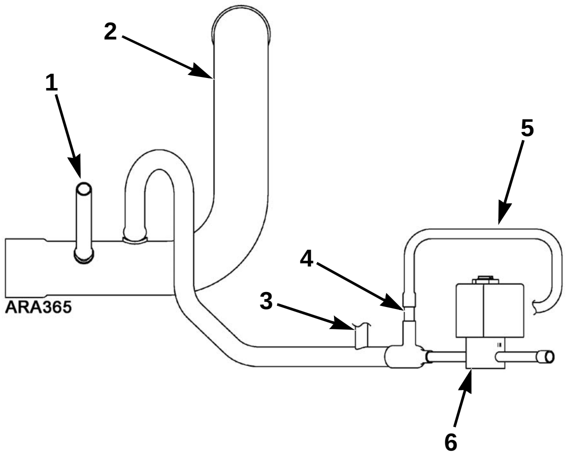
1.	Tube from Hot Gas Line
2.	Heating Bypass Orifice
3.	Main Suction Line

Figure 5: Early Style Heating Bypass Orifice Location on Condenser Side of Bulkhead



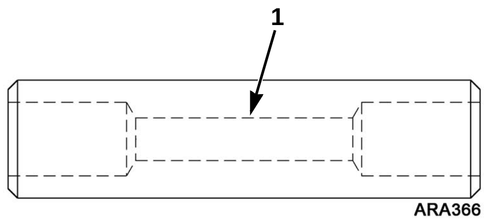
1.	Inside Diameter of 0.09 in. (2.29 mm)
2.	Groove (for Identification)

Figure 6: Cross Section of Early Style Heating Bypass Orifice



1.	Tube from Liquid Injection Valve
2.	Main Suction Line
3.	Tube to Suction Pressure Transducer
4.	Heating Bypass Orifice
5.	Tube from Hot Gas Line
6.	Pilot Solenoid

Figure 7: Late Style Heating Bypass Orifice Location on Condenser Side of Bulkhead



1.	Inside Diameter of 0.09 in. (2.29 mm)

Figure 8: Late Style Heating Bypass Orifice

SI10 Pressure Taps

When servicing a SB-400, it may be necessary to check system pressure at various locations. You can do this by installing a piercing valve or a saddle fitting in the system at the desired location and connecting it to a gauge manifold.

Piercing Valves

Piercing valves are available for different size tubes from various suppliers and include installation instructions.

Figure 9: Typical Piercing Valves

IMPORTANT: When unit service is complete, piercing valves should be removed to prevent refrigeration leaks. Nitrogen or another inert gas should be used to purge the tubes while soldering the pierced hole shut.

Saddle Fitting Installation

If a piercing valve is not available, a technician can fabricate and install a pressure tap fitting as follows:

1. Evacuate the system.
2. Use 35% silver solder and install a brass saddle fitting onto the refrigerant line.

IMPORTANT: Nitrogen or another inert gas should be used to purge the tubes while soldering the saddle fitting to the tube.

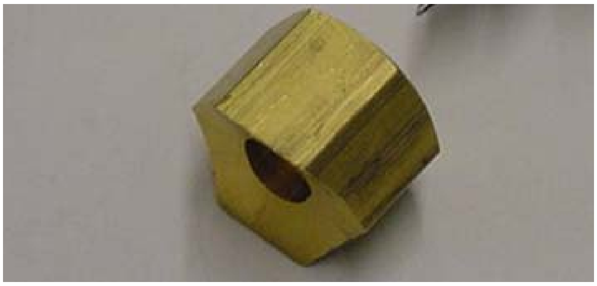


Figure 10: Saddle Fitting

3. Install a NTP to flare Schrader fitting onto saddle fitting.

Figure 11: Saddle Fitting and Schrader Valve

4. Leak check saddle fitting with nitrogen.
5. Remove Schrader fitting from saddle fitting and install piercing tool. Tighten piercing tool nut onto saddle fitting then tighten piercing tool center bolt to pierce tube. Remove piercing tool from saddle fitting.

Figure 12: Piercing Tool

NOTE: If the piercing tool is not available, pressurize the system with nitrogen or another inert gas, solder the saddle fitting to the tube. With the inert gas set at a low pressure, use the saddle fitting as a guide and carefully drill hole in tube being sure copper shavings are blown out of tube.

6. Install the Schrader fitting onto saddle fitting.
7. Leak check saddle fitting with nitrogen.
8. Recharge the unit.

SI11 Microprocessor Inputs

Input signals provide the microprocessor with information.

- The Sensor Location Column shows where the sensors are located.
- The Switch Location Column shows where the switches are located.
- The Power Column shows which circuits provide power (+) to the components.
  Together the Power and GND provide the signal for some components.
- The GND Column shows which circuits provide a ground (–) to the components.
- The Signal Column shows which circuits provide a signal from the component to the microprocessor.
- The Circuit Function Column explains what the input does.

Microprocessor Inputs Table

Input	Sensor Location	Switch Location	Power	GND	Signal	Circuit Function
Temperature						
Ambient Temperature	Condenser Inlet Air		ATP	ATN		Tells micro the ambient temperature.
Coil Temperature	Evaporator Coil Header Plate		CTP	CTN		Tells micro the evaporator coil temperature.
Return Air Temperature	Evaporator Inlet Air		RTP	RTN		Tells micro the return air temperature.
Discharge Air Temperature	Evaporator Outlet Air		DTP	DTN		Tells micro the discharge air temperature.
Engine Water Temperature	Cooling System		WTP	WTN		Tells micro the engine water temperature.
Compressor Temperature	Compressor Body		CTSP	CTSN		Tells micro the compressor temperature. *Make sure you use a sensor for an µP-VI, not an µP-IV.*

Microprocessor Inputs Table (Continued)

Input	Sensor Location	Switch Location	Power	GND	Signal	Circuit Function
Pressure						
Oil Pressure above LOPS setting		Engine Oil System	20B	CH		Micro looks at 20B for a ground. If the LOPS is closed, 20B is grounded. A grounded 20B when the engine is running tells the micro to shut off the engine. The micro ignores the grounded 20B if the engine is not supposed to be running.
Suction Pressure Transducer	Refrigeration Low Side		HSPP	HSPN	SPI	HSSP and HSSN provide power and ground to the suction transducer. The transducer sends a voltage signal back to the micro. As the pressure goes up the voltage up.
Discharge Pressure Transducer	Refrigeration High Side		HSPP	HSPN	DPI	The discharge pressure transducer works the same way as the suction pressure transducer.
Discharge Pressure above 450 psig (3103 kPa) HPCO		Refrigeration High Side			8D-7EHA	Shuts the unit off if discharge pressure exceeds 450 psig (3103 kPa).
Discharge Pressure above 425 psig (2930 kPa) HPCI		Refrigeration High Side			8F-HPCI	Backs up discharge pressure transducer.

Microprocessor Inputs Table (Continued)

Input	Sensor Location	Switch Location	Power	GND	Signal	Circuit Function
Other						
Setpoint		Set w/Keypad				Tells micro the required trailer temperature.
Engine RPM	Adjacent to Flywheel			FS1 (AC Volt)	FS2 (AC Volt)	Tells micro the engine RPM.
Alternator Voltage	Uses Existing Circuit				2PA	Tells micro the unit voltage.
Alternator Frequency (50 models only, SB-400 not available as 50 model)	Alternator W Stud				W	Tells micro the alternator RPM. If not same as engine RPM, the clutch is slipping.
Alternator Amperage	Voltage Drop Across Shunt		VHP	VHN	VHP-VHN	Micro calculates amperage from voltage drop across shunt.
Run Relay On/Off	Uses Existing Circuit				7K-8D	Determines if shut down is Alarm Code 35 or Alarm Code 10.
Engine Oil Level		Top of Oil Pan		2AAL	OLS	Tells micro the engine oil level.
Door Opening		At Rear Doors	2AAL	BIK-CH	DS	Detects open doors, shows doors were open on datalogger.
Coolant Level		Radiator Surge Tank	HSPP-CLP	HSPN-CLP	CLS	Tells micro the coolant level.
Unit Switch On, Backlight		On/Off Switch			8F	Tells micro the switch is on, and energizes the backlight.
Fuel Level (rail only)	Fuel Tank				8F-FL	Tells micro the fuel level in the fuel tank.
ETV			8F-8EV			Micro uses it to power ETV.
Sleep Mode (with Optional On/Off/Sleep Switch) Keypad Entry is Standard		On/Off/Sleep Switch			8F-SL	Tells micro to put the unit into Sleep mode.

SI12 Microprocessor Outputs

Output signals from the microprocessor control components.

- The Primary Device Column shows which components are directly controlled by the outputs.
- The GND Columns show which circuits provide a ground (–) to the components. The circuits are listed in order from the microprocessor to the component.
- The Power Columns show which circuits provide power (+) to the components. The circuits are listed in order from the relay board to the component.
- The Secondary Device Column shows which components are indirectly controlled by an output through a primary device.

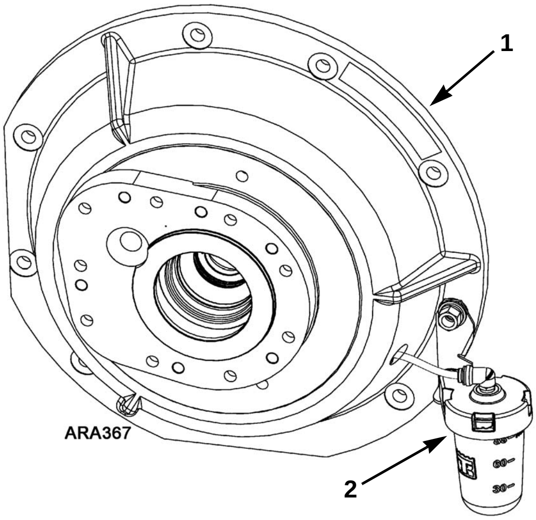
Microprocessor Outputs Table

Outputs	Primary Device	GND	Power	Secondary Device	GND	Power
Heat	Pilot Solenoid	14P-F6-26G	8F-F27-LLSPP-26P			
Modulation	ETV	EVA-EVB-EVC-EVD				
Loading Valve #1	Loader Valve	EBVP-F32-EBV-LV1-BRN	8F-LV1P-BLU			
Loading Valve #2	Loader Valve	ULP-F29-UL-LV2-BRN	8F-LV2P-BLU			
Liquid Injection Valve	Liquid Injection Valve	LQIP-LQI	8F-F25-LQIPP			
Water Valve	Water Valve	WVP-F30-WV	8F-WVPP			
Liquid Line Solenoid On/Off	Liquid Line Solenoid	LLSP-F26-LLS	8F-F27-LLSPP			
Buzzer On/Off	Buzzer	BZ	8F and 8F			
Alarm Signals	Alarm Light	ALP and CH	8F			
Setpoint Alarm On/Off	Setpoint Buzzer	SOP2	8F thru K7 NO			
Engine Speed	K2 Speed Relay	10P-F1-26ED	8P	Speed Solenoid	CH	2AB-F18-K2-7D
Defrost On/Off	K3 Defrost Relay	29P-29PF	8P	Damper Solenoid	CH	2AB-F3-29F-K2-29
Intake Heater On/Off	K4 Preheat Relay	PRP-PRPF	8F	Air Intake HRT Relay to Intake Heater	CH CH	2AB-K4-H 2-Air Intake HRT Relay-H1
Starter On/Off	K5 Start Relay	SRP-SRPF	8PA-8P	Starter Solenoid	CH	2AB-K5-8S
Engine Run	K7 Run Relay	RRP	8F	Fuel Solenoid Hold-In Coil	CH	8F-K7-7K-8P-8PA-HPCO-8D
Fuel Solenoid Pull-In	K1 Fuel Solenoid Relay	14P-F6-14PF1	2AB-K4-H	Fuel Solenoid Pull-In Coil	CH	2AB-K4-H-K1-8DP

SI13 Oil Collection Device

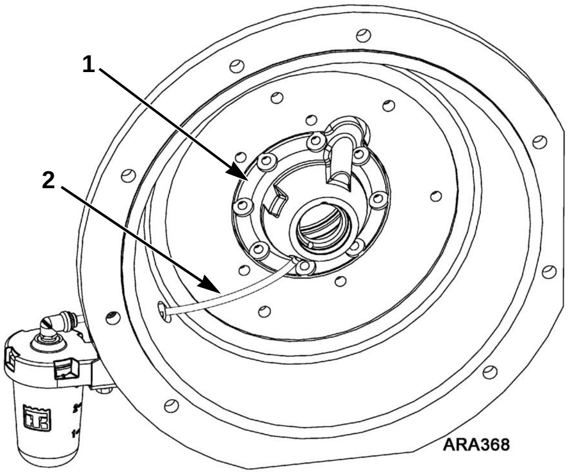
An oil collection device was added to the unit in the first quarter of 2004. The oil collection device is used to monitor the amount of oil that seeps from the compressor shaft seal. If the compressor shaft seal seeps more than 1 oz (30 ml) per 1,000 hours, the seal is seeping too much and should be replaced.

The oil collection device is mounted on the compressor mounting flange. A tube connects the oil collection device to the compressor shaft seal cover. The oil that seeps from the seal collects in the bowl of the oil collection device. The bowl is marked in ounces (oz) on one side and in milliliters (ml) on the other side. Remove (unscrew) the bowl and empty it at 1,000-hour intervals to help monitor how fast the oil seeps from the compressor shaft seal.



