SB-400

TK 51113-2-MM (Rev. 2, 08/02)

The maintenance 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 Refrigeration System Manual	**TK 51696**
SB-400 Operator's Manual	**TK 51212**
SB-400 Parts Manual	**TK 51356**
DAS Data Acquisition System Manual	**TK 50565**
TK 482 and TK 486 Engine Overhaul Manual	**TK 50136**
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.	

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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.

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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.

Refrigerant

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.

Specifications

Engine

Model	TK 486
Number of Cylinders	4
Cylinder Arrangement	In-line vertical, number 1 on flywheel end
Firing Order	1-3-4-2
Direction of Rotation	Counterclockwise viewed from flywheel end
Fuel Type	No. 2 diesel fuel under normal conditions No. 1 diesel fuel is acceptable cold weather fuel
Oil Capacity	13 quarts (12.3 liters) crankcase Fill to full mark on dipstick
Oil Type	API Classification CG-4 or better (ACEA Rating E2-96 or better for Europe)
Oil Viscosity	5 to 122 F (-15 to 50 C): SAE 15W-40 -13 to 104 F (-25 to 40 C): SAE 10W-40 -13 to 86 F (-25 to 30 C): SAE 10W-30 -22 to 32 F (-30 to 0 C): SAE 5W-30
Engine rpm: Low Speed Operation High Speed Operation	1450 ± 25 rpm 2200 ± 25 rpm
Engine Oil Pressure	18 psi (127 kPa) minimum in low speed 45 to 57 psi (310 to 390 kPa) in high speed
Intake Valve Clearance	0.006 to 0.010 in. (0.15 to 0.25 mm)
Exhaust Valve Clearance	0.006 to 0.010 in. (0.15 to 0.25 mm)
Valve Setting Temperature	70 F (21 C)
Fuel Injection Timing	11° to 13° BTDC (timed on No. 1 cylinder)
Low Oil Pressure Switch (Normally Closed)	17 ± 3 psi (117 ± 21 kPa)
Engine Coolant Thermostat	180 F (82 C)
Engine Coolant Type	ELC (Extended Life Coolant), which is “RED” Use a 50/50 concentration of any of the following equivalents: Texaco ELC (16445, 16447) Havoline Dex-Cool® (7994, 7995, 7997, 7998) Havoline XLC for Europe (30379, 33013) Shell Dexcool® (94040) Shell Rotella (94041) Saturn/General Motors Dex-Cool® Caterpillar ELC Detroit Diesel POWERCOOL® Plus ***CAUTION: Do not add “GREEN” or “BLUE-GREEN” conventional coolant to cooling systems using “RED” Extended Life Coolant, except in an emergency. If conventional coolant is added to Extended Life Coolant, the coolant must be changed after 2 years instead of 5 years.***
Coolant System Capacity	7.5 quarts (7.1 liters)
Radiator Cap Pressure	7 psi (48 kPa)
Drive	Direct to compressor; belts to fans, alternator and water pump

Belt Tension

Belt	Tension No. on TK Gauge P/N 204-427
Alternator Belt	35
Lower Fan Belt (Engine to Idler)	67
Upper Fan Belt (Fan to Idler)	74

Refrigeration System

Compressor	Thermo King S391
Refrigerant Charge—Type	19 lb (8.6 kg)—R-404A
Compressor Oil Charge	2.8 quarts (2.7 liters)*
Compressor Oil Type	Ester type P/N 203-515
Electronic Throttling Valve Setting	Variable
Heat/Defrost Method	Hot gas
High Pressure Cut In (Backup for Discharge Pressure Transducer): Opens Closes	325 ± 10 psi (2241 ± 69 kPa) 425 ± 10 psi (2930 ± 69 kPa)
High Pressure Cutout	470 ± 7 psi (3241 ± 48 kPa) Automatic reset @ 375 ± 38 psi (2586 ± 262 kPa)

***** *This is the total oil charge. It includes the oil in the compressor and the oil in the refrigeration system. The actual oil charge in the compressor alone is considerably less. The top of the compressor sight glass corresponds to approximately 1.4 quarts (1.3 liters). The bottom of the compressor sight glass corresponds to approximately 0.9 quarts (0.8 liters). When the compressor is removed from the unit, the oil level should be noted or the oil removed from the compressor should be measured so that the same amount of oil can be added before placing the replacement compressor in the unit.***

Electrical Control System

Voltage	12.5 Vdc
Battery	One, group C31, 12 volt battery
Fuse F3—Power to Defrost Relay/Damper	15 amp
Fuse F9—Main Control Power	40 amp
Fuse F18—Power to Throttle Solenoid	15 amp
Fuse F21—Power to On/Off Switch	25 amp
Other Fuses	2, 3, or 5 amp
Battery Charging	12 volt, 37 amp, brush type alternator
Voltage Regulator Setting	13.8 to 14.2 volts @ 77 F (25 C)

NOTE: Fuse F15 (Bypass Resistor for Prestolite Alternator) must be removed for the Bosch Alternator. The Bosch alternator has the word "BOSCH" on the end opposite the pulley (see Figure 17 on page 56).

Electrical Components

NOTE: Disconnect components from unit circuit to check resistance.		
Component	**Current Draw (Amps) at 12.5 Vdc**	**Resistance—Cold (Ohms)**
Fuel Solenoid: Pull-in Coil	35 to 45	0.2 to 0.3
Hold-in Coil	0.5	24 to 29
Damper Solenoid	5.7	2.2
High Speed (Throttle) Solenoid	2.9	4.3
Intake Air Heater	89	0.14
Liquid Line Solenoid	1.3	9.6
Loading Valve #1 (Economizer Bypass Solenoid)	1.25	10.0
Loading Valve #2	1.25	10.0
Water Valve Solenoid	1.25	10.0
Pilot Solenoid	0.7	17.0
Liquid Injection Valve	1.25	10.0
Electronic Throttling Valve:		
Coil A (Red and Blue Wires)	—	20 to 35
Coil B (Black and White Wires)	—	20 to 35
Starter Motor—Gear Reduction Type	250-375*	
**** On-the-engine cranking check. Bench test is approximately 80 amps on the gear reduction starter.***		

SMART REEFER µP-VI Microprocessor Temperature Controller

Temperature Controller	Electronic THERMOGUARD µP-VI Microprocessor with digital thermostat, thermometer and fault indicator monitor
Setpoint Range	Factory default setting -20 to 80 F (-29 to 27 C) Programmable setpoint range -25 to 90 F (-32 to 32 C)
Digital Temperature Display	-40 to 99.9 F (-40 to 40 C)
Internal Defrost Timer: Temperature Pulldown	2, 4, 6, 8 or 12 hours (selectable, standard setting 4)
Temperature In-range	4, 6, 8 or 12 hours (selectable, standard setting 6)
Defrost Initiation	Coil temperature must be below 45 F (7 C)
Defrost Termination	Terminates defrost at coil temperature above 57 F (14 C)
Defrost Interval Timer	Terminates defrost 30 to 45 minutes (programmable) after initiation if coil sensor has not terminated defrost

Design Features and Unit Photos

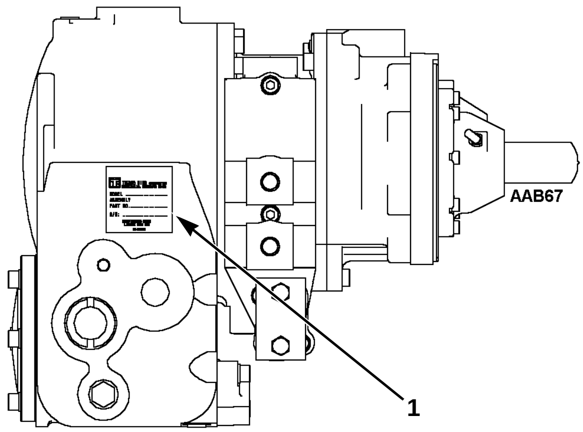
Design Features	Unit Model SB 400 (002004)
TK 486 Diesel Engine	•
S391 Compressor with Ester Base Compressor Oil	•
Top Mount Muffler	•
Low Noise Acoustical Design Grille	•
Stainless Steel Exterior Condenser Hardware	•
Stainless Steel Evaporator Hardware	•
Tapered Roller Bearing Fanshaft and Idler	•
Premium Drive Belts	•
3000 Hour Cyclonic Air Cleaner and Filter Inside Unit Frame	•
SMART REEFER µP-VI Microprocessor Controller	•
Electronic Throttling Valve (ETV)	•
3000 Hour Fuel Filter/Water Separator	•
3000 Hour Dual Lube Oil Filter	•
Side Mount Coolant Expansion Tank	•
12,000 Hour (Service Interval) Coolant	•
Defrost Timer	•
CYCLE-SENTRY System	•
37 Amp Alternator	•
Refrigerant R-404A	•
Silicone Coolant Hoses	•
Remote Status Light	•
Communications (Data Logging)	•
DAS (Data Acquisition System)	•
Sleep Mode Easy Switch	Opt
Fuel Heater	Opt
Frost Plug Heater	Opt
65 Amp Alternator	Opt
Fresh Air Exchange	Opt
Chrome Grills	Opt
Remote Controls	Opt
R:COM™ Automatic Data Transmission System	Opt
Satellite Communications System	Opt
Thermo King Bulkhead and Duct System	Opt
Dealer Installed Synthetic Engine Oil	Opt

Serial Number Locations

Unit: Nameplates on the on the bulkhead above compressor inside the curbside door, and on the top, roadside corner of evaporator.

Engine: Stamped on an nameplate on the valve cover.

Compressor: Stamped on the plate above the oil level sight glass.