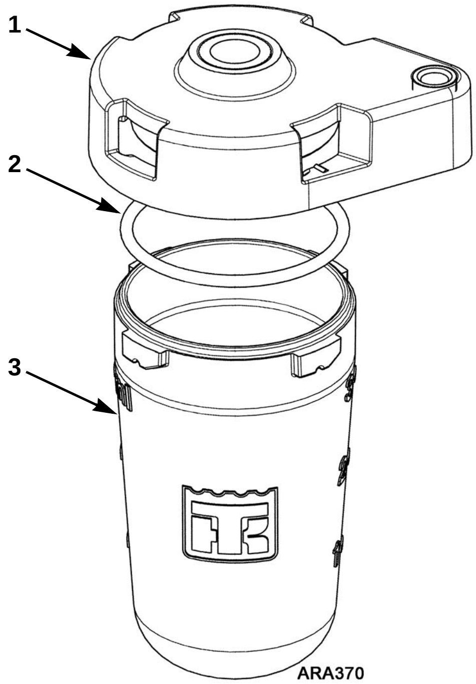
1.	Compressor Mounting Flange
2.	Oil Collection Device

Figure 13: Oil Collection Device Location



1.	Compressor Shaft Seal Cover
2.	Tube to Oil Collection Device

Figure 14: Oil Collection Device Tube Connection



1.	Top Cap
2.	O-Ring
3.	Bowl

Figure 15: Oil Collection Device Components

SI14 Heat Mode Charge Migration Cycle

Software Revision 4310 has a feature called the Heat Mode Charge Migration Cycle. It is used to increase the unit's heating capacity under certain conditions.

If the TPDF in heat is lower than expected for the current return air temperature and ambient temperature, the controller places the unit in low speed cool and closes the defrost damper for 2 minutes. This forces refrigerant into the heating circuit. After 2 minutes the unit goes back into heat and the defrost damper is opened. The additional refrigerant that was forced into the heating circuit increases the heating capacity.

The Heat Mode Charge Migration Cycle usually happens when the return air temperature and the ambient temperature are both low. If you notice the unit going into low speed cool and closing the defrost damper for 2 minutes when the setpoint is well above the return air temperature, the unit is running through a Heat Mode Charge Migration Cycle.

Service Test Mode

Purpose

This procedure should be used to operate the Service Test Mode feature. Service test modes are used to force the system into a fixed mode of operation for field service diagnosis.

See “Operating the Service Test Mode” on page 175 for the information about placing the unit in the Service Test Mode.

The “Service Test Component Status Table” on page 183 lists all the Service Test Modes, the status of the components, and comments about the mode.

⚠ ***CAUTION: Service Test mode should be used by qualified technicians and should not be used for temperature control or emergency operation.***

Important Information

- Service test modes can be activated with the unit operating or with the unit off. If the engine was running before entering Service Test mode it will remain running. If the engine was shut down before entering Service Test mode it will remain shut down. The engine can not be started from within Service Test mode.
- A running Service Test mode can not be entered until after the ETV/LV check (part of the standard unit startup routine) is completed (about 1 to 2 minutes). During the ETV/LV check, no mode icons will be visible in the display. When the startup checks are complete, the respective icon (cool, heat, defrost, or modulation) will be displayed, and Service Test modes can be accessed and activated.
- If a service test mode is selected but a test is not entered within 1 minute, the unit will start and run in normal operation. The Service Test mode display will revert back to the Standard Display 1 minute after the unit starts.
- The keypad keys function normally when in Service Test mode. Normal unit operating data is available through the Controller Display by pressing the SELECT or GAUGE key. The standard Controller Display mode Icons will be set as part of each service test mode.
- The protection circuits such as low oil pressure, high engine temperature and high discharge pressure function normally when in Service Test mode.
- Multiple modes can be enabled without exiting and re-entering service mode, (i.e., unit can be operated in high speed cool service test mode, then switched to low speed cool service test mode, then switched to high speed heat service test mode, etc.).
- Compression Ratio Limit mode and Low Suction Pressure Control mode (auxiliary operation modes), liquid injection control are disabled during service mode, and heat mode discharge superheat control. Discharge Pressure Control mode (an auxiliary operation mode) is enabled, but the loading valves are fixed in the selected test state, and the discharge pressure is controlled by the ETV only.

  NOTE: The system controlled components are disabled during Service Test modes to insure consistent test conditions and simplify system diagnosis. This may result in differences between the Service Test operating mode and the normal (temperature controlled) operating mode. The respective shutdown conditions are enabled.

- If a Shut Down Alarm occurs, the unit will record the alarm, shut down and exit Service Test mode.
- The controller will shutdown the system and log a code 54 alarm if the same Service Test mode is allowed to operate for 15 minutes.
- Once the Service Test Menu is entered, the unit must be turned off to exit.

Discharge Pressure Control in Cool Service Test Modes

Discharge pressure control is active during the cool service test modes, but the operation of the ETV and the loading valves is different than during the normal cool modes. During normal cool modes the ETV position and the status (open or closed) of the loading valves are used to control the discharge pressure. During cool service test modes the loading valve status is locked in by the selected service test mode, and only the ETV position is used control the discharge pressure.

For example, if a unit is overcharged and running in normal high speed cool, discharge pressure control may open both LV1 and LV2, and partially close the ETV. However, when the unit is placed in Service Test [HS.C] High Speed Cool, LV1 and LV2 are locked closed, which will force the ETV to a more closed position than during normal high speed cool. Normally the ETV will be in the full open position during Service Test [HS.C], but in this case the test mimics the normal operation.

Therefore, if the unit has a discharge pressure near or above 415 psi (2861 kPa) while running in a normal cool mode, use Valve Position Displays (see “SI02 Valve Position Displays” on page 156) to check the status of the loading valves. You can then use the service test mode that has the same loading valve status to test the unit.

Operating the Service Test Mode

<table>
<tr><th>Step</th><th>Action</th><th>Results</th><th>Comments</th></tr>
<tr><td></td><td>Preparing the Unit</td><td></td><td></td></tr>
<tr><td>1</td><td>The unit can not be in Pretrip mode, Defrost mode or Sleep mode.</td><td></td><td></td></tr>
<tr><td>2</td><td>Turn the unit on. Allow the unit to start if desired.</td><td></td><td>The tests will function with the engine stopped or running as required.</td></tr>
<tr><td>3</td><td>Clear any alarm codes by using the Code and Clear keys.</td><td>The display will show [00] and [ALRM], then return to the Standard Display.</td><td></td></tr>
<tr><td></td><td>Entering Service Test Mode</td><td></td><td></td></tr>
<tr><td>1</td><td>Press and hold the Thermo King Logo key continuously for 3-5 seconds.</td><td>The display will show [PrE TRIP].</td><td></td></tr>
<tr><td>2</td><td>Press the Select key as required to display [PRNT].</td><td>The display will show [PRNT].</td><td>This display is only present if the unit is configured with the Data Logger option.</td></tr>
<tr><td>3</td><td>Press the Select key as required to display [REV].</td><td>The display will show [REV] and the software revision number.</td><td></td></tr>
<tr><td>4</td><td>Press and hold both the Thermo King Logo key and Clear keys simultaneously for 3-5 seconds.</td><td>The display will show [tESt] and [HS.C].</td><td>The controller has entered the Service Test mode. If no test is selected, the microprocessor will return to normal operation in about 1 minute. Proceed with Using Service Test Modes below.</td></tr>
<tr><td></td><td>Using Service Test Modes</td><td></td><td></td></tr>
<tr><td colspan="4">

Unless otherwise noted, a different Test mode function can be selected by pressing the Up or Down arrow keys.
Once a Test mode is selected, pressing the Enter key when the test is shown in the display will activate the test (LOAD will appear in the display for 3 seconds).
Note: If the [ETV] test is activated, the test must be allowed to complete before another test is selected. If a different test is selected before the [ETV] test is complete, the [ETV] test will continue to run even though it appears another test has been selected.
The unit will remain in any Service Test mode function for 15 minutes if no other Test mode function is selected. At the end of 15 minutes, if no other Test mode is selected the unit will shut down and record Alarm Code 54 (Service Test Mode Shut Down).
IMPORTANT: All Service Test features are shown in this Service Procedure. However, the features that appear depend on the unit configuration as specified in Super Guarded Access mode. In addition, not all features are present in all versions of software.

</td></tr>
<tr><td>1</td><td>Upon entering Service Test mode as shown above [HS.C] will appear in the display. Press the Enter key to activate this mode.</td><td>The display will show [tESt] and [HS.C].</td><td>The unit is forced into High Speed Cool mode.

The Run Relay and High Speed Relay are energized.

The #1 and #2 Loading Valves are energized (closed).

The Cool and High Speed Icons are visible.</td></tr>
</table>

Step	Action	Results	Comments
2	Press the Up Arrow key to display [LS.C]. Press the Enter key to activate this mode. **Note:** The unit must be running in Low Speed Cool to enter the ETV test below.	The display will show [tESt] and [LS.C].	The unit is forced into Low Speed Cool mode. The Run Relay is energized. The #1 and #2 Loading Valves are energized (closed). The Cool Icon is visible.
3	Press the Up Arrow key to display [ETV] (if unit is running in Service Test mode Low Speed Cool). Press the Enter key to activate this mode. Or Press the Up Arrow key to display [EVA.C] (if the unit is not running). Press the Enter key to activate this mode.	The display will show [tESt] and [ETV] (if unit is running in Service Test mode Low Speed Cool) or [EVAC] (if the unit is not running).	To activate [ETV] the unit must be running, [LS.C] must be selected, and the return and ambient temperatures must be above 15 F (-9 C). Once the [ETV] test is activated, the test must be allowed to complete before another test is selected. If a different test is selected before the [ETV] test is complete, the [ETV] test will continue to run even though it appears another test has been selected. For additional information on the [ETV] test, see Service Procedure G03A in Section 6 of the THERMOGUARD µP-VI Microprocessor for Screw Compressor Applications Diagnostic Manual TK 51329. If the unit is not running [EVAC] mode will appear. Press Enter to fully open the ETV valve for system evacuation. Once activated, the only way to exit [EVA.C] is by turning the unit Off.
4	Press the Up Arrow key again to display [LS.H]. Press the Enter key to activate this mode.	The display will show [tESt] and [LS.H].	The unit is forced into Low Speed Heat mode. The Run Relay and Pilot Solenoid are energized. The Engine Coolant Valve is energized (open), and Liquid Line Solenoid Valve is energized (closed). Only the #2 Loading Valve is energized (closed). The Heat Icon is visible.

Step	Action	Results	Comments
5	Press the Up Arrow key to display [HS.H]. Press the Enter key to activate this mode.	The display will show [tESt] and [HS.H].	The unit is forced into High Speed Heat mode. The Run Relay, High Speed Relay, and Pilot Solenoid are energized. The Engine Coolant Valve is energized (open), and Liquid Line Solenoid Valve is energized (closed). Only the #2 Loading Valve is energized (closed). The Heat and High Speed Icons are visible.
6	Press the Up Arrow key again to display [DE.F]. Press Enter to activate this mode.	The display will show [tESt] and [DE.F].	The unit is forced into Defrost mode. The Run Relay, Pilot Solenoid, and Damper Relay are energized. The Engine Coolant Valve is energized (open), and Liquid Line Solenoid Valve is energized (closed). Only the #2 Loading Valve is energized (closed). The Defrost Icon is visible.
7	Press the Up Arrow key again to display [DEF.U]. Press Enter to activate this mode.	The display will show [tESt] and [DEF.U].	The unit is forced into Defrost Fully Unloaded mode. The Run Relay, Pilot Solenoid, and Damper Relay are energized. The Engine Coolant Valve is energized (open), and Liquid Line Solenoid Valve is energized (closed). The #1 and #2 Loading Valves are de-energized (open). The Defrost Icon is visible.
8	Press the Up Arrow key again to display [HSC.P]. Press the Enter key to activate this mode.	The display will show [tESt] and [HSC.P].	The unit is forced into High Speed Cool Partially Unloaded mode. The Run Relay and High Speed Relay are energized. Only the #2 Loading Valve is energized (closed). The Cool and High Speed Icons are visible.

Step	Action	Results	Comments
9	Press the Up Arrow key again to display [HSC.U]. Press the Enter key to activate this mode.	The display will show [tESt] and [HSC.U].	The unit is forced into High Speed Cool Fully Unloaded mode. The Run Relay and High Speed Relay are energized. The #1 and #2 Loading Valves are de-energized (open). The Cool and High Speed Icons are visible.
10	Press the Up Arrow key again to display [LSC.P]. Press the Enter key to activate this mode.	The display will show [tESt] and [LSC.P].	The unit is forced into Low Speed Cool Partially Unloaded mode. The Run Relay is energized. Only the #2 Loading Valve is energized (closed). The Cool Icon is visible.
11	Press the Up Arrow key again to display [LSC.U]. Press the Enter key to activate this mode.	The display will show [tESt] and [LSC.U].	The unit is forced into Low Speed Cool Fully Unloaded mode. The Run Relay is energized. The #1 and #2 Loading Valves are de-energized (open). The Cool Icon is visible.
12	Press the Up Arrow key again to display [HSH.U]. Press the Enter key to activate this mode.	The display will show [tESt] and [HSH.U].	The unit is forced into High Speed Heat Fully Unloaded mode. The Run Relay, High Speed Relay, and Pilot Solenoid are energized. The Engine Coolant Valve is energized (open), and Liquid Line Solenoid Valve is energized (closed). The #1 and #2 Loading Valves are de-energized (open). The Heat and High Speed Icons are visible.
13	Press the Up Arrow key again to display [LSH.U]. Press the Enter key to activate this mode.	The display will show [tESt] and [LSH.U].	The unit is forced into Low Speed Heat Fully Unloaded mode. The Run Relay and Pilot Solenoid are energized. The Engine Coolant Valve is energized (open), and Liquid Line Solenoid Valve is energized (closed). The #1 and #2 Loading Valves are de-energized (open). The Heat Icon is visible.

Step	Action	Results	Comments
14	Press the Up Arrow key again to display [MC1.0]. Press the Enter key to activate this mode.	The display will show [tESt] and [MC1.0].	The unit is forced into Modulation Cool mode - ETV 100 steps Open. The Run Relay is energized. The #1 and #2 Loading Valves are de-energized (open) for fresh temperature ranges. The #1 Loading Valve is de-energized (open), and the #2 Loading Valve is energized (closed) for frozen temperature ranges. The Cool and Modulation Icons are visible.
15	Press the Up Arrow key again to display [MC0.0]. Press the Enter key to activate this mode.	The display will show [tESt] and [MC0.0].	The unit is forced into Modulation Cool mode - ETV 30 steps Open (20 steps open for units running revision 4300 software). The Run Relay is energized. The #1 and #2 Loading Valves are de-energized (open) for fresh temperature ranges. The #1 Loading Valve is de-energized (open), and the #2 Loading Valve is energized (closed) for frozen temperature ranges. The Cool and Modulation Icons are visible.
16	Press the Up Arrow key again to display [BHT]. Press the Enter key to activate this mode.	The display will show [tESt] and [BHT].	The unit is forced into Bucking Heat mode. Only the #2 Loading Valve is energized (closed). If engine coolant temp is greater than the minimum engine coolant temperature, EWSV will energize after a 90 second delay. The Cool and Heat Icons are visible.

Step	Action	Results	Comments
17	Press the Up Arrow key again to display [RNU.L]. Press the Enter key to activate this mode.	The display will show [tESt] and [RNU.L].	The unit is forced into Running Null mode. With the unit running, and the engine coolant temperature above the minimum engine coolant temperature, there will be a 90 second delay before the Engine Coolant Solenoid Valve is energized (opens). The Engine Coolant Valve is energized (open), and Liquid Line Solenoid Valve is energized (closed). The #1 and #2 Loading Valves are de-energized (open). The Heat and Modulation Icons are visible.
18	Press the Up Arrow key again to display [LIV]. Press the Enter key to activate this mode.	The display will show [tESt] and [LIV].	The unit is forced into Liquid Injection Valve Test mode. The Liquid Injection Valve will cycle On and Off in 3 second intervals. LIV status can be viewed using the Embedded Gauges menu. The #1 and #2 Loading Valves are energized (closed). The ETV is active. The Cool Icon is visible.
19	Press the Up Arrow key again to display [CHT.A]. **Note:** Combined Heat Test Mode is a collection of 4 different tests [CHT.A], [CHT.B], [CHT.C], and [CHT.D]. This test checks the Condenser Check Valve, the Heat Check Valve, and the 3-Way Valve for leaks. Press the Enter key to activate this mode, or proceed directly to step 23.	The display will show [tESt] and [CHT.A].	The unit is forced into Combined Heat Test A mode, and the unit will operate in High Speed Cool mode. The #1 and #2 Loading Valves are energized (closed). To activate Combined Heat Test Mode the unit must be running. Once activated, the only way to exit any of the Combined Heat Test Mode tests is by turning the unit Off.

Step	Action	Results	Comments
20	Press the Up Arrow key again to display [CHT.B].	The display will show [tESt] and [CHT.B].	The unit is forced into Combined Heat Test B mode, and the unit will operate in Low Speed Cool mode. The Liquid Line Solenoid Valve is energized (closed). The #1 and #2 Loading Valves are energized (closed). Once activated, the only way to exit any of the Combined Heat Test Mode tests is by turning the unit Off.
21	Press the Up Arrow key again to display [CHT.C].	The display will show [tESt] and [CHT.C].	The unit is forced into Combined Heat Test C mode, and the unit will stop running. The Liquid Line Solenoid Valve is energized (closed). The #1 and #2 Loading Valves are de-energized (open). Once activated, the only way to exit any of the Combined Heat Test Mode tests is by turning the unit Off.
22	Press the Up Arrow key again to display [CHT.D].	The display will show [tESt] and [CHT.D].	The unit is forced into Combined Heat Test D mode. The Pilot Solenoid Valve is energized (open). The Liquid Line Solenoid Valve is energized (closed). Once activated, the only way to exit any of the Combined Heat Test Mode tests is by turning the unit Off.
23	Press the Up Arrow key again to display [OFC.T]. Press the Enter key to activate this mode.	The display will show [tESt] and [OFC.T].	The unit is forced into Heat Orifice Flow Check Test mode. To activate [OFC.T] the unit must be running. The #1 and #2 Loading Valves are energized (closed).

Step	Action	Results	Comments
24	Press the Up Arrow key again to display [LLS.T]. Press the Enter key to activate this mode.	The display will show [tESt] and [LLS.T].	The unit is forced into Liquid Line Solenoid Valve Test mode. To activate [LLS.T] the unit must be running. This test is not available if Alarm Code 87 or 89 is present. The #1 and #2 Loading Valves are energized (closed). The Liquid Line Solenoid Valve will remain de-energized (open) for approximately 30 seconds after the test begins. The suction pressure is measured, and must be above -3 psig (-21 kPa) for the test to continue. If suction pressure is below -3 psig (-21 kPa) the engine will stop and [LO SP] will appear in the display. The Liquid Line Solenoid Valve is then energized (closed). Approximately 2 minutes after the LLSV is energized (closed), the suction pressure must be below -5 psig (-34 kPa) to PASS the test. Unit shutdown occurs after test completion.
25	Press the Up Arrow key again to display [HSC] (the first Service Test).	The display will show [tESt] and [HSC].	
26	Pressing the Up Arrow or Down Arrow keys allows the operator to continue to scroll forward or backward through the tests in the order listed. Pressing Enter activates the selected test (LOAD will appear in the display for 3 seconds).		
	To Exit Service Test Mode		
1	Turn the unit off and back on.	The display will return to the Standard Display.	

Service Test Component Status Table

Test No.	Service Test	Component Status										Comments
		Run Relay[1]	**EHSS** Engine High Speed Solenoid	**LLSV (N.O.)** Liquid Line Solenoid Valve	**EWSV (N.C.)** Engine Coolant Solenoid Valve	**PSV (N.C.)** Pilot Solenoid Valve	**LV1 (N.O.)** #1 Loader Valve	**LV2 (N.O.)** #2 Loader Valve	**LIV (N.C.)** Liquid Injection Valve	**ETV**[2] Electronic Throttling Valve	**DDS** Defrost Damper Solenoid	
1	**[HS.C] High Speed Cool**	On	On				On	On	Disabled	Active		LV1 and LV2 locked on. Checks cooling capacity. Suction and discharge should follow ambient and box temperature. TPDF depends on box temperature. Above 35 F (2 C) TPDF = -10. Near 0 F (-18 C) TPDF = -6 or greater.
2	**[LS.C] Low Speed Cool**	On					On	On	Disabled	Active		LV1 and LV2 locked on. Low speed cool should be similar to high speed cool. TPDF should be similar. Compressor speed drops with reduced air flow. Economizer suction pressure may also drop some.
3	**[ETV] ETV Check**	On					On	On	Disabled	Active		Available in running mode only, RAT and AMB must be at least 15 F (-9 C). Must be in LSC test, then select ETV test.
4	**[ETV.C] ETV Evacuation**									800 steps open		Available in non-running mode only. Unit power must be turned Off to exit this test.

1. For non-running tests, energize the preheat relay and pilot solenoid valve coils for 2 seconds prior to energizing run relay, (fuel solenoid needs to be pulled in to prevent high current in the fuel solenoid hold windings). Pre-heat and pilot solenoid outputs need to be pulled in to provide power to fuel solenoid pull in relay.
2. ETV position not controlled during non-running service mode tests. Display will indicate valve at position 0.
3. Component On state will be delayed until engine coolant is greater than the minimum engine coolant temp. (running test only). The minimum engine coolant temperature is 140 F (60 C) for units running revision 4310 software, and 120 F (49 C) for units running revisions 4300 and 4301 software. No delay for non-running test.
4. LLSV On state delayed 30 seconds after test start to allow suction pressures to stabilize.
5. If return air temperature is less than the current Fresh/Frozen range select [FRFZ] setting.
6. 20 steps open for units running revision 4300 software.

Service Test Component Status Table (Continued)

Test No.	Service Test	Component Status										Comments
		Run Relay[1]	EHSS Engine High Speed Solenoid	LLSV (N.O.) Liquid Line Solenoid Valve	EWSV (N.C.) Engine Coolant Solenoid Valve	PSV (N.C.) Pilot Solenoid Valve	LV1 (N.O.) #1 Loader Valve	LV2 (N.O.) #2 Loader Valve	LIV (N.C.) Liquid Injection Valve	ETV[2] Electronic Throttling Valve	DDS Defrost Damper Solenoid	
5	**[LS.H] Low Speed Heat**	On		On[3]	On[3]	On		On	Disabled	30[6] steps open		Similar to high speed heat test. Operating pressures will be slightly less
6	**[HS.H] High Speed Heat**	On	On	On[3]	On[3]	On		On	Disabled	30[6] steps open		Checks heating capacity. Pressures dependent on ambient and box temperatures. Discharge Pressure Control (DPC) is not active, so unit may heat less in Service Test mode then in normal operation. TPDF should be from +6 at low box and ambient temps, up to +12 at higher temps. Suction pressure should be higher than economizer suction pressure. Economizer suction line to compressor should frost. The heating capacity of the SB-400 is dependant on engine coolant temperature and the economizer superheat setting. Heating capacity is therefore less influenced by ambient temperatures than other units.

1. For non-running tests, energize the preheat relay and pilot solenoid valve coils for 2 seconds prior to energizing run relay, (fuel solenoid needs to be pulled in to prevent high current in the fuel solenoid hold windings). Pre-heat and pilot solenoid outputs need to be pulled in to provide power to fuel solenoid pull in relay.
2. ETV position not controlled during non-running service mode tests. Display will indicate valve at position 0.
3. Component On state will be delayed until engine coolant is greater than the minimum engine coolant temp. (running test only). The minimum engine coolant temperature is 140 F (60 C) for units running revision 4310 software, and 120 F (49 C) for units running revisions 4300 and 4301 software. No delay for non-running test.
4. LLSV On state delayed 30 seconds after test start to allow suction pressures to stabilize.
5. If return air temperature is less than the current Fresh/Frozen range select [FRFZ] setting.
6. 20 steps open for units running revision 4300 software.

Service Test Component Status Table (Continued)

Test No.	Service Test	Component Status										Comments
		Run Relay[1]	EHSS Engine High Speed Solenoid	LLSV (N.O.) Liquid Line Solenoid Valve	EWSV (N.C.) Engine Coolant Solenoid Valve	PSV (N.C.) Pilot Solenoid Valve	LV1 (N.O.) #1 Loader Valve	LV2 (N.O.) #2 Loader Valve	LIV (N.C.) Liquid Injection Valve	ETV[2] Electronic Throttling Valve	DDS Defrost Damper Solenoid	
7	**[DE.F] Defrost**	On		On[3]	On[3]	On		On	Disabled	30[6] steps open	On	Similar to low speed heat. Checks damper door and helps diagnose defrost problems. Pressures will be somewhat higher then in heat mode operation. Ignore TPDF.
8	**[DEF.U] Defrost Fully Unloaded**	On		On[3]	On[3]	On			Disabled	30[6] steps open	On	Checks if LV2 is de-energizing (unloading) in unloaded defrost operation. Switching from defrost to unloaded defrost test mode should show a discharge and suction pressure change.
9	**[HSC.P] High Speed Cool Partly Unloaded**	On	On					On	Disabled	Active		LV1 locked off. LV2 locked on. Compressor is partially unloaded. Switching from HSC.U to HSC.P should show a change in suction and discharge pressures.
10	**[HSC.U] High Speed Cool Fully Unloaded**	On	On						Disabled	Active		LV1 and LV2 locked off. Compressor is fully unloaded. Cycling between HSC.U and HSC.P should show a change in suction and discharge pressures to determine if LV2 is working in high speed cool.

1. For non-running tests, energize the preheat relay and pilot solenoid valve coils for 2 seconds prior to energizing run relay, (fuel solenoid needs to be pulled in to prevent high current in the fuel solenoid hold windings). Pre-heat and pilot solenoid outputs need to be pulled in to provide power to fuel solenoid pull in relay.
2. ETV position not controlled during non-running service mode tests. Display will indicate valve at position 0.
3. Component On state will be delayed until engine coolant is greater than the minimum engine coolant temp. (running test only). The minimum engine coolant temperature is 140 F (60 C) for units running revision 4310 software, and 120 F (49 C) for units running revisions 4300 and 4301 software. No delay for non-running test.
4. LLSV On state delayed 30 seconds after test start to allow suction pressures to stabilize.
5. If return air temperature is less than the current Fresh/Frozen range select [FRFZ] setting.
6. 20 steps open for units running revision 4300 software.

Service Test Component Status Table (Continued)

Test No.	Service Test	Component Status										Comments
		Run Relay[1]	EHSS Engine High Speed Solenoid	LLSV (N.O.) Liquid Line Solenoid Valve	EWSV (N.C.) Engine Coolant Solenoid Valve	PSV (N.C.) Pilot Solenoid Valve	LV1 (N.O.) #1 Loader Valve	LV2 (N.O.) #2 Loader Valve	LIV (N.C.) Liquid Injection Valve	ETV[2] Electronic Throttling Valve	DDS Defrost Damper Solenoid	
11	**[LSC.P] Low Speed Cool Partially Unloaded**	On						On	Disabled	Active		LV1 locked off. LV2 locked on. Compressor is partially unloaded. Switching from LSC.U to LSC.P should show a change in suction and discharge pressures.
12	**[LSC.U] Low Speed Cool Fully Unloaded**	On							Disabled	Active		LV1 and LV2 locked off. Compressor is fully unloaded. Cycling between LSC.U and LSC.P should show a change in suction and discharge pressures to determine if LV2 is working in low speed cool.
13	**[HSH.U] High Speed Heat Fully Unloaded**	On	On	On[3]	On[3]	On			Disabled	30[6] steps open		Checks the loading valves in high speed heat operation. Both loading valves are Off, compressor is fully unloaded.
14	**[LSH.U] Low Speed Heat Fully Unloaded**	On		On[3]	On[3]	On			Disabled	30[6] steps open		Checks the loading valves in low speed heat operation. Both loading valves are Off, compressor is fully unloaded.
15	**[MC1.0] Modulation Cool - ETV 100 Steps Open**	On						On[5]	Disabled	100 steps open		
16	**[MC0.0] Modulation Cool - ETV 30[6] Steps Open**	On						On[5]	Disabled	30[6] steps open		

1. For non-running tests, energize the preheat relay and pilot solenoid valve coils for 2 seconds prior to energizing run relay, (fuel solenoid needs to be pulled in to prevent high current in the fuel solenoid hold windings). Pre-heat and pilot solenoid outputs need to be pulled in to provide power to fuel solenoid pull in relay.
2. ETV position not controlled during non-running service mode tests. Display will indicate valve at position 0.
3. Component On state will be delayed until engine coolant is greater than the minimum engine coolant temp. (running test only). The minimum engine coolant temperature is 140 F (60 C) for units running revision 4310 software, and 120 F (49 C) for units running revisions 4300 and 4301 software. No delay for non-running test.
4. LLSV On state delayed 30 seconds after test start to allow suction pressures to stabilize.
5. If return air temperature is less than the current Fresh/Frozen range select [FRFZ] setting.
6. 20 steps open for units running revision 4300 software.