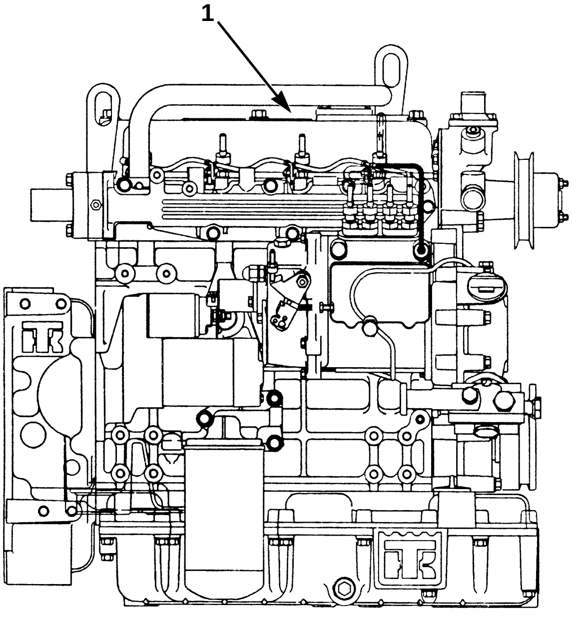


1.	Serial Number Location

Figure 1: Compressor Serial Number Location

1.	Serial Number Location

Figure 2: Unit Serial Number Locations



1.	Serial Number Location

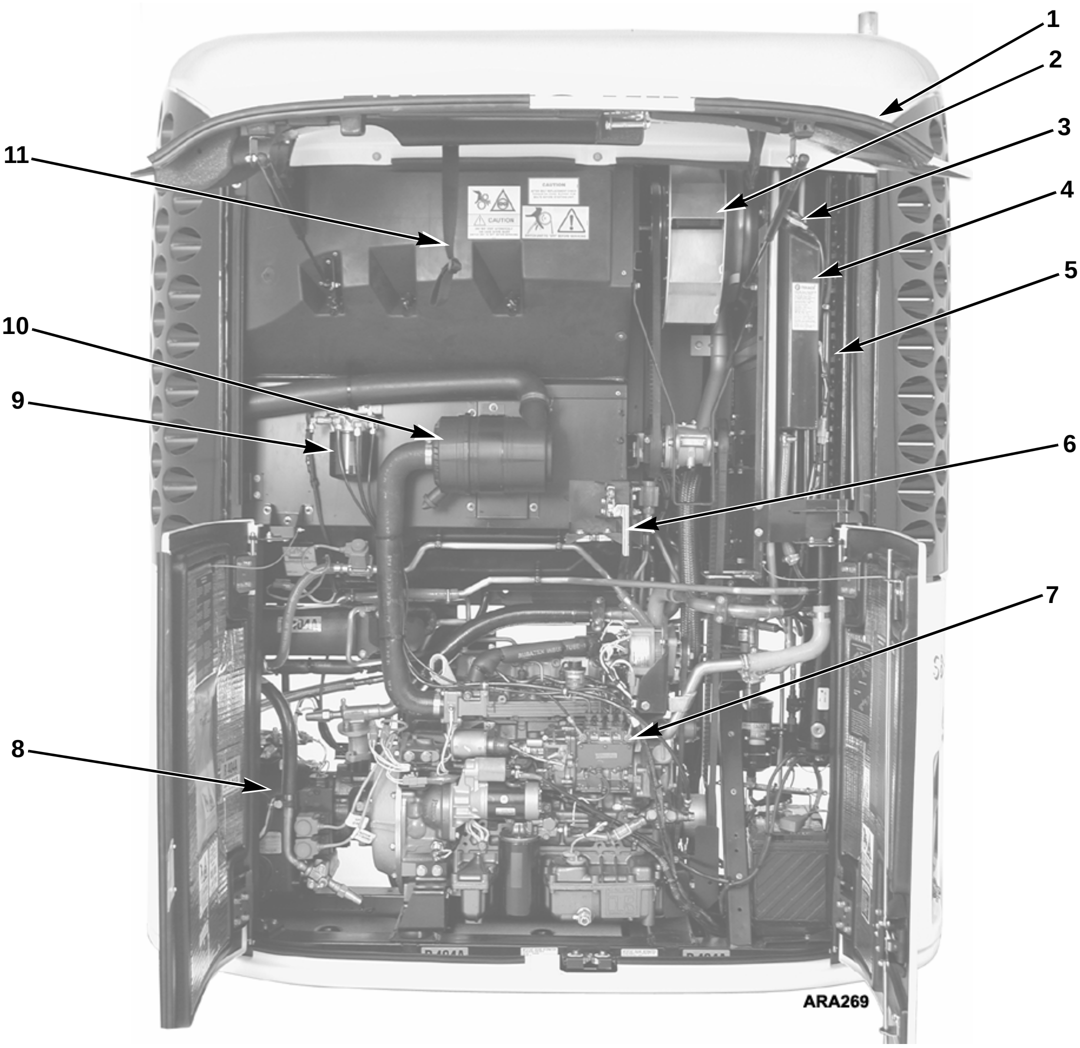
Figure 3: Engine Serial Number Location

Unit Photos

Figure 4: Front View

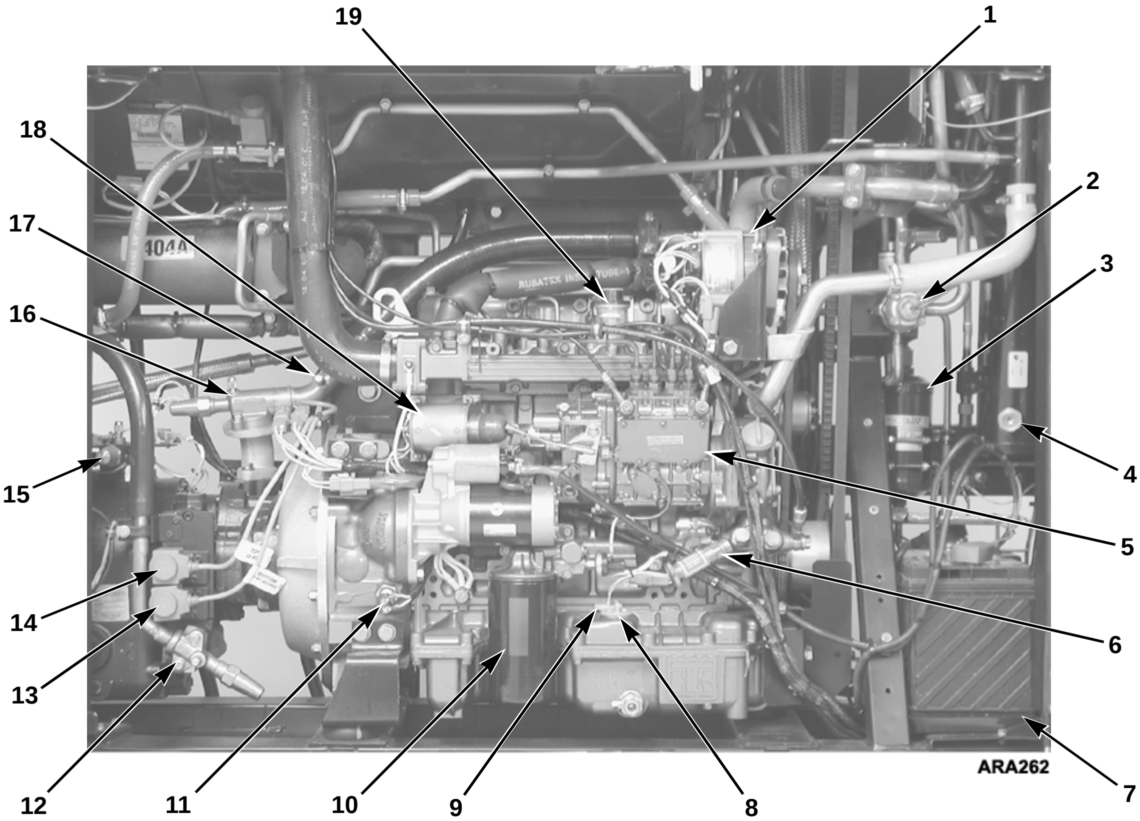
1.	Defrost Damper
2.	S391 Compressor
3.	TK 486 Engine

Figure 5: Back View



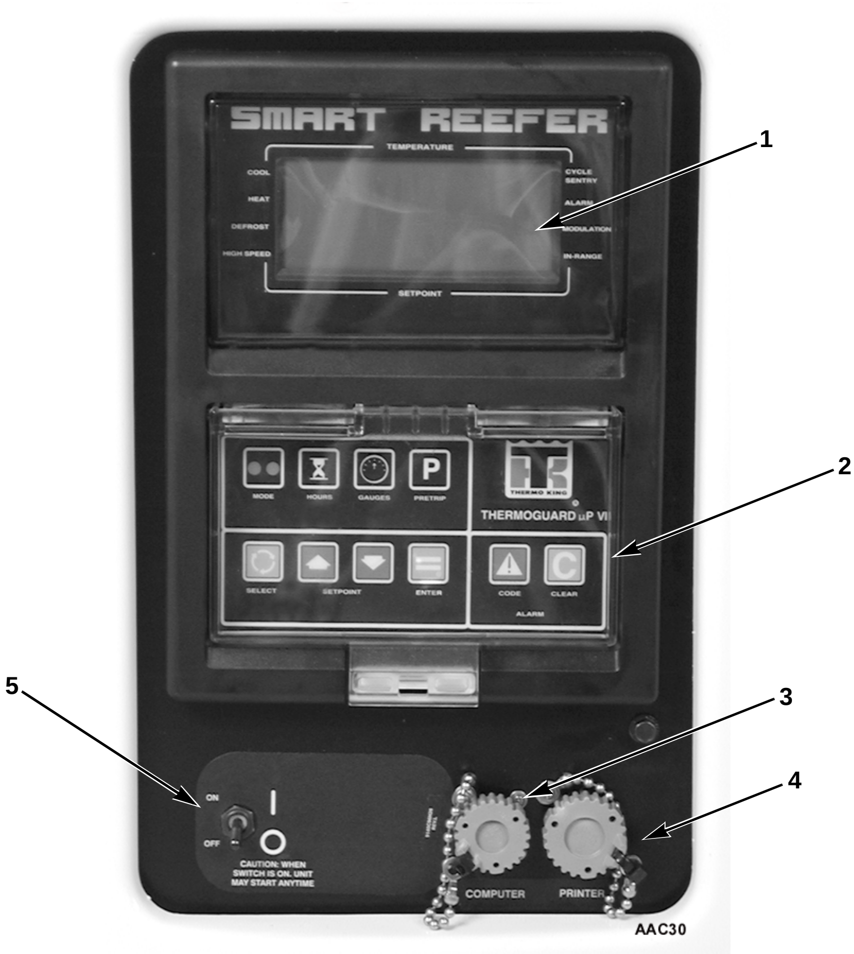
1.	Top Access Door	7.	TK 486 Engine
2.	Condenser Fan	8.	S391 Compressor
3.	Radiator Cap (Coolant Fill)	9.	Fuel Filter
4.	Expansion Tank	10.	Air Cleaner
5.	Subcooler/Condenser/Radiator Coil	11.	Top Access Door Pull Down Strap
6	Top Access Door Latch Handle		

Figure 6: Front View with Doors Open



1.	Alternator	11.	Engine RPM Sensor
2.	Three-way Valve	12.	Economizer Suction Service Valve
3.	Filter Drier	13.	Loading Valve #1
4.	Receiver Tank Sight Glass	14.	Loading Valve #2
5.	Fuel Injection Pump	15.	Discharge Service Valve
6.	Hand Primer Pump	16.	Suction Service Valve
7.	Battery Tray	17.	Suction Access Port
8.	Oil Dipstick	18.	Throttle Solenoid
9.	Low Oil Level Switch	19.	Air Restriction Indicator
10.	Oil Filter		

Figure 7: Engine Compartment



1.	Display
2.	Microprocessor Control Panel
3.	Computer Port
4.	Printer Port
5.	ON/OFF Switch

Figure 8: Control Panel

Maintenance Inspection Schedule

Pretrip	Every 1,500 Hours	Every 3,000 Hours*	Annual/ 4,500 Hours	Inspect/Service These Items
				Microprocessor
•				Run Pretrip Test (refer to Pretrip Test in the Operating Manual).
				Engine
•				Check fuel supply.
•				Check engine oil level.
•	•	•	•	Inspect belts for condition and proper tension (belt tension tool No. 204-427).
•	•	•	•	Check engine oil pressure hot, on high speed (should display “OK”).
•	•	•	•	Listen for unusual noises, vibrations, etc.
•		•		Check air cleaner restriction indicator (change filter when indicator reaches 25 in.). Replace EMI 3000 air cleaner element (see “EMI 3000 Air Cleaner” on page 75) at 3,000 hours or two years (whichever occurs first) if indicator has not reached 25 in.
	•	•	•	Drain water from fuel tank and check vent.
	•	•	•	Inspect/clean fuel transfer pump inlet strainer (prefilter).
	•	•	•	Check and adjust engine speeds (high and low speed).
			•	Check engine mounts for wear.
		•		Replace fuel filter/water separator.
		•		Change engine oil and filter (hot). Requires oil with API Rating CG-4 or better (ACEA Rating E2-96 for Europe).
			—	Change ELC (red) engine coolant every 5 years or 12,000 hours. Units equipped with ELC have an ELC nameplate on the expansion tank (see page 61).
			—	Test fuel injection nozzles at least every 10,000 hours.
				Electrical
	•	•	•	Inspect battery terminals and electrolyte level.
	•	•	•	Inspect wire harness for damaged wires or connections.
•	•	•	•	Check operation of damper door (closes on defrost initiation and opens on defrost termination).
			•	Inspect alternator wire connections for tightness.
				Refrigeration
•	•	•	•	Check refrigerant level.
			•	Check compressor oil level and condition.
			•	Check compressor efficiency and pump down refrigeration system.
				Replace dehydrator and check discharge and suction pressure every two (2) years.

**3,000 hours or two years, whichever occurs first.*

Pretrip	Every 1,500 Hours	Every 3,000 Hours*	Annual/ 4,500 Hours	Inspect/Service These Items
				Structural
•	•	•	•	Visually inspect unit for fluid leaks.
•	•	•	•	Visually inspect unit for damaged, loose or broken parts (includes air ducts and bulkheads).
	•	•	•	Inspect tapered roller bearing fanshaft and idlers for leakage and bearing wear (noise).
	•	•	•	Clean entire unit including condenser and evaporator coils and defrost drains.
	•	•	•	Check all unit and fuel tank mounting bolts, brackets, lines, hoses, etc.
	•	•	•	Check evaporator damper door adjustment and operation.

**3,000 hours or two years, whichever occurs first.*

Unit Description

General Description

The SB-400 is a one-piece, self-contained, diesel powered refrigeration-heating unit. The unit mounts on the front of the trailer with the evaporator portion extending into the trailer. The unit uses hot gas to heat and defrost.

Power is provided by the TK 486, a four-cylinder, water cooled, direct injection diesel engine. The TK 486 displaces 2.09 liters and is rated at 33.9 horsepower (25.3 kilowatts) at 2200 rpm. An in-line power pack provides direct drive power transfer from the engine to the compressor. A belt drive system transfers power to the fans, the alternator, and the water pump.

The engine uses a spin-on, duel element, full flow/bypass oil filter and “CG-4” rated petroleum engine oil for extended 3,000 hour maintenance intervals.