Service Test Component Status Table (Continued)

Test No.	Service Test	Run Relay[1]	EHSS Engine High Speed Solenoid	LLSV (N.O.) Liquid Line Solenoid Valve	EWSV (N.C.) Engine Coolant Solenoid Valve	PSV (N.C.) Pilot Solenoid Valve	LV1 (N.O.) #1 Loader Valve	LV2 (N.O.) #2 Loader Valve	LIV (N.C.) Liquid Injection Valve	ETV[2] Electronic Throttling Valve	DDS Defrost Damper Solenoid	Comments
		Component Status										
17	**[BHT] Bucking Heat**	On			On	On		On	Disabled	200 steps open		If engine coolant temperature is greater than the minimum engine coolant temperature, EWSV will energize after a 90 second delay. The minimum engine coolant temperature is 140 F (60 C) for units running revision 4310 software, and 120 F (49 C) for units running revisions 4300 and 4301 software.
18	**[RNU.L] Running Null**	On		On[3]	On[3]				Disabled	Inactive		Checks running null cycle
19	**[LIV] Liquid Injection Valve**	On					On	On	50% duty cycle	Active		Checks LIV operation. LIV goes to 50%, CTMP should drop, LIV outlet should become cold. LIV cycles On for 3 seconds, then Off for 3 seconds. LV1 and LV2 locked on. Use embedded gauges menu to determine LIV state.

1. For non-running tests, energize the preheat relay and pilot solenoid valve coils for 2 seconds prior to energizing run relay, (fuel solenoid needs to be pulled in to prevent high current in the fuel solenoid hold windings). Pre-heat and pilot solenoid outputs need to be pulled in to provide power to fuel solenoid pull in relay.
2. ETV position not controlled during non-running service mode tests. Display will indicate valve at position 0.
3. Component On state will be delayed until engine coolant is greater than the minimum engine coolant temp. (running test only). The minimum engine coolant temperature is 140 F (60 C) for units running revision 4310 software, and 120 F (49 C) for units running revisions 4300 and 4301 software. No delay for non-running test.
4. LLSV On state delayed 30 seconds after test start to allow suction pressures to stabilize.
5. If return air temperature is less than the current Fresh/Frozen range select [FRFZ] setting.
6. 20 steps open for units running revision 4300 software.

Service Test Component Status Table (Continued)

Test No.	Service Test	Component Status										Comments
		Run Relay[1]	EHSS Engine High Speed Solenoid	LLSV (N.O.) Liquid Line Solenoid Valve	EWSV (N.C.) Engine Coolant Solenoid Valve	PSV (N.C.) Pilot Solenoid Valve	LV1 (N.O.) #1 Loader Valve	LV2 (N.O.) #2 Loader Valve	LIV (N.C.) Liquid Injection Valve	ETV[2] Electronic Throttling Valve	DDS Defrost Damper Solenoid	
20	**[CHT.A] Combined Heat**	On	On				On	On	Disabled	400 steps open		Available in running mode only. Unit emulates High Speed Cool operation. Unit power must be turned Off to exit this test.
21	**[CHT.B] Combined Heat**	On		On			On	On	Disabled	Position Unchanged from [CHT.A]		Unit emulates Low Speed Cool operation. Unit power must be turned Off to exit this test.
22	**[CHT.C] Combined Heat**			On					Disabled	close to 0 at 50 steps per second		Unit stops running. Unit power must be turned Off to exit this test.
23	**[CHT.D] Combined Heat**			On		On			Disabled	Inactive		Unit power must be turned Off to exit this test.
24	**[OFC.T] Heat Orifice Flow Check**	On		On		On	On	On	Disabled	200 steps open		Available in running mode only.

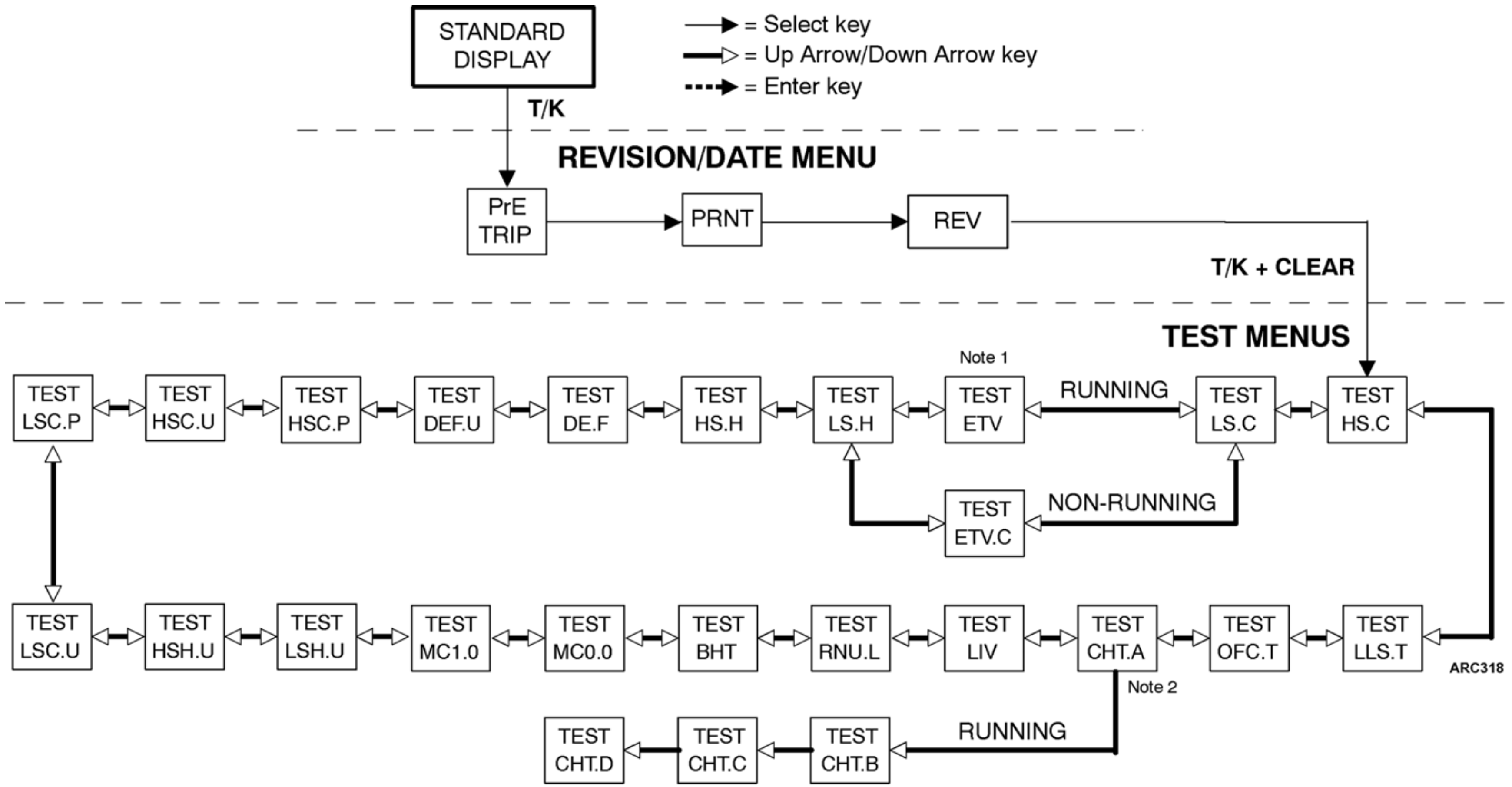
1. For non-running tests, energize the preheat relay and pilot solenoid valve coils for 2 seconds prior to energizing run relay, (fuel solenoid needs to be pulled in to prevent high current in the fuel solenoid hold windings). Pre-heat and pilot solenoid outputs need to be pulled in to provide power to fuel solenoid pull in relay.
2. ETV position not controlled during non-running service mode tests. Display will indicate valve at position 0.
3. Component On state will be delayed until engine coolant is greater than the minimum engine coolant temp. (running test only). The minimum engine coolant temperature is 140 F (60 C) for units running revision 4310 software, and 120 F (49 C) for units running revisions 4300 and 4301 software. No delay for non-running test.
4. LLSV On state delayed 30 seconds after test start to allow suction pressures to stabilize.
5. If return air temperature is less than the current Fresh/Frozen range select [FRFZ] setting.
6. 20 steps open for units running revision 4300 software.

Service Test Component Status Table (Continued)

Test No.	Service Test	Component Status										Comments
		Run Relay[1]	EHSS Engine High Speed Solenoid	LLSV (N.O.) Liquid Line Solenoid Valve	EWSV (N.C.) Engine Coolant Solenoid Valve	PSV (N.C.) Pilot Solenoid Valve	LV1 (N.O.) #1 Loader Valve	LV2 (N.O.) #2 Loader Valve	LIV (N.C.) Liquid Injection Valve	ETV[2] Electronic Throttling Valve	DDS Defrost Damper Solenoid	
25	**[LLS.T] Liquid Line Solenoid Valve**	On		On[4]			On	On	Disabled	Position based on ambient and return air temp.		LLS is cycled to determine if it is working. Unit should go into a vacuum state when LLS is On. Available in running mode only. Not available if alarm code 87 or 89 is present. ETV position is calculated to prevent HPCO, High Compression Ratio, and Low Suction Pressure alarms. Unit Pass/Fail indication after test is complete.

1. For non-running tests, energize the preheat relay and pilot solenoid valve coils for 2 seconds prior to energizing run relay, (fuel solenoid needs to be pulled in to prevent high current in the fuel solenoid hold windings). Pre-heat and pilot solenoid outputs need to be pulled in to provide power to fuel solenoid pull in relay.
2. ETV position not controlled during non-running service mode tests. Display will indicate valve at position 0.
3. Component On state will be delayed until engine coolant is greater than the minimum engine coolant temp. (running test only). The minimum engine coolant temperature is 140 F (60 C) for units running revision 4310 software, and 120 F (49 C) for units running revisions 4300 and 4301 software. No delay for non-running test.
4. LLSV On state delayed 30 seconds after test start to allow suction pressures to stabilize.
5. If return air temperature is less than the current Fresh/Frozen range select [FRFZ] setting.
6. 20 steps open for units running revision 4300 software.

Service Test Menu Flow Chart

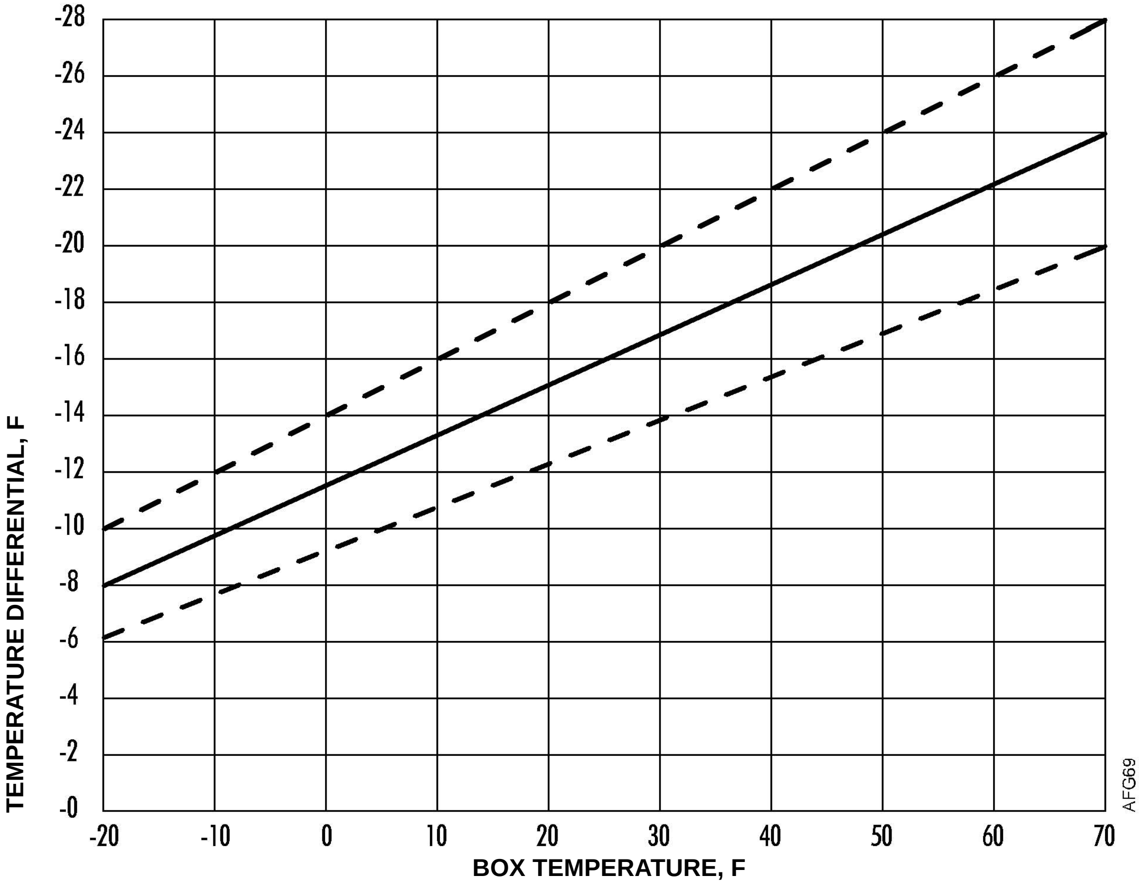


Note 1: Available only after LS.C test has been selected and return air temperature sensor and ambient air temperature sensor is above 15 F (-9 C)
Note 2: Press the Enter key to activate CHT test mode, then press the Up/Down Arrow key to select from the various CHT tests.

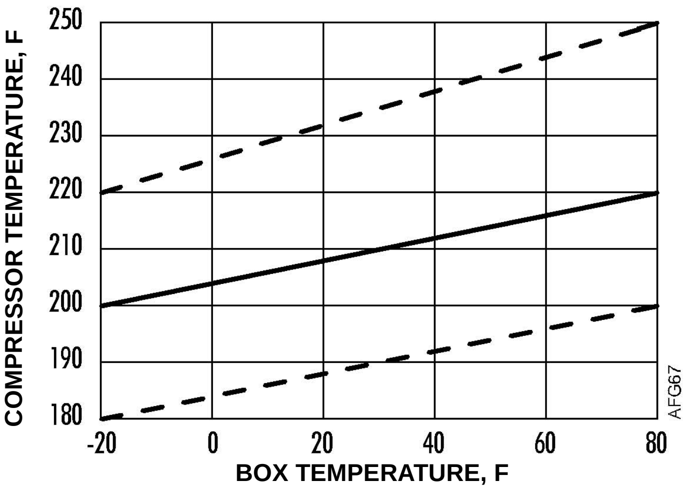
Typical Operating Conditions In Service Test Modes

The following graphs show operating temperatures and pressures as they relate to the box temperature in certain service test modes with the ambient temperature at 100 F (38 C).

The temperatures on the graphs are given in degrees F. The pressures on the graphs are given in psig. The solid line shows the average value. The dashed lines show the approximate limits of the normal range.

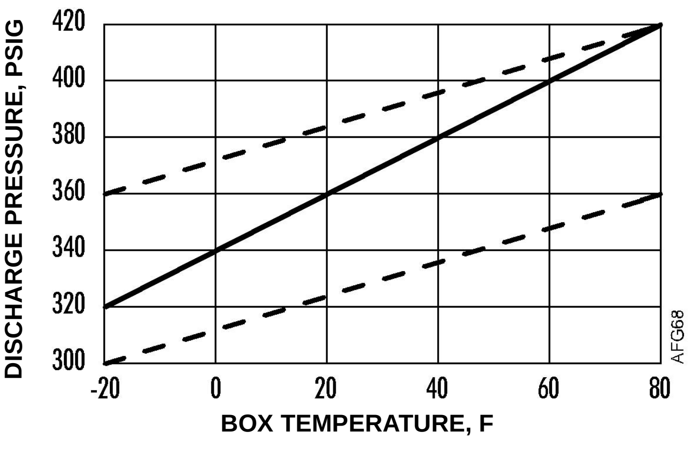


Evaporator Temperature Differential (TPDF) Versus Box Temperature
Service Test Mode [HS.C] High Speed Cool with Ambient Temperature of 100 F (38 C)

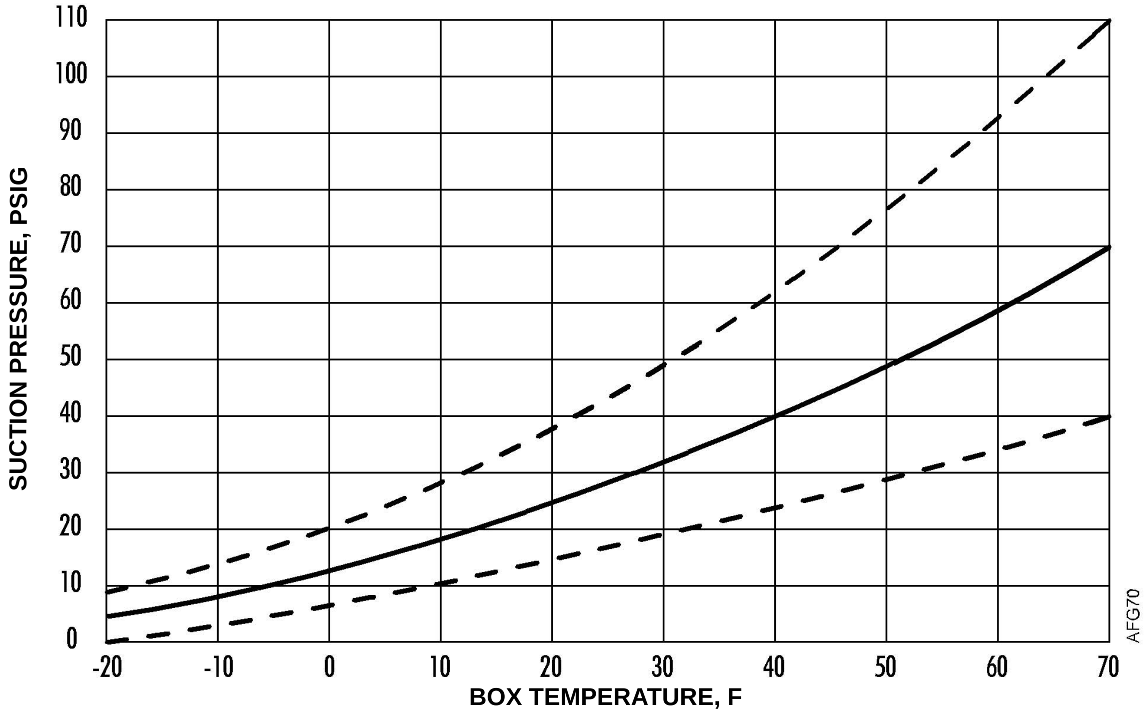


Compressor Temperature (CTMP) Versus Box Temperature
Service Test Mode [HS.C] High Speed Cool with Ambient Temperature of 100 F (38 C)

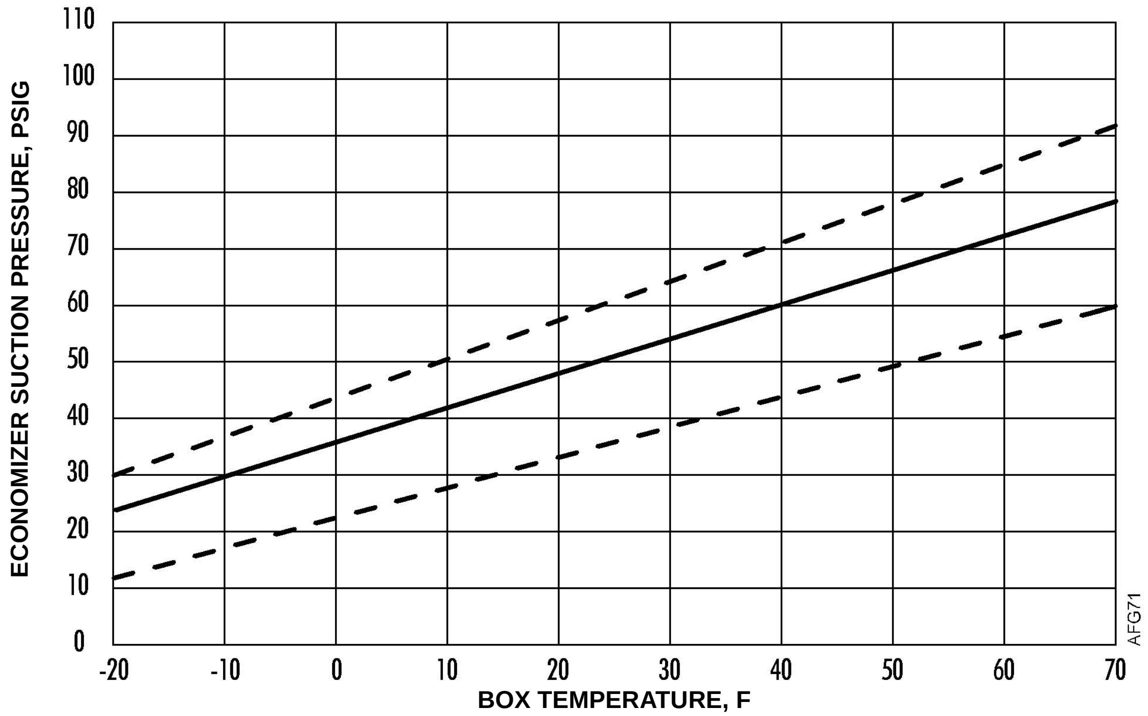
NOTE: The CTMP reading on the microprocessor is approximately equal to the discharge temperature.



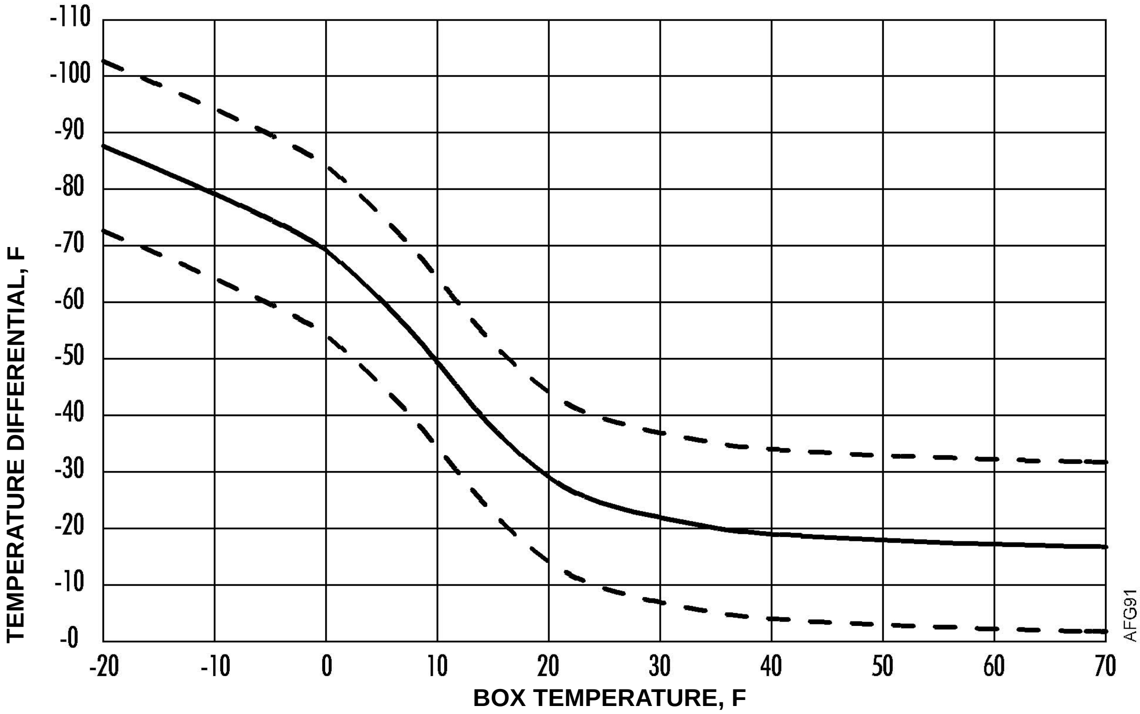
Discharge Pressure Versus Box Temperature
Service Test Mode [HS.C] High Speed Cool with Ambient Temperature of 100 F (38 C)



Main Suction Pressure Versus Box Temperature
Service Test Mode [HS.C] High Speed Cool with Ambient Temperature of 100 F (38 C)



Economizer Suction Pressure Versus Box Temperature
Service Test Mode [HS.C] High Speed Cool with Ambient Temperature of 100 F (38 C)



Economizer Liquid Line Temperature Differential Versus Box Temperature
Service Test Mode [HS.C] High Speed Cool with Ambient Temperature of 100 F (38 C)

See the explanation of Economizer Liquid Line Temperature Differential on page 28 and “STP18 Checking Economizer Liquid Line Temperature Differential” on page 136 for more information.