SMART REEFER µP-VI Microprocessor

The SMART REEFER µP-VI is a microprocessor control system designed for a transport refrigeration system. The µP-VI integrates the following functions: thermostat, digital thermometer, hourmeters, oil pressure condition, water temperature gauge, ammeter, voltmeter, tachometer, mode indicator, refrigeration system controller, and diagnostic system.

The CYCLE-SENTRY system, an integral defrost timer, data logging, and remote status lights are standard features. Remote controls are an optional feature.

The microprocessor mounts inside a weather tight control box. The LCD display is clearly visible through a transparent cover. Opening the keypad door provides quick access to the microprocessor keypad. The keypad is used to control the operation of the microprocessor.

CYCLE-SENTRY Start-Stop Controls

A CYCLE-SENTRY Start-Stop fuel saving system provides optimum operating economy.

⚠ ***WARNING: With the unit On/Off switch in the On position, the unit may start at anytime without prior warning.***

NOTE: A buzzer sounds when the unit is automatically preheating.

NOTE: The microprocessor has an OptiSet™ feature, which can lockout CYCLE-SENTRY operation and force Continuous Run within a programmable range of setpoints. If this feature is active and the setpoint is within the programmed lockout range, the CYCLE-SENTRY symbol will flash while the unit is automatically starting. After the unit starts, the CYCLE-SENTRY symbol will disappear and the unit will operate in Continuous Run as long as the setpoint is within the programmed lockout range. Refer to the appropriate THERMOGUARD Microprocessor Diagnostic Manual for specific information about the OptiSet™ feature.

The CYCLE-SENTRY system automatically starts the unit on microprocessor demand, and shuts down the unit when all demands are satisfied. In addition to maintaining the box temperature, engine block temperature and battery charge levels are monitored and maintained. If the block temperature falls below 30 F (-1 C), the engine will start and run until the block temperature is above 90 F (32 C). If the battery voltage falls to the programmed limit selected by CYCLE-SENTRY Battery Voltage (typically 12.2 volts) and Diesel CYCLE-SENTRY mode is selected, the engine will start and run until the charge rate falls below that programmed by CYCLE-SENTRY Amps (typically 5 amperes).

Features of the CYCLE-SENTRY system are:

- Offers either CYCLE-SENTRY or Continuous Run operation.
- Microprocessor controlled all season temperature control.
- Maintains minimum engine temperature in low ambient conditions.
- Battery Sentry keeps batteries fully charged during unit operation.
- Variable preheat time.
- Preheat indicator buzzer.

Data Logging

Data logging is a part of the microprocessor that records operating events, alarm codes and compartment temperatures as they occur and at preset intervals. Because the unit is also equipped with a DAS, this trip data is retrieved with the data logged in the DAS (see DAS below).

DAS

The DAS (Data Acquisition System) is an independent data logger that logs information from dedicated external DAS sensors and inputs. The DAS features up to six directly connected sensors. The DAS is also connected through a serial port to the unit microprocessor. This allows unit operating information to be logged as well.

The data can be retrieved using an IBM® PC compatible laptop or desktop computer and Thermo King WinTrac 4.1 (or higher) software. The computer is connected to the Computer Port on the front of the control box. Detailed graph or table trip reports can then be created. A brief graphical or tabular report can be printed on a compatible printer (P/N 204-844 or P/N 204-1020). The printer is connected to the Printer Port on the front of the control box. Refer to the DAS Data Acquisition System Manual TK 50565 for more information.

Tracker

Tracker is a part of the microprocessor that interfaces a satellite communication system (SCS) located in the tractor. The Tracker and the SCS are connected with a data cable. The Tracker transmits data (recorded in the microprocessor) through the SCS to a central location for processing. The Tracker transmits data at preset intervals or on demand depending on the type of SCS. Data can also be transmitted through a Tracker to the microprocessor with some systems.

Electronic Throttling Valve (ETV)

The Electronic Throttling Valve (ETV) is a variable position valve operated by a stepper motor. The ETV is located in the suction line near the evaporator outlet. Discharge and suction pressure transducers supply pressure information to the microprocessor control system. The microprocessor controls the ETV directly, and uses the ETV to control the refrigerant flow from the evaporator. The ETV replaces both the throttling valve and the modulation valve used in other units.

Refrigeration System Components

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

* The evaporator coil is actually divided into two separate circuits, one is used during heating and defrost and one during cooling.

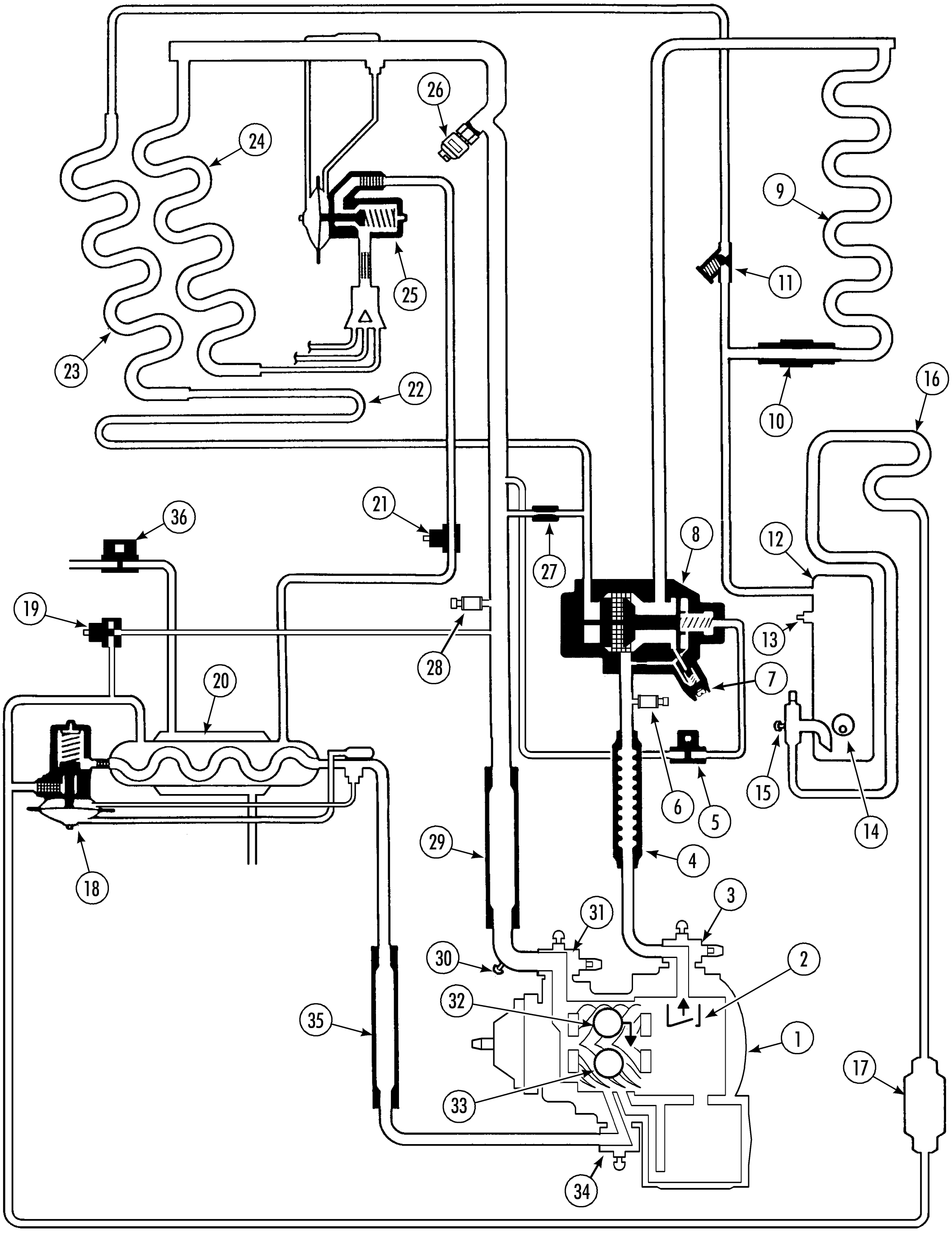


Figure 9: Refrigeration System Components

Thermo King S391 Screw Compressor with Loading Valves

The unit features a Thermo King S391 screw compressor with loading valves. Some of the characteristics of this screw compressor are:

- It does not have an oil pump.
- It has an oil separator and an oil sump on the discharge side.
- It has two suction connections and one discharge connection.
- It will not maintain a pressure differential across itself during shutdown, but has an internal discharge check valve to slow equalization.
- It requires a special pump down procedure.
- It has been improved with an internal discharge check valve and ported to accept loading valve assemblies.

NOTE: It cannot be replaced with a standard S391 (P/N 102-651) non-loading valve screw compressor.

- It has two loading valves. Each loading valve bypasses pressure until its coil is energized, then pressure forces a piston to close the port. This lengthens the distance the refrigerant must travel up the rotor, thus increasing the volume of gas that is compressed.
- LV1 (Loading Valve #1) performs the same function as the Economizer Bypass Solenoid used in earlier screw compressor systems, but it is internal to the compressor.
- LV2 (Loading Valve #2) 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.

Refrigeration System

The S391 screw compressor refrigeration system is different from the reciprocating compressor refrigeration system. Some of the characteristics of the screw compressor refrigeration system are:

- It has no accumulator tank.
- It has no suction gas/high pressure liquid heat exchanger.
- It has a subcooler that removes heat from the liquid refrigerant after the refrigerant leaves the receiver tank.
- It has an economizer type system that precools liquid refrigerant going to the cooling coil.
- It has two expansion valves.
  - One for the evaporator coil
  - One for the economizer. This is a Maximum Operating Pressure (MOP) expansion valve. The outlet pressure from this expansion valve is limited to a maximum of 50 psi (345 kPa), regardless of the inlet pressure.
- It has a separate heating circuit, called the heat coil, in the evaporator coil assembly. The heat coil is used for hot gas heat/defrost. Heat/defrost uses the economizer as an evaporator (engine coolant is supplied to the economizer) to heat the refrigerant.
- It has a Compressor Temperature Sensor (CTMP). The microprocessor uses the input from the CTMP to protect the compressor from high compressor temperatures.

The following characteristics are not used in earlier screw compressor systems:

- It has 2 normally open loading valves.
- It has discharge and suction pressure transducers. The microprocessor uses the inputs from the pressure transducers to help control the refrigeration system.
- It has an ETV (Electronic Throttling Valve). The microprocessor uses the ETV to control the refrigerant flow from the evaporator.

- It has a liquid injection valve. The microprocessor uses the liquid injection valve to control the compressor temperature, discharge pressure, and compression ratio.
- It has a condenser pressure bypass check valve on the three-way valve. This improves the three-way valve response time when shifting from heat to cool.

Refer to the illustration of the "Refrigeration System Components" on page 28 and 29.

Sequence of Operation

When the unit is turned On, the microprocessor will run a pre-start self check. The LCD display will then show the setpoint and return air temperature as the screen illuminates. The buzzer will sound as the controller initiates a configuration check. It does not matter if the unit is in Cycle-Sentry or Continuos mode, if no keys are pressed, the unit will start in approximately 30 to 50 seconds. After the unit starts, the microprocessor will perform an ETV check that tests the operation of the ETV, the loading valves, and the suction and discharge pressure transducers. The ETV check takes approximately 30 to 40 seconds. No mode icons are displayed during the ETV check. The appropriate mode icons will appear when ETV check is finished and the microprocessor is controlling the temperature to setpoint.

Operating Modes

The microprocessor uses a complex program to determine which operating mode the unit should be in. Therefore, it is difficult to predict which operating mode the unit should be in by comparing the setpoint to the box temperature.

The unit usually runs in the following modes. The microprocessor also uses special modes and protection modes called "auxiliary modes" under certain conditions. These modes are explained on the following pages.

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

Use the diagrams found on the following pages to assist you in understanding the various modes.

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.

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)
Heat Check Valve	Closed
Condenser Check Valve	Open
Damper Solenoid	Off (Open)

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 heat bypass orifice.

The liquid refrigerant then flows to the receiver tank.

Refrigerant then passes through the condenser subcooler where more heat is removed from the refrigerant. This improves the efficiency of the cooling cycle. The refrigerant flows through the drier and arrives at a tee fitting located near the economizer expansion valve. 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 down the liquid going to the evaporator and again increases efficiency 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. The hotter it is, the more refrigerant is metered in due to an increase in super heat across the economizer inner coil. The economizer actually is 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.

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. It would be similar to having a high side leak into the low side. 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 normal pressure for the economizer suction on cool is 50 psi (345 kPa). It is set by the MOP of the expansion valve. Normal pressure for the main suction line is variable because it is controlled by the ETV. 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.

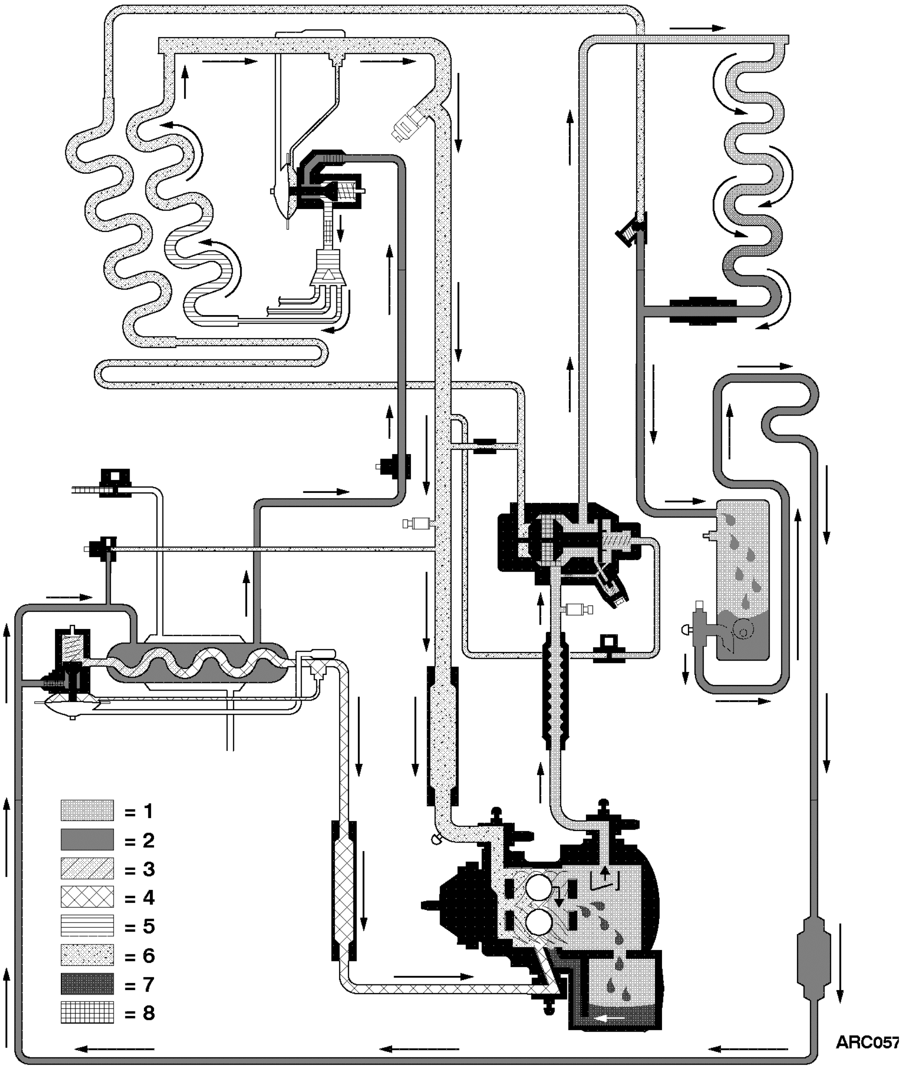
The refrigerant boils off in the evaporator and the low pressure suction gas travels through the ETV. The ETV regulates the suction pressure to the compressor to vary capacity. The gas passes by the heat bypass orifice but there is no flow either way through the orifice. The heat circuit is closed at 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

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)
Heat Check Valve	Closed
Condenser Check Valve	Open
Damper Solenoid	Off (Open)

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



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 10: High and Low Speed Cool

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*
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
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.*	

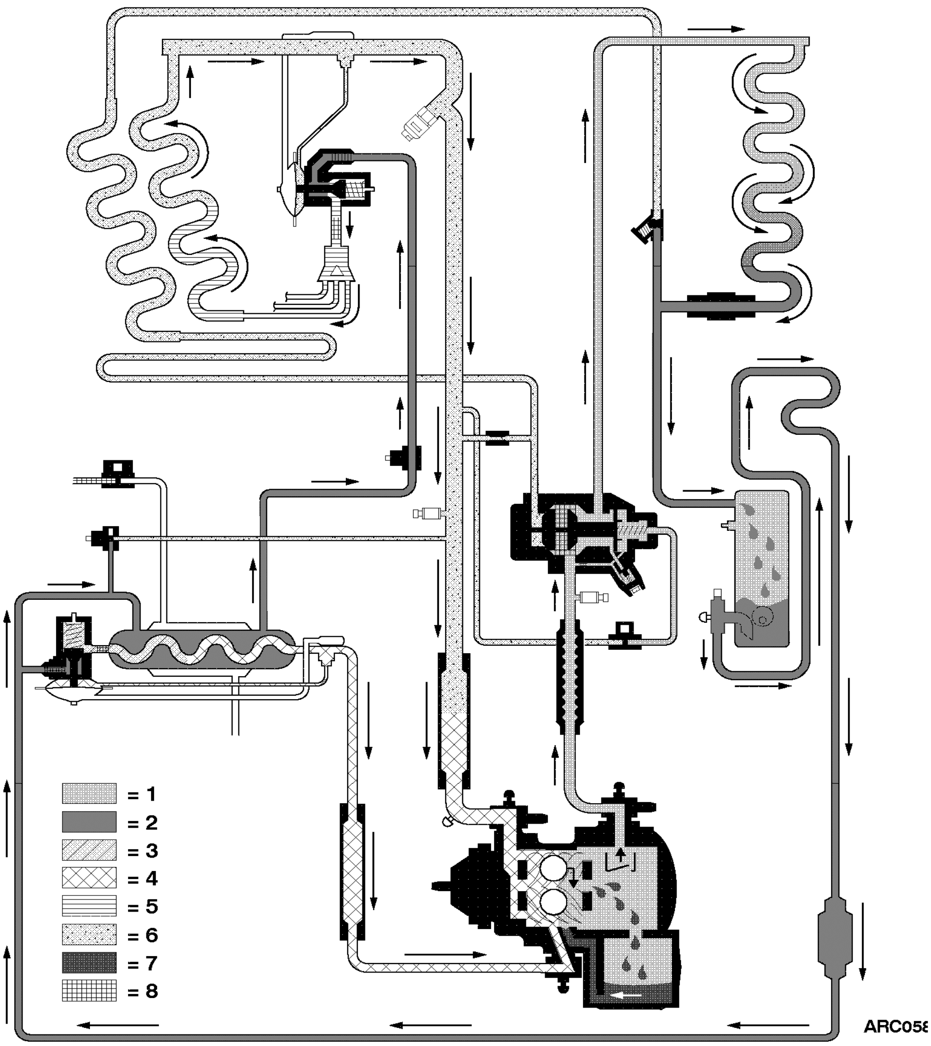
The engine remains at low speed. The microprocessor controls the cooling capacity by controlling the ETV position. The microprocessor also opens and closes the loading valves to change the compressor capacity.

When LV1 (economizer bypass solenoid) is opened to reduce the capacity, the economizer suction gas will travel 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, therefore 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 reduce the capacity, and closes LV1 to increase the capacity. LV2 is always closed at setpoints in the frozen range in modulated cool.



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: 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)
Heat Check Valve	Closed
Condenser Check Valve	Open
Damper Solenoid	Off (Open)

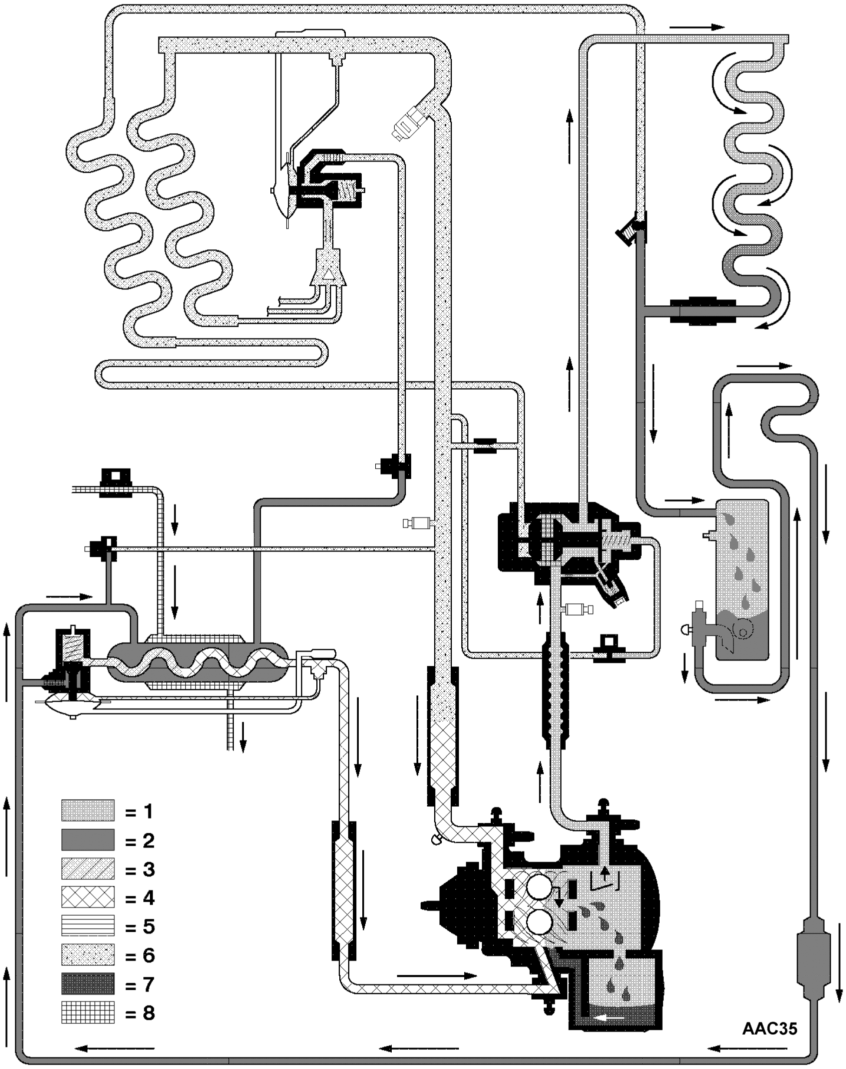
Running null is used when the microprocessor determines that the engine should be running but the refrigeration system should not be cooling or heating. This usually happens when the unit is operating in Continuous Run and the return air temperature is near the setpoint.

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 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, the condenser check valve, the receiver tank, the subcooler, the drier, the economizer expansion valve, the 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 is done 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

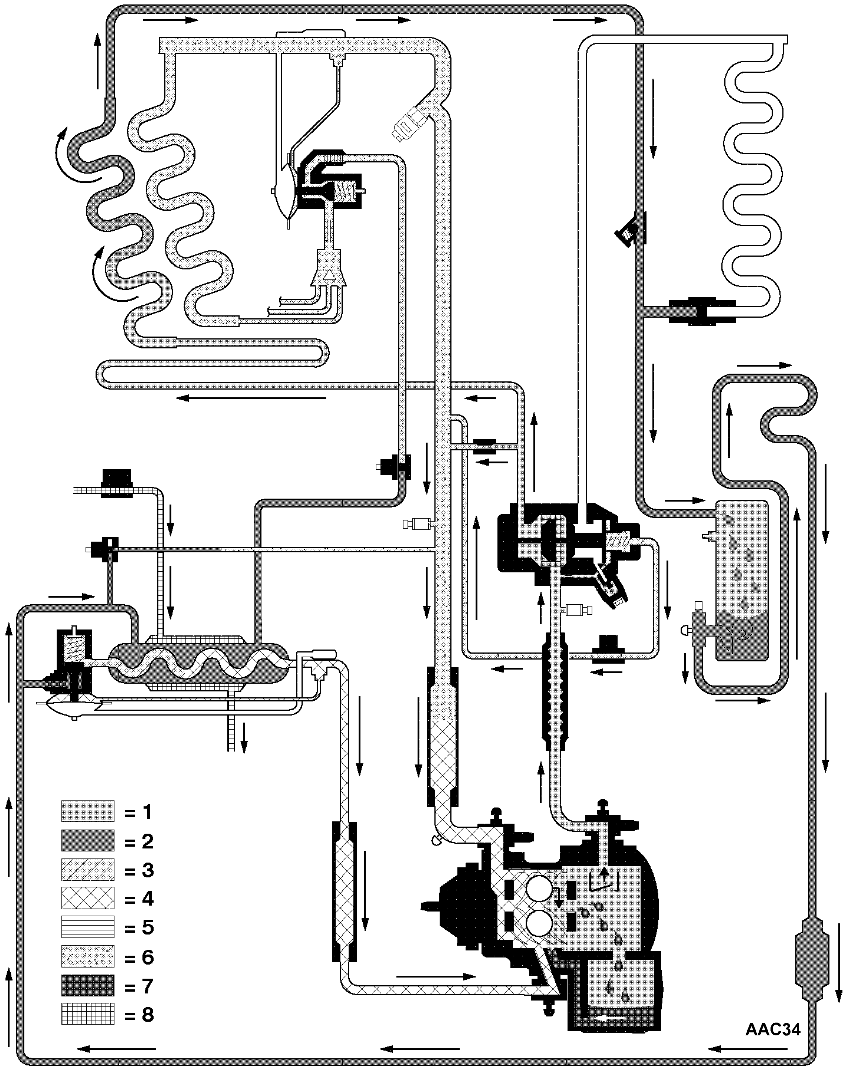
Figure 12: Running Null

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*
Heat Check Valve	Open
Condenser Check Valve	Closed
Damper Solenoid	Off (Open)
** The LIV goes On (Open) when the discharge pressure falls below 100 psi (689kPa), and goes Off (Closed) when the discharge pressure rises to 150 psi (1034 kPa).*	