Index

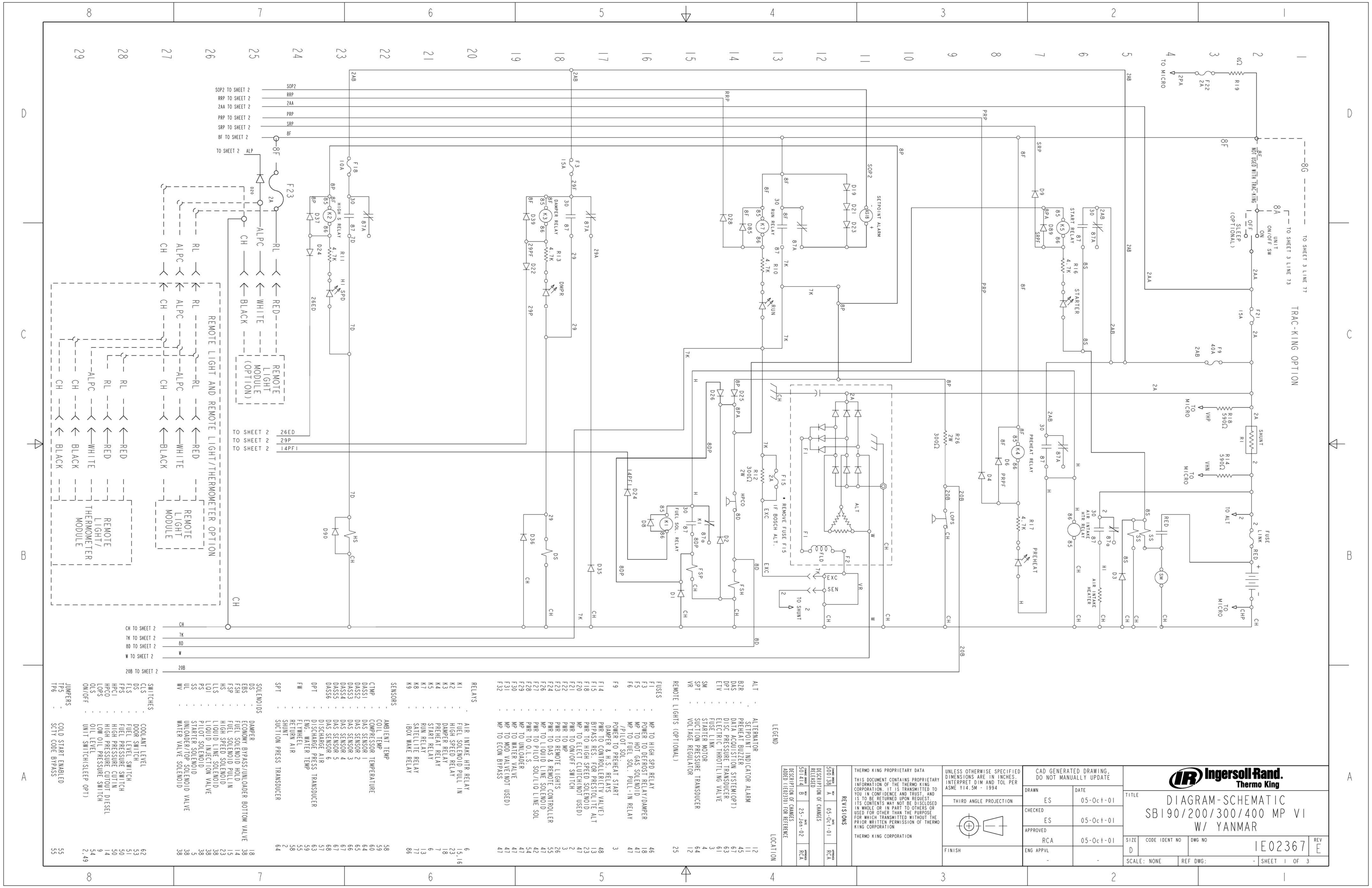
Table and Diagram Index

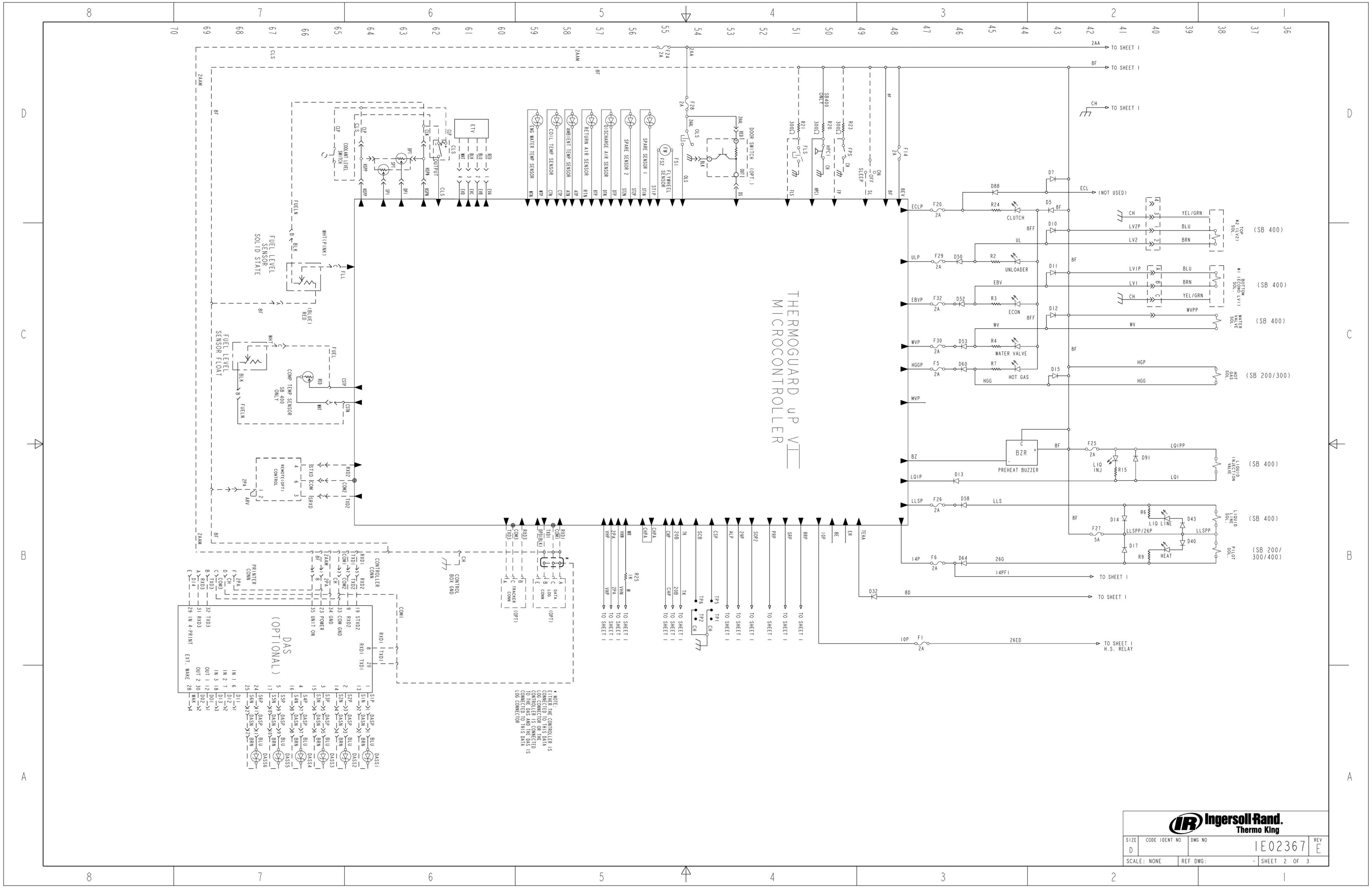
Component Failure Symptoms Table

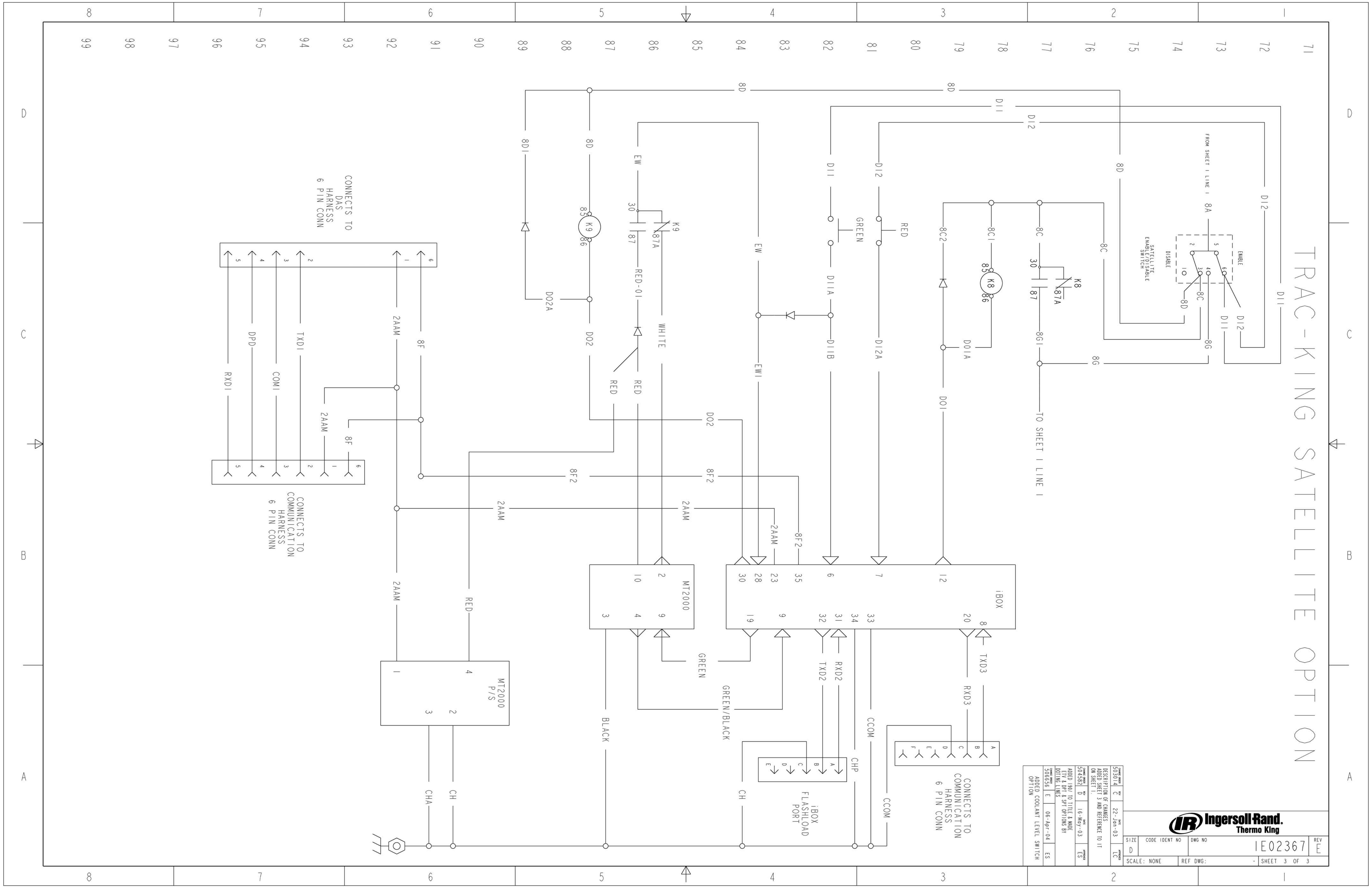
Use this table and the information you recorded in the “Table of Information Recorded in Service Test Modes” on page 62 to diagnose component failures that cause condition alarms. The graphs in the “Typical Operating Conditions In Service Test Modes” on page 137 show the normal range of operation conditions. If it is a cooling capacity alarm, use the information for Service Test Mode HS.C. If it is a heating capacity alarm, use the information for Service Test Mode HS.H. Match the conditions in the “Table of Information Recorded in Service Test Modes” with those in the following table to determine which component has probably failed. Then test the component use the procedure in the “Service Test Procedures” chapter. The following table is sorted by column going from left to right.

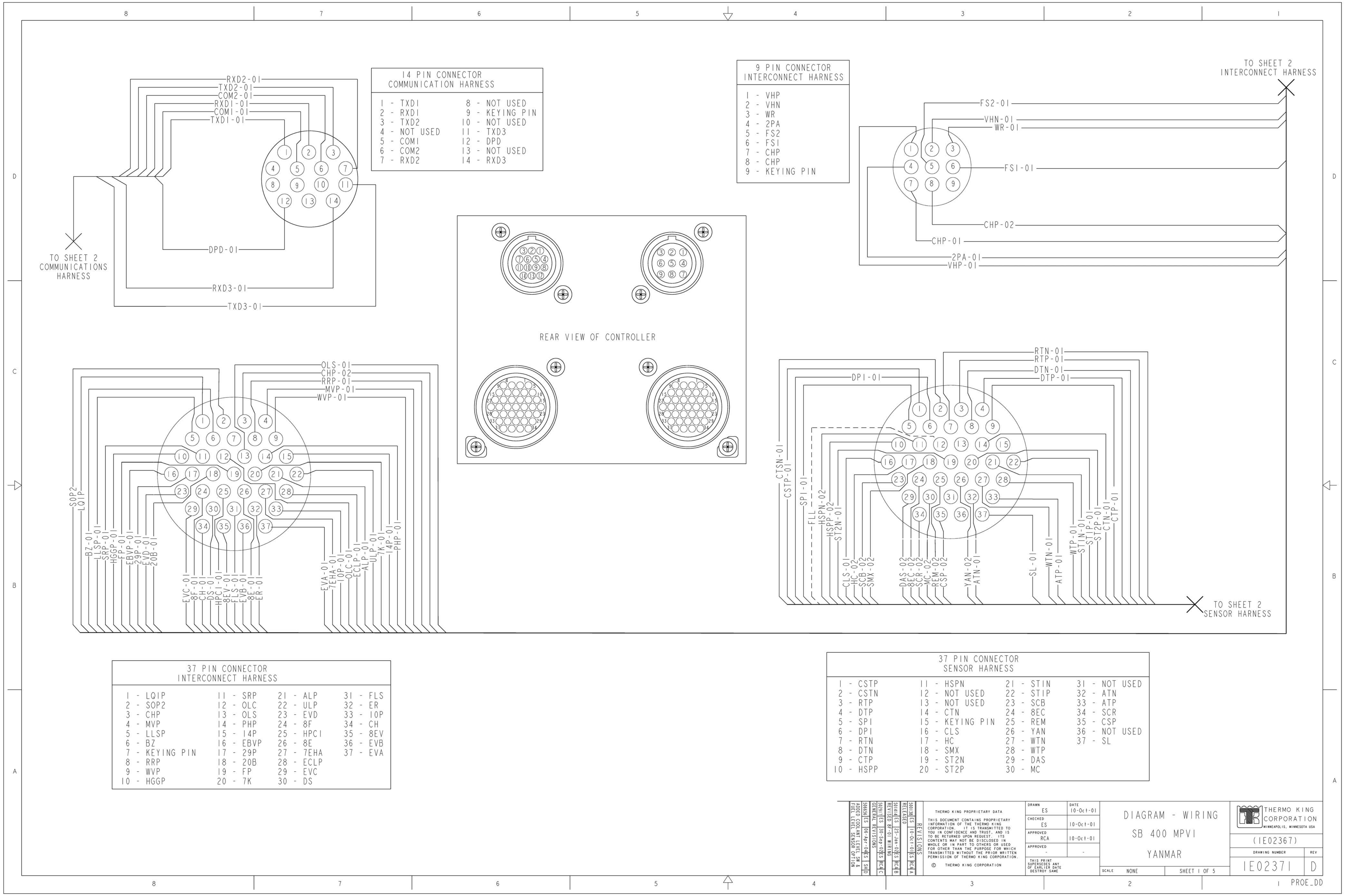
Cool or Heat	TPDF	Main Suction Line Condition	Main Suction Pressure	Economizer Suction Line Condition	Economizer Suction Pressure	CTMP	Discharge Pressure	Receiver Sight Glass	Component Failure	Comments
Cool	Low	Frosty after the Heating Bypass Orifice	Normal to High	Normal	Normal	Low	Close to Normal	Empty	Heat Check Valve Open in Cool	The compressor oil may be milky (indicates flooding). The frosty suction line after the orifice and the empty sight glass are good indicators.
Cool	Low	Frosty after LIV Tube to Main Suction Line Connection	High	Normal	Normal to High	Low	Normal to High	Low	LIV Open In Cool	In normal cool modes the LIV will be on if CTMP is above 270 F (132 C), suction pressure is below –6 psig (–41 kPa), or compression ratio is above 25:1.
Cool	Low	Frosty	High	Normal	High	Low	Normal to High	Low	Evaporator Expansion Valve too Open, Flooding, Low Super Heat in Cool	
Cool	Low for HSC	Normal	High for Box Temp	Normal	Low for Box Temp	Normal to Low	Normal to Low	Normal	Compressor LV1 Open In Cool	
Cool	Low at Low Box Temps Normal at High Box Temps	Normal to Warm	Normal to Low at Low Box Temps	Warm	Low	High	Low	Full	Economizer Expansion Valve too Closed, Starving, High Superheat in Cool	
Cool	Low	Normal to Warm	High	Warm	High	Normal to High	High	Normal to Low	Water Valve Open in Cool	
Cool	Low	Will tend to be Warm	Low	Normal	May Be Low	High	Low	Full	Evaporator Expansion Valve too Closed, Starving, High Super Heat in Cool	
Cool	Low	Warm	Low	Frosty (very)	Low	Low	Low	Full	Liquid Line Solenoid Closed in Cool	The low side will pump down if the LLS sticks closed in cool.
Cool	Low	Warm	Low	Warm	Low	High	Low	Empty	Condenser Check Valve Closed in Cool	Would pump down from Condenser Check valve. Condenser will hold the total refrigerant charge.
Cool	Low	Warm	Low	Normal	Normal	Normal to High	Low	Low	Heat Bypass Orifice Plugged in Cool	This looks like low refrigerant charge.
Cool	Low	Warm	High	Warm	High	Normal	High for Ambient	Low (Maybe)	Three-Way Valve Leaking (or Stuck in the Middle) in Cool	
Cool	Low	Warm	High	Warm	High	Normal to High	Low	Normal	Compressor Capacity Low	
Cool	Very Low and gets worse as box temp falls	Warm	High	Warm	High up to MOP	Normal to High	Low	Normal	Compressor LV2 Open In Cool	
Cool	Normal to Low	Normal to Frosty	Normal to Low	Normal	Normal to Low	Normal to High	Normal to Low	Full	Evaporator Expansion Valve Internal Leak from Liquid Line to Equalizer in Cool	Mimics Evaporator Expansion Valve too Closed
Cool	Normal to Low	Normal	Normal	Frosty	High	Low	High to Normal	Normal to Low	Economizer Expansion Valve too Open, Flooding, Low Superheat in Cool	Frosty economizer suction line is a good indicator.
Cool	Normal	Normal	Low	Normal	Normal	Normal to High	Normal	Normal	Compressor LV2 Closed In Modulated Cool	Most things would appear normal, except Micro may go into Compression Ratio Control and Suction Pressure Control and unit would have increased Fuel Consumption on modulated loads.Would have a High TD in HSCU
Cool	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Compressor LV1 Closed In Cool	Everything would appear normal, but the ETV would probably be more closed than normal in modulated cool