In the heat cycle the hot gas travels from the compressor discharge to the three-way valve. The pilot solenoid has been activated 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. 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 there will be a small amount of flow 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 back 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 heat or defrost under those conditions, 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 and the heat circuit will now heat normally. To enhance the speed of building discharge pressure, the LIV is energized when the discharge pressure is below 100 psi (689 kPa) to add liquid refrigerant into the suction line. Once discharge pressure rises to 150 psi (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 13: 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*
Heat Check Valve	Open
Condenser Check Valve	Closed
Damper Solenoid	Off (Open)
** The LIV goes On (Open) when the discharge pressure falls below 100 psi (689kPa), and goes Off (Closed) when the discharge pressure rises to 150 psi (1034 kPa).*	

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

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*
Heat Check Valve	Open
Condenser Check Valve	Closed
Damper Solenoid	On (Closed)
** The LIV goes On (Open) when the discharge pressure falls below 100 psi (689kPa), and goes Off (Closed) when the discharge pressure rises to 150 psi (1034 kPa).*	

Defrost is the same as low speed heat except the damper solenoid is activated along with LV2.

Defrost is initiated manually through the defrost prompt using the microprocessor **MODES** and **ENTER** keys. Defrost is initiated automatically on demand by the microprocessor or by a defrost timer.

The evaporator coil temperature must be below 45 F (7 C) to allow defrost. When the Defrost Icon appears, the damper door is closed by the damper solenoid.

A demand defrost cycle will occur if the differences between the return air temperature, discharge air temperature, and coil temperature are greater than predetermined values.

Two defrost timers are used. When the unit is In-Range (within a few degrees of setpoint), defrost intervals are controlled by the Defrost Interval In-Range timer (DEFI). This timer can be set for 4, 6, 8 or 12 hours. The standard setting is 6 hours. When the unit is not In-Range, defrost intervals are determined by the Defrost Interval Not In-Range timer (DEFN). This timer can be set for 2, 4, 6, 8 or 12 hours. The standard setting is 4 hours. This feature allows a shorter defrost interval to be used when the unit is out of range during a pulldown and more frequent defrost cycles may be beneficial.

Normally, longer defrost timer intervals are used for colder loads. The defrost interval may need to be changed if the unit will not hold the compartment temperature at setpoint.

- Use a longer defrost interval if defrost is not being initiated on demand.
- Use a shorter defrost interval if defrost is frequently being initiated on demand.

Data logger event codes starting with the letters DFF, DFI, and DFT are logged when defrost occurs. DFF indicates defrost was forced. DFI indicates defrost was initiated manually. DFT indicates defrost was initiated by a timer.

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 (13 C). If the evaporator coil temperature does not rise above 57 F (13 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.

Special Start-up Modes

The microprocessor uses special modes for conditions that usually exist only when the unit is started.

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)
Heat Check Valve	Open
Condenser Check Valve	Closed
Damper Solenoid	Off (Open)

The unit has a mode called bucking heat. It only occurs when the engine coolant temperature is below 120 F (49 C) and the unit is started in heat. 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 the maximum load on the engine. The increased load quickly warms the coolant to 120 F (49 C), and the unit then goes back into the mode required by the box temperature and setpoint. The reason this mode exists is that if the unit is started in the heat cycle in extremely cold ambients (usually less than 0 F [-18 C]), the engine coolant that surrounds the economizer can be frozen by the refrigerant boiling off in the economizer coil.

Therefore, if the unit is started in the heat cycle and the engine coolant temperature is below 120 F (49 C), even though the unit says it is in heat, it is actually running in the bucking heat mode until it warms up to 120 F (49 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
Condenser Check Valve	Closed
Damper Solenoid	On (Closed)

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

High Box Temperature Startup

Component	Status
Engine Speed	1450/2200 rpm
High Speed Solenoid	Off/On
LV1—Loading Valve #1 (Economizer Bypass Solenoid)	Off (Open)
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)
Heat Check Valve	Closed
Condenser Check Valve	Open
Damper Solenoid	Off (Open)

High box temperature startup occurs when the unit is started in cool and the return air temperature is above 80 F (27 C). The microprocessor delays energizing LV1 (economizer bypass solenoid), to reduce the internal pressures in the compressor. LV2 will be energized. The unit will stay in this mode for 5 minutes, or until the return air temperature drops below 80 F (27 C), whichever occurs first. The engine runs in low speed for the first 2 minutes. The engine runs in high speed for the last 3 minutes. The display screen does not show this special start-up mode. The only indication that it is occurring is that the temperature differential is lower than normal for the first 5 minutes. This mode will also occur in the service test modes that run the unit in cool.

Compressor Temperature (CTMP) System

A special RTD (Resistance Thermal Detector) temperature sensor is installed in the compressor body and is wired into the microprocessor with wires CSTP and CSTN through pins 1 and 2 of the sensor harness plug. The sensor allows the microprocessor to do the following.

- The GAUGE key displays a screen called CTMP. This screen shows the current temperature of the compressor.
- The microprocessor has three additional alarm codes:
  - Code 80 indicates the CTMP sensor or circuit has failed.
  - Code 81 indicates the compressor temperature has been over 290 F (143 C) for 1 minute. This is a check alarm.
  - Code 82 indicates the compressor has been between 295 and 310 F (146 and 154 C) for 15 minutes or above 310 F (154 C) for 1 minute. This is a shutdown alarm.

The procedures for calibrating, diagnosing and repairing the CTMP system are found in the THERMOGUARD µP-VI Microprocessor for Screw Compressor Applications Diagnostic Manual (TK 51329).

Auxiliary Modes

The microprocessor has Auxiliary Modes that provide some unique protection features. In the Auxiliary Modes, the microprocessor uses refrigeration components to control the following conditions:

- High Discharge Pressure
- High Compressor Temperature
- High Compressor Compression Ratio
- Low Suction Pressure

If this cannot be accomplished, the unit may shut down to protect the compressor and other components.

Discharge Pressure Control

The microprocessor uses the discharge pressure transducer to monitor the discharge pressure. If the discharge pressure rises above 415 psi (2861 kPa), the microprocessor will use the ETV and the loading valves to reduce the discharge pressure in cool. The microprocessor will use LV2, LIV, and the PS to reduce the discharge pressure in heat.

Compressor Temperature Control

The microprocessor uses the CTMP System to monitor the compressor temperature. If the CTMP rises to 270 F (132 C) the LIV starts to pulse on and off. At a CTMP of 290 F (143 C) the LIV stops pulsing and is turned on completely. If the CTMP does not fall, the loading valves will be opened in an attempt to reduce the CTMP.

Compression Ratio Control

The microprocessor uses the discharge and suction pressure transducers to monitor the discharge and suction pressures. If the compression ratio of the discharge to suction pressure rises above 25:1, the microprocessor will use the LIV and the loading valves to reduce the compression ratio.

Suction Pressure Control

The microprocessor uses the suction pressure transducer to monitor the discharge pressure. If the suction pressure falls below an 8 to 14 in. Hg vacuum (-28 to -48 kPa), the microprocessor will use the loading valves and the LIV to increase the suction pressure.

Alarm Codes

This unit has some alarm codes other units do not have. The following text explains some of the alarm codes used in this unit. Alarm Code 10 is used in other units. Alarm Codes 81 and 82 are used in other screw compressor units. Alarm Codes 93, 94, 95, 99, and 121 are unique to this unit. Also refer to the “Alarm Code Table” below.

Alarm Code 10—High Discharge Pressure Shutdown

When the shutdown occurs the unit is usually in the Discharge Pressure Control Auxiliary Mode. The discharge pressure rises above 470 psi (3241 kPa) to open the HPCO. The unit immediately shuts down and the microprocessor records alarm code 10.

Code 10 in this unit is similar to other SR units. The only difference is that in this unit the Prevent System will usually be trying to reduce the head pressure when the Code 10 appears.

Alarm Code 81—High CTMP Check

Alarm code 81 occurs when the compressor temperature has been over 290 F (143 C) for 1 minute. It is a check alarm.

Alarm Code 82—High CTMP Shutdown

Shutdown code 82 occurs when compressor temperature has been between 295 and 310 F (146 and 154 C) for 15 minutes, or above 310 F (154 C) for 1 minute. The microprocessor shuts the unit down and records alarm code 82. The microprocessor will use the Compressor Temperature Control Auxiliary Mode to try to reduce the compressor temperature before shutting down on Code 82.

Alarm Code 93—Low Compressor Suction Pressure Check

Alarm code 93 occurs when the suction pressure is lower than expected for the current conditions. It is a check alarm.

Alarm Code 94—LV1 Failure Check

Alarm code 94 occurs if the suction pressure drops less than 5 psi (34kPa) when LV1 is energized. It is a check alarm.

Alarm Code 95—LV2 Failure Check

Alarm code 95 occurs if the suction pressure drops less than 5 psi (34kPa) when LV2 is energized. It is a check alarm.

Alarm Code 99—High Compressor Pressure Ratio Check

Alarm code 99 occurs if the If the compression ratio of the discharge to suction pressure rises above 25:1. It is a check alarm.

Alarm Code 121—LIV Failure Check

Alarm code 121 only occurs during the Pretrip Test if the suction pressure changes less than expected when LIV is energized. It is a check alarm.

Alarm Code Table		
Alarm Code	**Conditions that Cause Alarm Code**	**Result**
10	Discharge pressure above 450 psi (3103 kPa)	Shutdown
81	CTMP above 290 F (143 C) for 1 minute	Alarm Only
82	CTMP between 295 and 310 F (146 and 154 C) for 15 minutes, or above 310 F (154 C) for 1 minute	Shutdown
93	Suction pressure lower than expected	Alarm Only
94	Suction pressure drops less than 5 psi (34kPa) when LV1 is energized	Alarm Only
95	Suction pressure drops less than 5 psi (34kPa) when LV2 is energized	Alarm Only
99	Compression ratio above 25:1	Alarm Only
121	Pretrip Test Only—Suction pressure changes less than expected when LIV is energized	Alarm Only

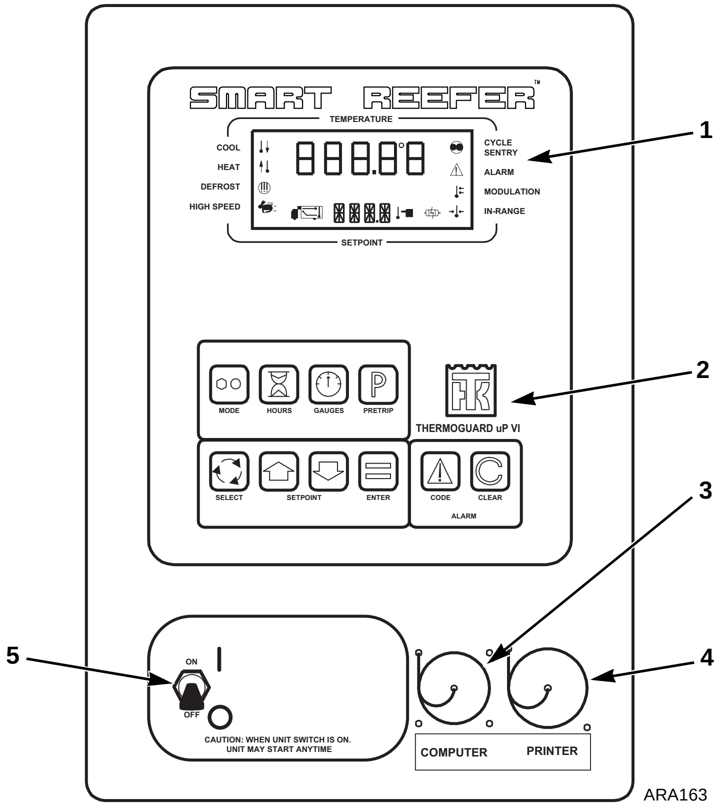
Control Panel

Most of the controls used to operate the unit are located on the control panel. Refer to the SB-400 Operator’s Manual TK 51212 or the THERMOGUARD µP-VI Microprocessor for Screw Compressor Applications Diagnostic Manual TK 51329 for more complete operating information.

On/Off Switch

This switch turns the unit on and off. When the switch is in the Off position, the display will be off and the display backlight will be off. The switch should always be placed in the Off position before servicing the unit. When the switch is in the On position, the display backlight will turn on and the Standard Display will appear.

WARNING: The unit may start and run automatically any time the On/Off switch is in the On position.



1.	Display	4.	Printer Port
2.	Keypad	5.	On/Off Switch
3,	Computer Port		

Figure 14: Control Panel

Optional On/Off/Sleep Switch

This switch turns the unit on and off and also places the unit directly into the Sleep Mode without an exit time. When the switch is in the Off position, the display will be off and the display backlight will be off. The switch should always be placed in the Off position before servicing the unit. When the switch is in the On position, the display backlight will turn on and the Standard Display will appear. When the switch is in the Sleep position, the unit will enter the Sleep mode (without an exit time), the display backlight will turn on, and the display will show [SLEEP] and [MODE].

WARNING: The unit may start and run automatically any time the On/Off/Sleep switch is in the On or Sleep position.

NOTE: The unit will not control the box temperature when the switch is in the Sleep position.

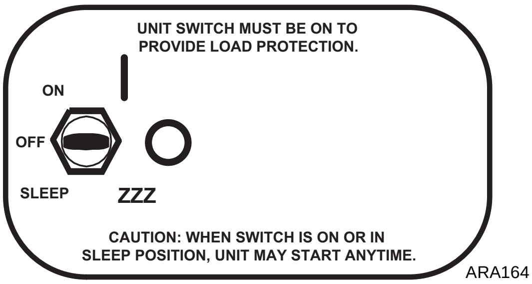


Figure 15: On/Off/Sleep Switch

Display

The display normally shows the Standard Display of return air temperature and setpoint. Other operating and unit information can also be shown here. All possible segments and operating icons are shown in the illustration on page 45.

Icons

An icon will appear next to the appropriate description when the unit is operating in that mode or if an alarm condition exists.

Cool Icon: Appears when the unit is operating in cool mode.

Cool and Heat Icons displayed at the same time indicate the unit is operating in Bucking Heat.

Cool and Modulation Icons displayed at the same time indicate the unit is operating in Running Null.

Heat Icon: Appears when the unit is operating in heat mode.

Defrost Icon: Appears when the unit is operating in defrost mode.

High Speed Icon: Appears when the diesel engine is operating in high speed.

CYCLE-SENTRY Icon: Appears when the unit is operating in CYCLE-SENTRY mode.

Alarm Icon: Appears when the microprocessor detects an alarm condition.

Modulation Icon: Appears when the unit is operating in modulation mode.

In-Range Icon: Appears when the box temperature is within a few degrees of setpoint.

Discharge Air Icon: (Arrow pointing from unit) Discharge air temperature is being shown.

Return Air Icon: (Arrow pointing to unit) Return air temperature is being shown.

Setpoint Icon: Appears when the setpoint is being shown in the lower display.

Keypad

These touch sensitive keys are used to change the setpoint, view operating conditions and other unit information, and to control the unit.

MODE Key: Allows selection of a Manual Defrost Cycle, and CYCLE-SENTRY or Continuous Mode.

HOURMETER Key: Displays Total Hours, Engine Hours, Electric Hours and the 3 programmable hour meters.

GAUGES Key: Displays Water Temperature, Oil Pressure (OK or Low), Amps, Battery Volts, Engine RPM, Compressor Temperature [CTMP], Suction Pressure, Discharge Pressure, and ETV Position. The state of LV1, LV2, LIV, LLSV, and EWSV can also be displayed showing ON (energized) or OFF (de-energized) under a service menu subset by pressing the THERMO KING LOGO key for 3 seconds.

Pretrip Key: Allows selection of Pre-trip Test, print, or start of trip marker.

Thermo King Logo Key: Allows selection of Pretrip Test, Print and Start of Trip and displays software revision and clock/calendar settings.

Clear Key: This key is pressed to clear alarm codes when they are shown on the display.

Code Key: Pressing this key displays any alarm codes that may be present. [00] means no codes are present.

Enter Key: Pressing this key will execute a prompt or load a new setpoint or other setting.

NOTE: An audible enter prompt is available. If enabled, this feature sounds a buzzer when the display flashes to remind you to press the Enter key.

Up and Down Arrow Keys: Pressing these keys will change a displayed prompt or increase/decrease the setpoint or other setting.

Select Key: Pressing this key displays temperature sensor readings and Sleep Mode Wakeup Time (if programmed). See the following list:

[DIS.A]	Discharge Air Temp
[TPDF]	Temp Differential
[COIL]	Coil Temp
[AMB.T]	Ambient Temp
[SPR.1]	Spare Sensor 1 Temp
[SPR.2]	Spare Sensor 2 Temp
[DAS.1]	DAS Temp Sensor 1*
[DAS.2]	DAS Temp Sensor 2*
[DAS.3]	DAS Temp Sensor 3*
[DAS.4]	DAS Temp Sensor 4*
[DAS.5]	DAS Temp Sensor 5*
[DAS.6]	DAS Temp Sensor 6*
[SDAY]	Sleep Mode Wakeup Day**
[SHR]	Sleep Mode Wakeup Hour**
[SMN]	Sleep Mode Wakeup Minute**

** DAS Sensors are optional.*

*** Only if Sleep Mode Wakeup Time is Programmed*

Computer Port

A serial cable from a computer is connected to the download port to access the Data Logging functions of the DAS. Refer to the DAS Data Acquisition System Manual TK 50565 for more information.

Printer Port

A serial cable from a printer is connected to the printer port to print a report for the directly connected DAS sensors. Refer to the SB-400 Operator’s Manual TK 51212 of the DAS Data Acquisition System Manual TK 50565 for more information.

Unit Indicators

Receiver Tank Sight Glass: The receiver tank sight glass is used to check the amount of refrigerant in the system, and the moisture content of the refrigerant.

Compressor Oil Sight Glass: The compressor oil sight glass is used to check the relative level of compressor oil in the compressor sump.

Air Restriction Indicator: An air restriction indicator is attached to the intake manifold. Visually inspect the restriction indicator periodically to assure the air filter is not restricted. Service the air filter when the yellow diaphragm indicates 25 in. of water column. Press the button on the top of the restriction indicator after servicing the air filter. Replace the EMI 3000 air cleaner element (see “EMI 3000 Air Cleaner” on page 75) at 3,000 hours or two years (whichever occurs first) if air clean indicator has not reached 25 in.

Remote Status Light: The remote status light indicates the operating status of the unit. The green “T” indicates the unit is functioning properly. The amber “K” indicates the unit has a check alarm but is still functioning. The green “T” and amber “K” both flash to indicate the unit has a shutdown alarm and is not functioning.

Unit Protection Devices

Fuse Link (Current Limiter): The fuse link is located in the positive battery cable. The fuse link protects the electric system from a short in the 2 circuit.

Fuses: A number of fuses, located on the relay board, protect various circuits and components. See “Fuses” on page 56 for more information.

High Pressure Cutout: The high pressure cutout is a pressure sensitive switch that is located in the compressor discharge service valve. If the discharge pressure rises above 470 psi (3241 kPa), the switch opens the 8D circuit to the fuel solenoid, which stops the engine.

High Pressure Relief Valve: The high pressure relief valve is designed to relieve excess pressure within the refrigeration system. The valve is a spring-loaded piston that lifts off its seat when refrigerant pressure exceeds 500 psi (3447 kPa). The valve will reseat when the pressure drops to 400 psi (2758 kPa). The valve could possibly leak refrigerant after it has relieved excess pressure. Tapping the valve lightly may help the valve reseat and SEAL PROPERLY. The valve is non-repairable and requires no adjustment. If the valve fails to reseat properly, remove the refrigerant charge and unscrew and replace the valve.

The high pressure relief valve is located on the receiver tank. Its location is such that when the pressure is expelled from the valve, it would be directed away from anyone servicing the unit.

Low Oil Level Switch: The low oil level switch closes if the oil drops below a certain level. If it stays closed for a specified time, the microprocessor will shut the unit down and record alarm code 66.

Preheat Buzzer: The preheat buzzer sounds when the CYCLE-SENTRY system energizes the air heater. This should warn anyone near the unit that the CYCLE-SENTRY system is about to start the diesel engine.

High Pressure Cut In Switch (HPCI): The microprocessor uses the input from the HPCI to protect the compressor from high discharge pressures if the discharge pressure transducer fails.

Compressor Temperature Sensor (CTMP): The microprocessor uses the input from the CTMP to protect the compressor for high compressor temperatures.

Unit Operation

Manual Pretrip Inspection (Before Starting Unit)

The following Manual Pretrip Inspection should be completed before starting the unit and loading the trailer. While the Manual Pretrip Inspection is not a substitute for regularly scheduled maintenance inspections, it is an important part of the preventive maintenance program designed to head off operating problems and breakdowns before they happen.

1. FUEL. The diesel fuel supply must be adequate to guarantee engine operation to the next check point.
2. ENGINE OIL. The engine oil level should be at the FULL mark with the dipstick turned (threaded) into oil pan. Never overfill.
3. COOLANT. The engine coolant must have antifreeze protection to -30 F (-34 C). Code 37 indicates low coolant. Add coolant in the expansion tank.

CAUTION: Do not remove the expansion tank cap while coolant is hot.

CAUTION: Do not add “RED” Extended Life Coolants to cooling systems using “GREEN” or “BLUE-GREEN” coolants. Do not add “GREEN” or “BLUE-GREEN” coolants to cooling systems using “RED” Extended Life Coolants. See “ELC (Extended Life Coolant)” on page 61 for more information.

4. BATTERY. The terminals must be clean and tight.
5. BELTS. The belts must be in good condition and adjusted to the proper tensions.
6. ELECTRICAL. The electrical connections should be securely fastened. The wires and terminals should be free of corrosion, cracks or moisture.

7. STRUCTURAL. Visually inspect the unit for leaks, loose or broken parts and other damage. The condenser and evaporator coils should be clean and free of debris. Check the defrost drain hoses and fittings to make sure they are open. Make sure all the doors are latched securely.

Starting Unit With Electronic Full Pretrip

This procedure is used for a complete checkout of the unit and unit control circuits. It should be used when first starting the unit for a trip before the cargo is loaded. A full Pretrip procedure may take up to 30 minutes and the unit will run unattended.

1. Perform a Manual Pretrip Inspection.
2. Adjust the setpoint to the desired load temperature (refer to the appropriate Operator's Manual or Diagnostic Manual for detailed information about adjusting the setpoint).
    a. Change the setpoint display with the **Arrow** keys.
    b. Enter the new setpoint by pressing the **Enter** key within 5 seconds.
3. Initiate a Pretrip Test (refer to the appropriate Operator's Manual or Diagnostic Manual for detailed information about the Pretrip Test). This procedure is automatic and can be performed on the way to the loading area or while waiting to load.
    a. Place the On/Off switch in the On position.
    b. Clear any alarms.
    c. Press the **Pretrip** key.
        - PRE TRIP will appear on the display.
    d. Press the **Enter** key while PRE TRIP is displayed.
        - PRE LOAD will appear on the display and the PRE TRIP test will start.
        - PRE AMPS will appear on the display indicating that the amps check is running and the PRE TRIP has started.
        - The amps check will continue for several minutes, then the unit will start automatically and the operational tests will be performed.
4. When the PRE TRIP test is complete, PASS, CHECK, or FAIL will appear on the display until a function key (e.g., SELECT or ENTER) is pressed. Continue as follows:
    - PASS—The unit is running and no alarms have been recorded. The unit has passed the PRE TRIP. Go to step 6.
    - CHECK—The unit is running but Check Alarms have been recorded. Go to step 5.
    - FAIL—The unit has shut down, recorded Alarm Code 28, and possibly recorded other Shutdown Alarms. Go to step 5.
5. View the Alarms with the **Code** key (refer to the appropriate Diagnostic Manual for detailed information about alarms).
    a. Correct the alarm conditions.
    b. Clear the alarms with the **Clear** key (refer to the appropriate Diagnostic Manual for detailed information about alarms).
    c. Repeat the PRE TRIP test until PASS appears (the unit passes the Pretrip).
6. Recheck the setpoint.
7. Complete the “After Start Inspection” on page 51.