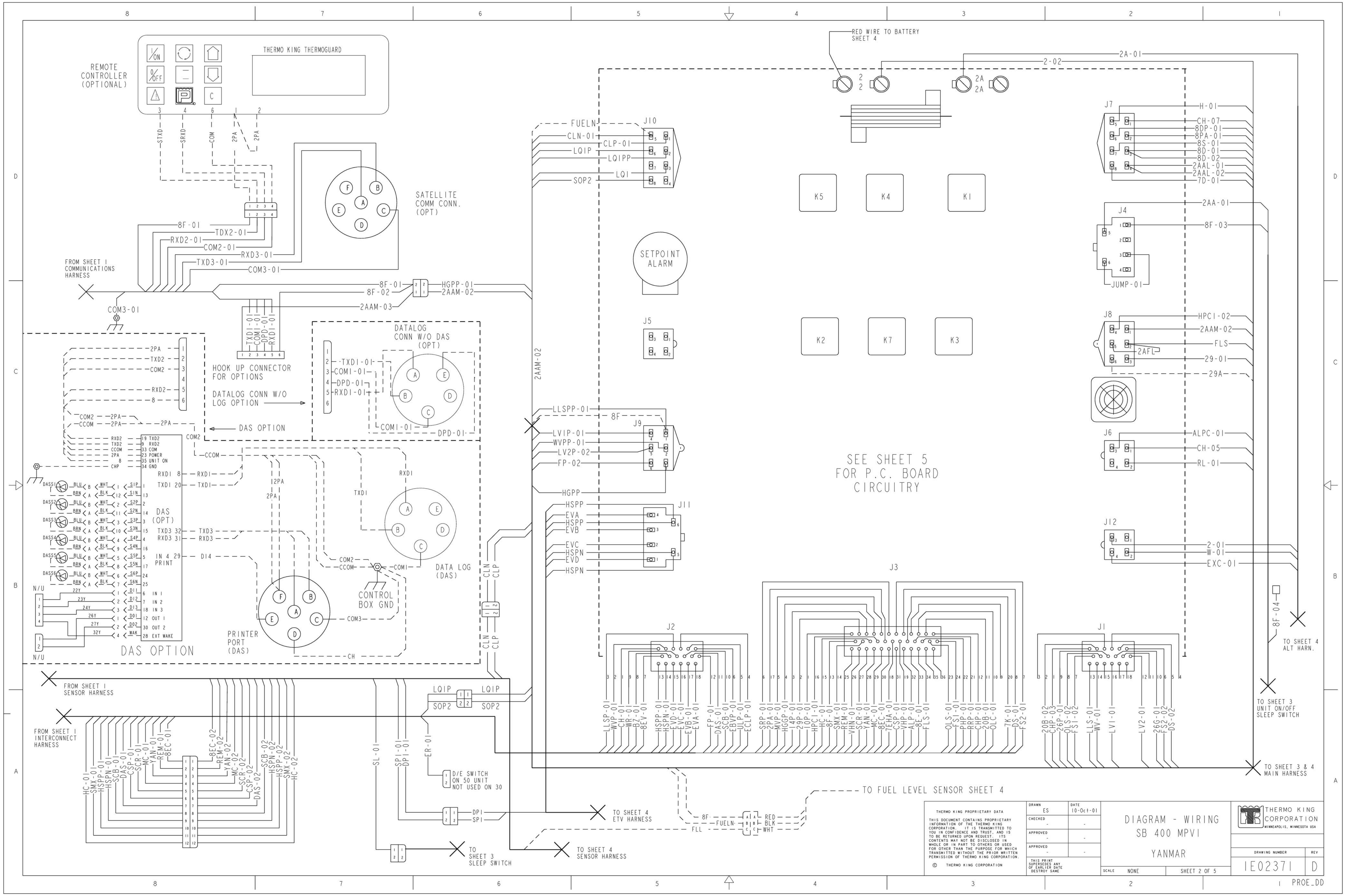
Cool or Heat	TPDF	Main Suction Line Condition	Main Suction Pressure	Economizer Suction Line Condition	Economizer Suction Pressure	CTMP	Discharge Pressure	Receiver Sight Glass	Component Failure	Comments
Cool	Normal	Normal	Normal	Normal	Normal	High in High Ambient	Normal	Normal	LIV Closed In Cool	May see Discharge pressure control and Compression Ratio Control. Will probably see Compression Ratio Control with high ambient and low box temperatures.
Cool and Heat	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Compressor Discharge Check Valve Stuck Open Cool or Heat	One symptom is that in CYCLE-SENTRY Mode the unit will cycle off and on more than usual. Another symptom is that the engine turns backwards when it is shut off at higher discharge pressures.
Cool and Heat									Compressor Discharge Check Valve Stuck Closed in Cool or Heat	Stops the engine. Compressor will not turn.
Heat	Low		Low	Frosty	Low	High	Low	Full	Water Valve Closed in Heat	
Heat	Low	Not Frosted	High	Frosted to Normal	High	Low	High	Low	Liquid Line Solenoid Open in Heat	
Heat	Low			Warm	Low	May Be High	Switches between Low and High		Heat Check Valve Closed in Heat	The micro will shift the 3-way valve to cool to reduce discharge pressure in Discharge Pressure Control. The pressure will then drop and the micro will shift the 3-way valve back to heat. Eventually the unit will probably shut down on high discharge pressure.
Heat	Low			Warm	Low	High	Low	Empty	Condenser Check Valve Open in Heat	
Heat	Low	Warm		Warm	Low	High	Low	Low	Three-Way Valve Leaking (or Stuck in the Middle) in Heat	Will tend to fill condenser with liquid. Discharge pressure will go the saturated ambient pressure.
Heat	Low			Warm	Low with Low MOP	High	Low to start, then goes High	Full	Economizer Expansion Valve too Closed, Starving, High Superheat in Heat	If the Economizer suction pressure goes above the MOP, the valve will close to reduce the pressure. Refrigerant in economizer is heated by engine coolant which causes pressure in liquid line to rise quickly.This also causes the discharge pressure to rise quickly and the micro will go into Discharge Pressure Control.
Heat	Low			Warm	High	Normal to High	Low	Normal (Full)	Compressor Capacity Low	
Heat	Low			Warm	High	Normal	Low	Normal (Full)	Compressor LV2 Open In Heat	
Heat	Low initially then becomes Normal								Heat Bypass Orifice Plugged in Heat	The LIV will inject liquid to get the pressures up. Everything will appear normal after that.
Heat	Normal to Low	Normal	Very Low	Normal		Normal	Normal to Low	Normal to Low	Compressor LV1 Closed In Heat	
Heat	Normal (Low with low ambient and box temps)	Normal	Normal	Normal	Normal	High with High Box Temps	Normal (Low with low ambient and box temps)	Normal	LIV Closed In Heat	Will not heat very well with low ambient and box temperatures and the suction and discharge pressures will be low.
Heat	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Compressor LV1 Open In Heat	
Heat	Normal			Normal	Normal	Normal	Normal to High	Normal	Compressor LV2 Closed In Heat	May see 3-way valve dumping to control discharge pressure. This is normal pressure control algorithm.
Heat	Normal to High			Frosty	High with a High MOP	Low	High	Normal to Low	Economizer Expansion Valve too Open, Flooding, Low Superheat in Heat	Frosty economizer suction line is a good indicator.
Heat	High	Frosty	High	Normal	High	Low	Normal to High	Normal to Low	LIV Open In Heat	Frosty Main Suction line is a good indicator.


Ingersoll-Rand
Thermo King
DIAGRAM-SCHEMATIC
SB190/200/300/400 MP VI
W/ YANMAR
1E02367
SHEET 1 OF 3

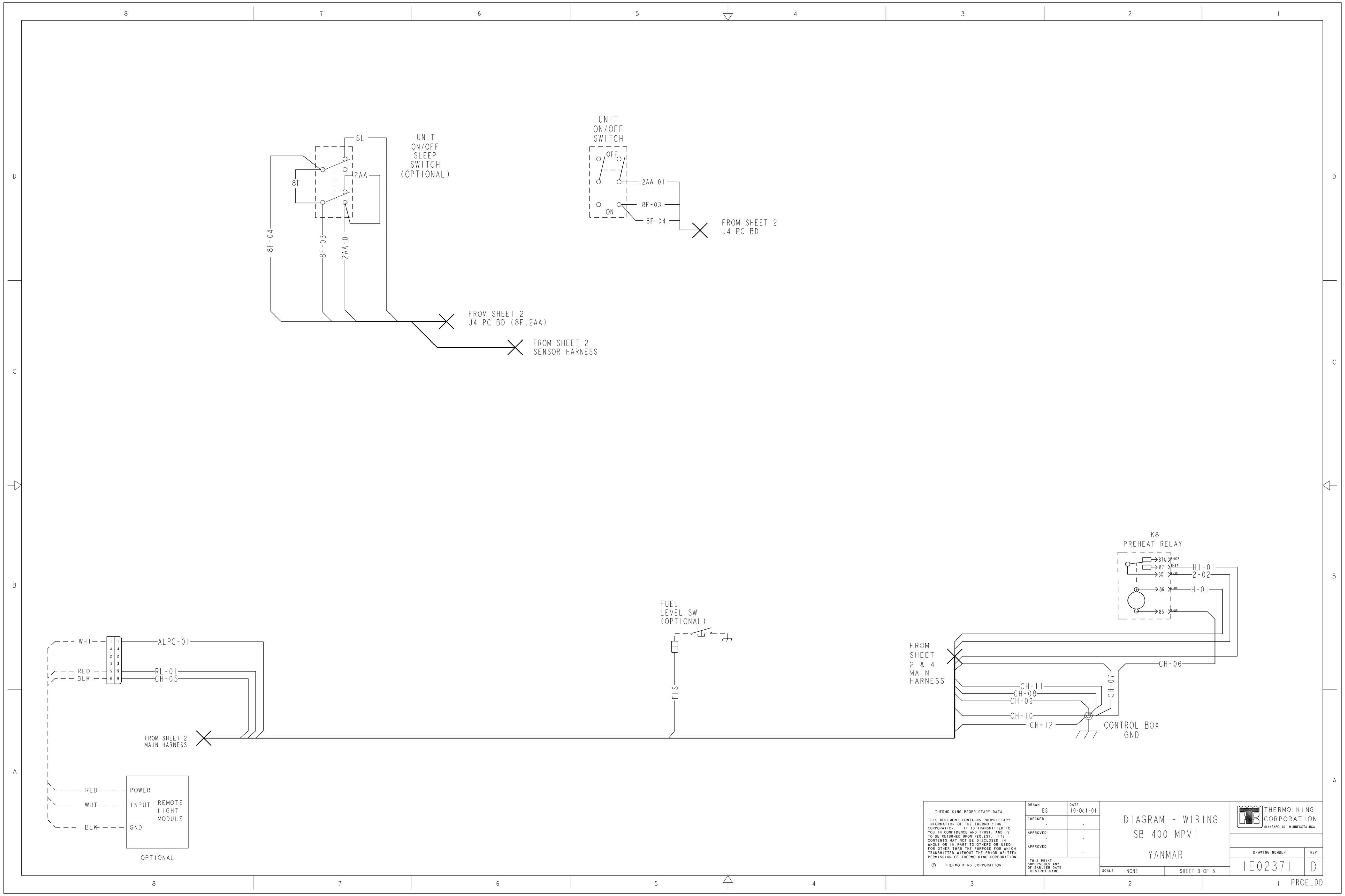

THERMOGUARD uP VI
MICROCONTROLLER
FUEL LEVEL SENSOR SOLID STATE
FUEL LEVEL SENSOR FLOAT
DAS (OPTIONAL)
PREHEAT BUZZER
TO SHEET 1
(NOT USED)
(SB 400)
(SB 200/300)
(SB 200/300/400)
Ingersoll-Rand
Thermo King
SIZE D
1E02367
REV E
SCALE: NONE
SHEET 2 OF 3