Selection of Operating Modes

The Thermo King CYCLE-SENTRY system is designed to save refrigeration fuel costs. The savings vary with the commodity, ambient temperatures and trailer insulation. However, not all temperature controlled products can be properly transported using CYCLE-SENTRY operation. Certain highly sensitive products normally require continuous air circulation.

- The microprocessor has a CYCLS screen, which is used to select CYCLE-SENTRY (CYCLS YES) or Continuous Run (CYCLS No) operation. Refer to the appropriate Operator’s Manual or Diagnostic Manual for detailed information about CYCLE-SENTRY selection.
- The microprocessor has an OptiSet™ feature that can lockout CYCLE-SENTRY operation and force Continuous Run operation within a programmable range of setpoints. This feature can be used to provide continuous air circulation (within the programmed setpoint range) during CYCLE-SENTRY operation. Refer to the appropriate Operator’s Manual or Diagnostic Manual for specific information about the OptiSet™ feature.

Your selection of the operating mode for the proper protection of a particular commodity should use the following guidelines:

Examples of Products Normally Acceptable for CYCLE-SENTRY Operation

- Frozen foods (in adequately insulated trailers)
- Boxed or processed meats
- Poultry
- Fish
- Dairy products
- Candy
- Chemicals
- Film
- All non-edible products

Examples of Products Normally Requiring Continuous Run Operation for Air Flow

- Fresh fruits and vegetables, especially asparagus, bananas, broccoli, carrots, citrus, green peas, lettuce, peaches, spinach, strawberries, sweet corn, etc.
- Non-processed meat products (unless pre-cooled to recommended temperature)
- Fresh flowers and foliage

The above listings are not all inclusive. Consult your grower or shipper if you have any questions about the operating mode selection of your type of load.

Restarting Unit

This procedure is used when starting units that have been shut off for short periods of time. When a unit that has been shut off for a long period of time is first started, it should be started and put through a pretrip.

1. Place the On/Off switch in the On position.
2. After a 40 second delay, the unit should preheat and start automatically.

   NOTE: When the CYCLE-SENTRY Icon is active, the unit may not start if: the compartment temperature is near the setpoint, the engine is warm, and the battery is fully charged.

If cooling or heating is required and the engine temperature is below approximately 90 F (32 C), but the engine fails to start automatically:

- Turn the On/Off switch to the OFF position.
- Check for and correct any alarm conditions and clear the alarm codes. View the alarms with the **CODE** key, clear the alarms with the **CLEAR** key, and then repeat the auto start procedure. Refer to the appropriate Diagnostic Manual for detailed information about alarms.
- If the engine will still not start, turn the On/Off switch to the Off position, determine and correct the cause of the failure.

After Start Inspection

After the unit is running, the following items can be quickly checked to confirm that the unit is running properly.

1. OIL PRESSURE. Check the engine oil pressure in high speed by pressing the GAUGES key. The oil pressure should read OK, not LOW.
2. AMMETER. Check the ammeter reading by pressing the GAUGES key. The ammeter should indicate normal battery charging current. It may be fairly high right after starting the unit, but should taper off as the battery is recharged.
3. COMPRESSOR OIL. The compressor oil level should be visible in the sight glass.
4. REFRIGERANT. Check the refrigerant charge. See Refrigerant Charge in the Refrigeration Maintenance chapter.
5. PRE-COOLING. Make sure that the setpoint is at the desired temperature and allow the unit to run for a minimum of 1/2 hour (longer if possible) before loading the trailer.

   This provides a good test of the refrigeration system while removing residual heat and the moisture from the trailer interior to prepare it for a refrigerated load.
6. DEFROST. When the unit has finished pre-cooling the trailer interior, manually initiate a defrost cycle. This will remove the frost that builds up while running the unit to pre-cool the trailer.

   To manually initiate a defrost cycle, press the MODES key until the dEF (defrost) prompt screen appears, then press the ENTER key.

   Refer to the appropriate Operator’s Manual or Diagnostic Manual for detailed information about Manual Defrost.

   The defrost cycle should end automatically.

   NOTE: The unit will not defrost unless the evaporator coil temperature is below 45 F (7 C).

Loading Procedure

1. Make sure the unit is turned Off before opening the doors to minimize frost accumulation on the evaporator coil and heat gain in the trailer. (Unit may be running when loading the trailer from a warehouse with door seals.)
2. Spot check and record load temperature while loading. Especially note any off-temperature product.
3. Load the product so that there is adequate space for air circulation completely around the load. DO NOT block the evaporator inlet or outlet.
4. Products should be pre-cooled before loading. Thermo King transport refrigeration units are designed to maintain loads at the temperature at which they were loaded. Transport refrigeration units are not designed to pull hot loads down to temperature.

Post Load Procedure

1. Make sure all the doors are closed and locked.
2. Start the unit if it was shut off to load (see Restarting Unit).
3. Make sure the setpoint is at the desired setting.
4. One-half hour after loading, manually initiate a defrost cycle. If the evaporator coil sensor temperature is below 45 F (7 C), the unit will defrost. The microprocessor will terminate defrost automatically when the evaporator coil temperature reaches 57 F (13 C) or the unit has been in the defrost mode for 30 or 45 minutes (depending on setting).

Post Trip Checks

1. Wash the unit.
2. Check for leaks.
3. Check for loose or missing hardware.
4. Check for physical damage to the unit.

Alternator (Australian Bosch)

Charging System Diagnostic Procedures

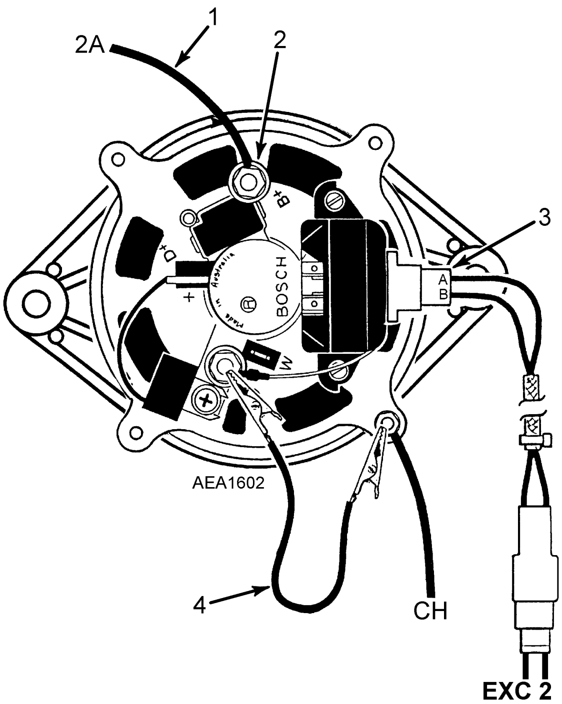
NOTE: Units manufactured with CYCLE-SENTRY and alternators with integral regulators MUST use replacement alternators with integral regulators.

CAUTION: Full-fielding alternators with the integral regulator is accomplished by installing a jumper from terminal F2 to ground. Attempting to full-field the alternator by applying battery voltage to terminal F2 will cause voltage regulator failure.

CAUTION: The F15 fuse must be removed from the relay board on units equipped with the Australian Bosch alternator. The voltage regulator will be damaged if the unit is turned On with the F15 fuse in place on the relay board.

Complete the following checkout procedure before replacing the voltage regulator or the alternator.

- When testing alternators use accurate equipment such as a Thermo King P/N 204-615 (FLUKE 23) digital multimeter and a Thermo King P/N 204-613 amp clamp or an equivalent.



1.	Check Point for 2A Amperage	3.	Check Point for Sense Circuit and Excitation Circuit Voltages
2.	Check Point for B+ Voltage	4.	Position for Full Fielding Jumper

Figure 16: Check Points for Alternator Test

- Make sure the drive belts and pulleys of the charging system are in good condition and are adjusted properly before testing the alternator. Worn belts and pulleys or loose belts will lower the output of the alternator.
- The battery must be well charged, the battery cable connections must be clean and tight, and the 2A and excitation circuits must be connected properly.

NOTE: All voltage readings should be taken between the negative battery terminal, or a good chassis ground, and the terminals indicated, unless stated otherwise.

1. Check to make sure that the F15 fuse has been removed from the relay board. If not, it must be removed, however, the voltage regulator has probably already been damaged.
2. Set the unit for continuous run operation and place the On/Off switch in the Off position.
3. Check the battery voltage. If the battery voltage is less than 12 volts, the battery must be charged or tested to determine if it should be replaced.
4. Check the voltage at the B+ terminal on the alternator. Battery voltage must be present. If not, check the 2A circuit.
5. Disconnect the alternator harness from the voltage regulator by carefully pushing on the spring clip to release the plug lock.
6. Place the On/Off switch in the On position and enter Service Test Mode (HSC) before the unit starts. Refer to the appropriate Diagnostic Manual for specific information about the Service Test Mode.
7. Check the voltage at the A pin and at the B pin in the two pin connector on the alternator harness.
    a. The A pin is the battery sense circuit and should be at battery voltage. If not, check the sense circuit (2 or equivalent) in the alternator harness and in the main wire harness.
    b. Energize the run relay in the relay board test. The B pin is the excitation circuit and should be at 10 volts or higher. If not, check the excitation circuit (7K or equivalent) in the alternator harness and in the main wire harness.
8. If battery voltage is present on the sense and excitation circuits, connect the alternator harness to the voltage regulator and check the voltage on the B pin in the two pin connector on alternator harness. The voltage should be 0.7 to 1 volt using the relay board test.
    a. No voltage or a voltage reading below 0.7 volts indicates that the rotor or the voltage regulator may be shorted. Perform the field current test to further isolate the problem.
    b. A voltage reading above 3 volts indicates that the field circuit may be open or have high resistance. The brushes or the rotor are probably defective.
9. Attach a clamp-on ammeter to the 2A wire connected to the B+ terminal on the alternator.
10. Connect a voltmeter between the B+ terminal and a chassis ground.
11. Start the unit and run it in high speed.
12. Connect a jumper wire between the F2 terminal and a chassis ground. This will full field the alternator.

CAUTION:* *DO NOT full field the alternator for more than seven seconds while checking the meter readings, or the electrical system may be damaged.

13. Check the amperage in the 2A wire and record the reading. Check the voltage at the B+ terminal and continue to observe this voltage for a few seconds to see if it increases, decreases, or stays the same. Note the change in voltage and record the voltage reading.

    Amperage in the 2A wire =____amps.

    Voltage at the B+ terminals =____volts.

    The voltage at the B+ terminal should be 13 to 18 volts and the amperage in the 2A wire should be at least as high as the rated output of the alternator.

NOTE: An alternator can easily exceed its rated output. An alternator MUST at least reach its rated output when full fielded. An alternator that has a defective rectifier diode may reach 75% of its rated output with a full field.

14. Stop the unit.
15. Use the readings obtained previously to determine the problem by referring to the Diagnosis Chart.

    NOTE: This assumes that the alternator did not charge properly prior to the full field test.

Field Current Test (Checks the field windings, brushes and slip rings)

Perform this test with the On/Off switch in the Off position.