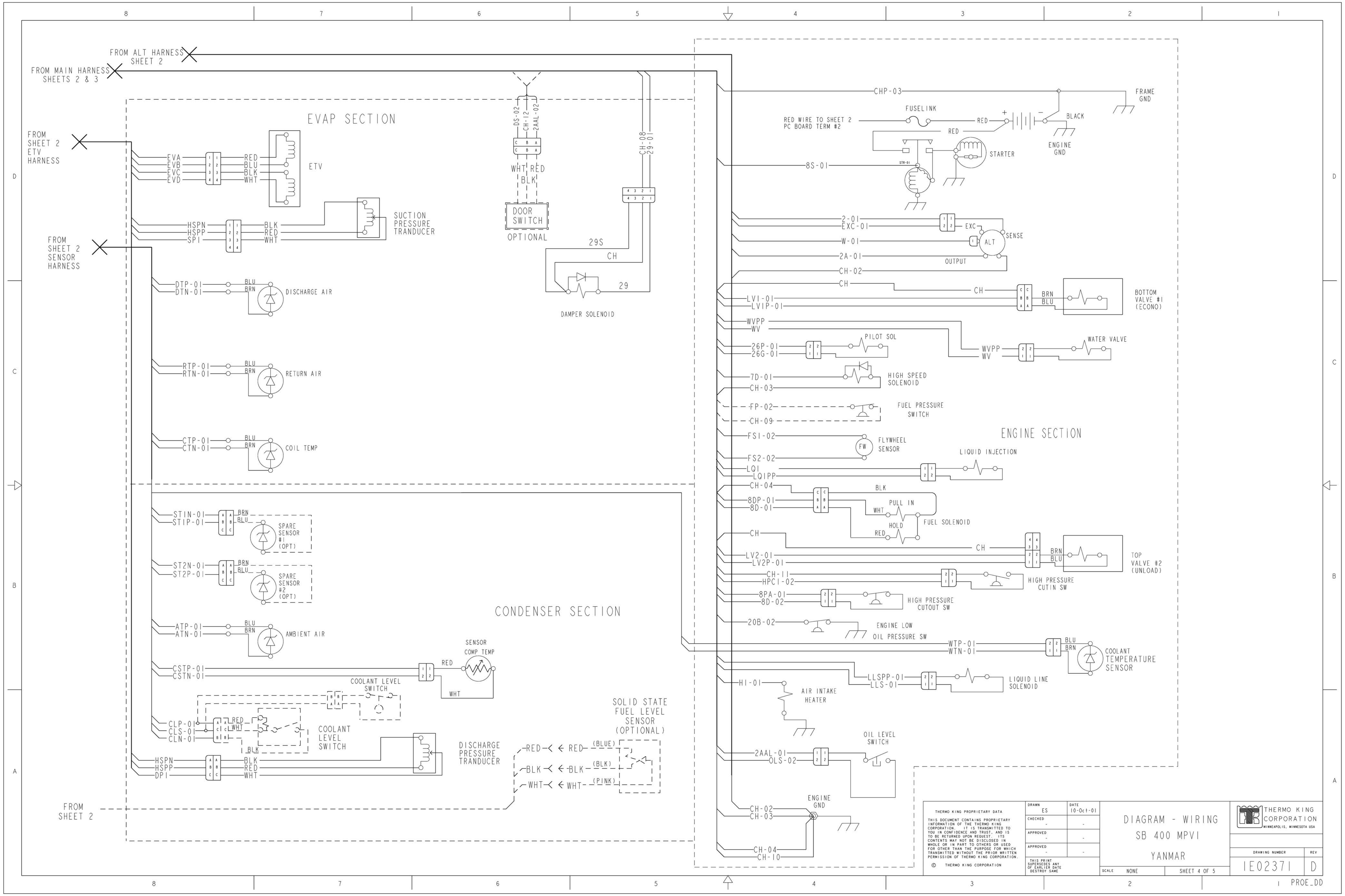

TRAC-KING SATELLITE OPTION
CONNECTS TO DAS HARNESS 6 PIN CONN
CONNECTS TO COMMUNICATION HARNESS 6 PIN CONN
MT2000
MT2000 P/S
iBOX
iBOX FLASHLOAD PORT
TO SHEET 1 LINE 1
FROM SHEET 1 LINE 1
SATELLITE ENABLE/DISABLE SWITCH
ENABLE
DISABLE
Ingersoll Rand
Thermo King
1E02367
SHEET 3 OF 3
SCALE: NONE

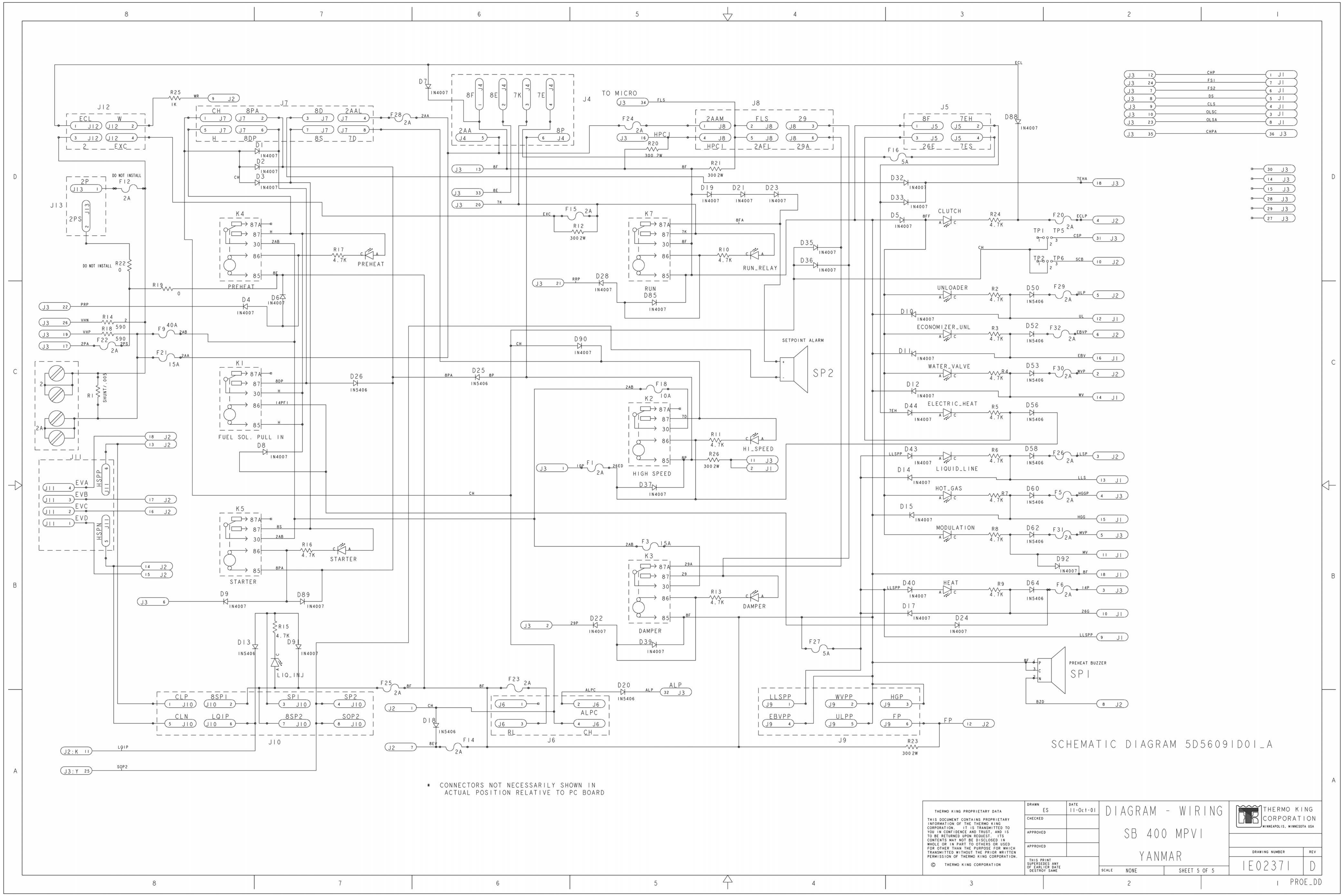

14 PIN CONNECTOR
COMMUNICATION HARNESS
1 - TXD1
2 - RXD1
3 - TXD2
4 - NOT USED
5 - COM1
6 - COM2
7 - RXD2
8 - NOT USED
9 - KEYING PIN
10 - NOT USED
11 - TXD3
12 - DPD
13 - NOT USED
14 - RXD3
9 PIN CONNECTOR
INTERCONNECT HARNESS
1 - VHP
2 - VHN
3 - WR
4 - 2PA
5 - FS2
6 - FS1
7 - CHP
8 - CHP
9 - KEYING PIN
TO SHEET 2
INTERCONNECT HARNESS
TO SHEET 2
COMMUNICATIONS
HARNESS
REAR VIEW OF CONTROLLER
TO SHEET 2
SENSOR HARNESS
37 PIN CONNECTOR
INTERCONNECT HARNESS
1 - LQIP
2 - SOP2
3 - CHP
4 - MVP
5 - LLSP
6 - BZ
7 - KEYING PIN
8 - RRP
9 - WVP
10 - HGGP
11 - SRP
12 - OLC
13 - OLS
14 - PHP
15 - 14P
16 - EBVP
17 - 29P
18 - 20B
19 - FP
20 - 7K
21 - ALP
22 - ULP
23 - EVD
24 - 8F
25 - HPC1
26 - 8E
27 - 7EHA
28 - ECLP
29 - EVC
30 - DS
31 - FLS
32 - ER
33 - 10P
34 - CH
35 - 8EV
36 - EVB
37 - EVA
37 PIN CONNECTOR
SENSOR HARNESS
1 - CSTP
2 - CSTN
3 - RTP
4 - DTP
5 - SPI
6 - DPI
7 - RTN
8 - DTN
9 - CTP
10 - HSPP
11 - HSPN
12 - NOT USED
13 - NOT USED
14 - CTN
15 - KEYING PIN
16 - CLS
17 - HC
18 - SMX
19 - ST2N
20 - ST2P
21 - STIN
22 - STIP
23 - SCB
24 - 8EC
25 - REM
26 - YAN
27 - WTN
28 - WTP
29 - DAS
30 - MC
31 - NOT USED
32 - ATN
33 - ATP
34 - SCR
35 - CSP
36 - NOT USED
37 - SL
DIAGRAM - WIRING
SB 400 MPVI
YANMAR
THERMO KING
CORPORATION
(1E02367)
1E02371
D
PROE_DD


REMOTE CONTROLLER (OPTIONAL)
THERMO KING THERMOGUARD
SATELLITE COMM CONN. (OPT)
FROM SHEET 1 COMMUNICATIONS HARNESS
HOOK UP CONNECTOR FOR OPTIONS
DATALOG CONN W/O LOG OPTION
DAS OPTION
DATALOG CONN W/O DAS (OPT)
DATA LOG (DAS)
CONTROL BOX GND
PRINTER PORT (DAS)
DAS (OPT)
SETPOINT ALARM
SEE SHEET 5 FOR P.C. BOARD CIRCUITRY
RED WIRE TO BATTERY SHEET 4
FROM SHEET 1 SENSOR HARNESS
FROM SHEET 1 INTERCONNECT HARNESS
D/E SWITCH ON 50 UNIT NOT USED ON 30
TO SHEET 4 ETV HARNESS
TO SHEET 3 SLEEP SWITCH
TO SHEET 4 SENSOR HARNESS
TO FUEL LEVEL SENSOR SHEET 4
TO SHEET 4 ALT HARN.
TO SHEET 3 UNIT ON/OFF SLEEP SWITCH
TO SHEET 3 & 4 MAIN HARNESS
DIAGRAM - WIRING
SB 400 MPVI
YANMAR
THERMO KING CORPORATION
1E02371
D
SHEET 2 OF 5
PROE_DD

Wiring Diagram — Page 3 of 5




FROM ALT HARNESS SHEET 2
FROM MAIN HARNESS SHEETS 2 & 3
EVAP SECTION
CONDENSER SECTION
ENGINE SECTION
DIAGRAM - WIRING
SB 400 MPVI
YANMAR
THERMO KING CORPORATION
1E02371
D
SHEET 4 OF 5


SCHEMATIC DIAGRAM 5D56091D01_A
* CONNECTORS NOT NECESSARILY SHOWN IN ACTUAL POSITION RELATIVE TO PC BOARD
DIAGRAM - WIRING
SB 400 MPVI
YANMAR
THERMO KING CORPORATION
1E02371
D
PROE_DD