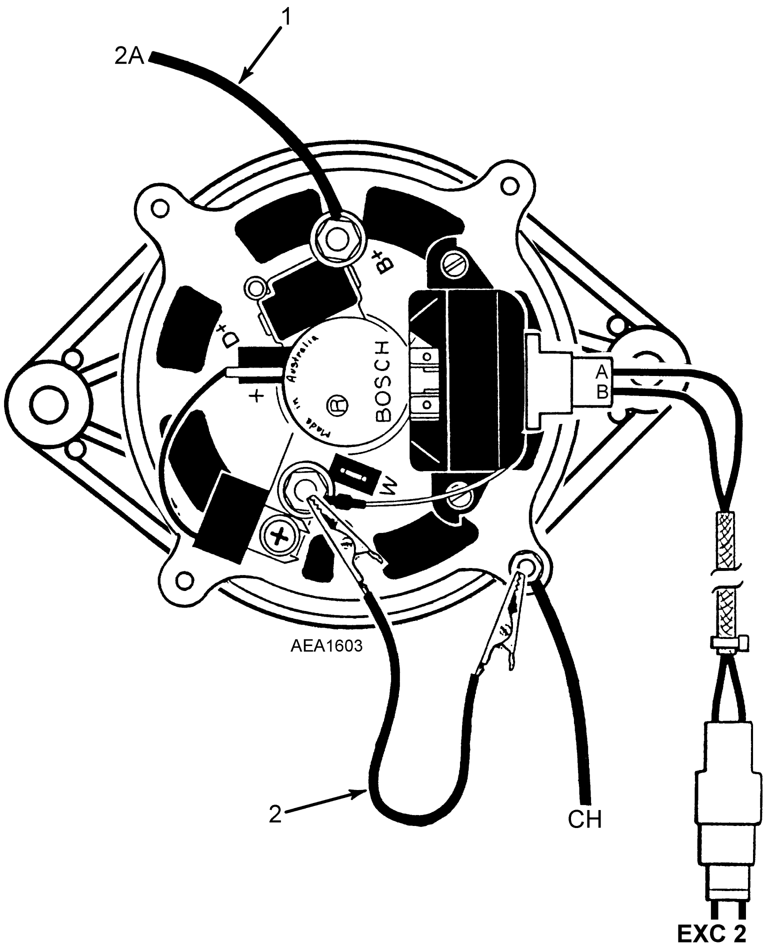
1. Attach a clamp-on ammeter to the 2A wire near the B+ terminal on the alternator.
2. Connect a jumper wire between the F2 terminal on the alternator and a chassis ground, and note the ammeter reading.
3. The ammeter reading indicates field current. The following chart shows the field current for each alternator with 12 volts applied to the field:

Alternator Rating	Field Current @ 12 Volts
23 Amp	1.0 to 3.0 Amps
37 Amp	3.5 to 4.5 Amps
65 Amp	4.0 to 5.0 Amps

   a. No field current or a low field current indicates an open circuit or excessive resistance in the field circuit. Replace the voltage regulator and brush assembly, inspect the slip rings and repeat the test. If the brushes are not the problem, replace the rotor or the alternator.

   b. High field current indicates a short in the field circuit. Repair or replace the alternator.

Diagnosis Chart		
Amperage in 2A	**Voltage at B+**	**Problem/Solution**
At or above rated output	At or above battery voltage and increasing	Voltage regulator defective / Replace voltage regulator and brush assembly
Approximately 60% of rated output	Approximately equal to battery voltage and does not change, or rises slightly	Rectifier diode defective / Repair or replace alternator
Low or no output	Less than or equal to battery voltage and decreasing	Stator windings, field windings, brush or diode defective / Perform Field Current Test to check brushes and field coil, or replace alternator



1.	Check Point for 2A Amperage
2.	Position for Full Fielding Jumper

Figure 17: Full Field Test

Battery

Inspect/clean the battery terminals and check the electrolyte level during scheduled maintenance inspections. A dead or low battery can be the cause of an ammeter indicating discharge due to lack of initial excitation of the alternator even after the unit has been boosted for starting. The minimum specific gravity should be 1.235. Add distilled water as necessary to maintain the proper water level.

Unit Wiring

Inspect the unit wiring and the wire harnesses during scheduled maintenance inspections for loose, chaffed or broken wires to protect against unit malfunctions due to open or short circuits.

Fuses

A number of fuses, located on the relay board, protect various circuits and components. The relay board is located inside the control box. Refer to the appropriate THERMOGUARD Microprocessor Controller Diagnostic Manual for a complete list of the size and function of the fuses.

- Fuse F3 (15 amp) protects the circuit that provides power to defrost relay and the damper.
- Fuse F9 (40 amp) protects the main control power circuit.
- Fuse F18 (15 amp) protects the circuit that provides power to the throttle solenoid.

- Fuse 21 (25 amp) protects the circuit that provides power to the On/Off switch.
- A number of 2, 3, or 5 amp fuses protect microprocessor circuits, control relay circuits, remote status light circuits and various components.

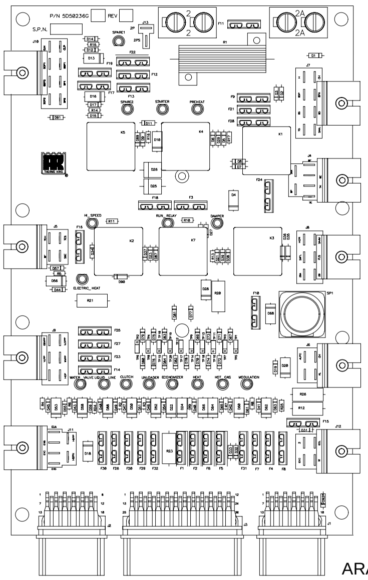


Figure 18: Relay Board

Fuse Link

The fuse link is located in the positive battery cable. The fuse link protects the electrical system from a short in the 2 circuit. If the fuse link burns out, check for a grounded 2 wire before replacing the fuse link. Replace this fuse link by replacing the positive battery cable.

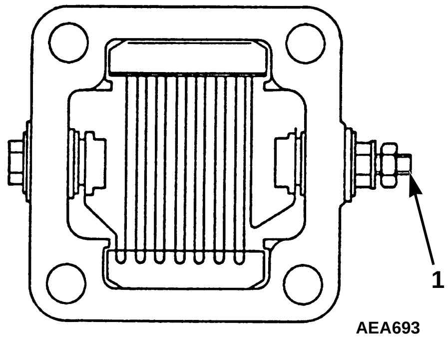
Air Heater

The air heater is mounted on the open end of the intake manifold. It heats the intake air to help the engine start in cold weather. The air heater is energized by the microprocessor during preheat, just before the engine is started.

The heater is probably defective if the resistance is more than 0.2 ohms and the current draw is less than 60 amps, or if the current draw is more than 100 amps.

Check the resistance of the air intake heater with an ohmmeter between the M6 terminal on the front of the heater and the screw on the back of the heater (or the heater case). The resistance should be 0.1 to 0.2 ohms.

Check the current draw of the heater with a clamp-on ammeter at the H1 wire near the M6 terminal on the front of the heater. During preheat the current draw should be approximately 89 amps at 12.5 volts and approximately 77 amps at 11 volts.



1.	M6 Terminal

Figure 19: Air Heater

SMART REEFER µP-VI Microprocessor Controller

Refer to the appropriate THERMOGUARD Microprocessor Diagnostic Manual for complete service information about the Microprocessor Controller and the related components.

Engine Maintenance

EMI 3000

EMI 3000 is an extended maintenance interval package that is standard equipment on this unit. The EMI 3000 package consists of the following key components:

- New EMI 3000-Hour Cyclonic Air Cleaner Assembly and Air Cleaner Element
- New EMI 3000-Hour Fuel Filter (black with gold lettering)
- New EMI 3000-Hour Dual Element Oil Filter (black with gold lettering)
- API Rating CG-4 Mineral Oil (ACEA Rating E2-96 for Europe)
- Five Year or 12,000 Hour ELC (Extended Life Coolant).

The EMI package allows standard maintenance intervals to be extended to 3,000 hours, or 2 years, whichever occurs first.

NOTE: Units equipped with the EMI 3000 package do require regular inspection in accordance with Thermo King's maintenance recommendations.

NOTE: The new EMI 3000 oil filters and new EMI 3000 air cleaners are NOT interchangeable with the oil filters and air cleaners previously used in trailer units.

Engine Lubrication System

The TK 486 engine has a pressure lubrication system. Refer to the TK 482 and TK 486 Engine Overhaul Manual TK 50136 for a detailed description of the engine lubrication system.

Engine Oil Change

The engine oil should be changed according to the Maintenance Inspection Schedule. Drain the oil only when the engine is hot to ensure that all the oil drains out. When changing oil, keep unit and trailer level so all the oil can flow from the oil pan. It is important to get as much of the oil out as possible because most of the dirt particles are contained in the last few quarts of oil that drain out of the pan. Refill the pan with 13 quarts (12.3 liters) and check the dipstick level. Run the unit, and then recheck the oil level. The engine oil level should be at the FULL mark with the dipstick turned (threaded) into the oil pan. Never overfill. See Specifications section for correct type of oil.

Oil Filter Change

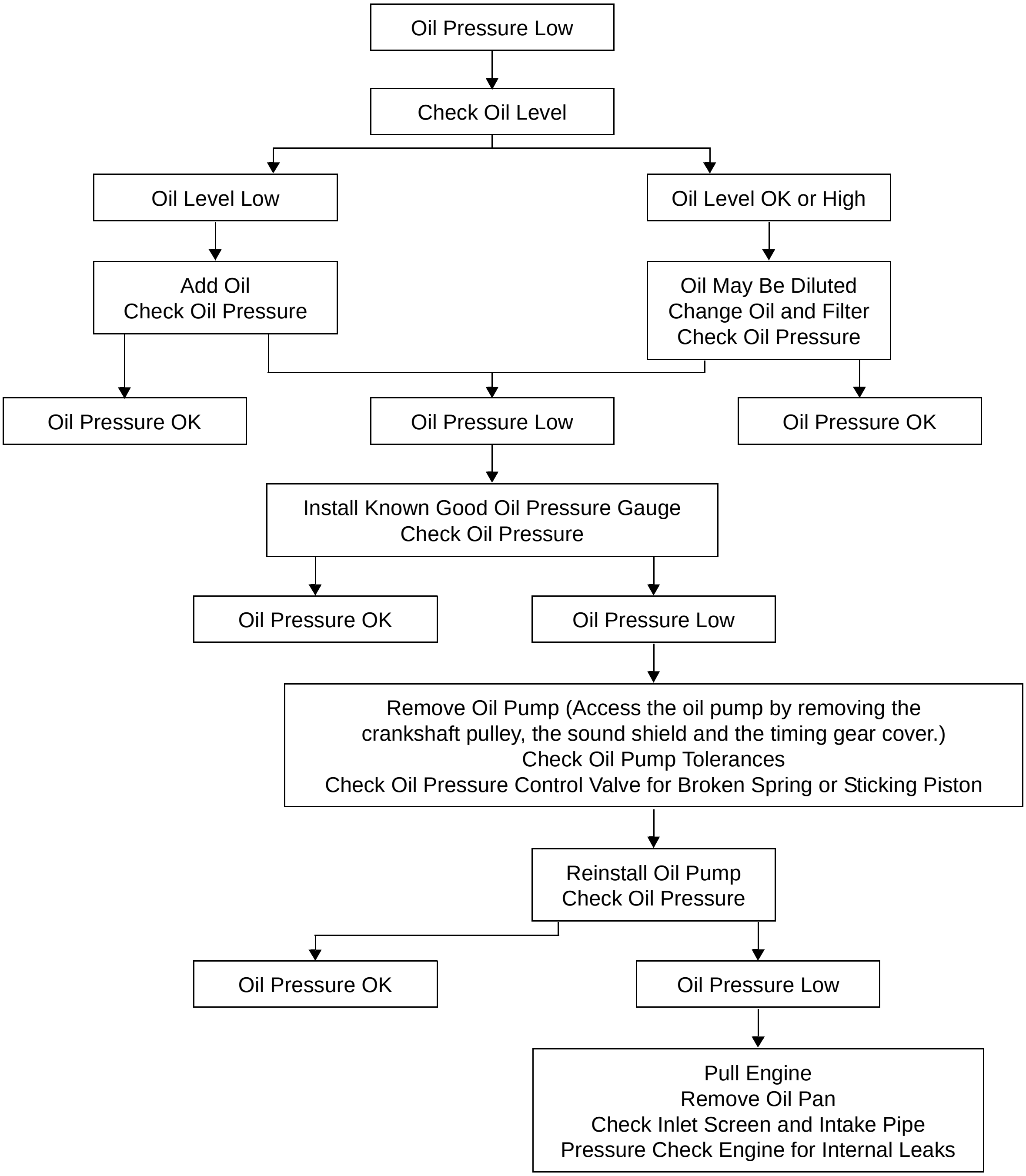
The oil filter should be changed along with the engine oil. Use a genuine Thermo King extended maintenance oil filter.

1. Remove the filter.
2. Apply oil to the rubber ring of the new filter and install the filter.
3. Tighten the filter until the rubber ring makes contact, then tighten 1/2 turn more.
4. Start the unit and check for leaks.

Low Oil Pressure

Oil pressure is affected by oil temperature, oil viscosity, and engine speed. Low oil pressure can usually be traced to the lack of oil, a faulty oil pressure regulating valve, or worn bearings. Low oil pressure is not normally caused by a faulty oil pump. Use the "Low Oil Pressure Flow Chart" on the following page to help diagnose low oil pressure.

Low Oil Pressure Flow Chart



Engine Cooling System

The engine employs a closed, circulating type, pressurized cooling system. Correct engine temperatures are controlled and maintained by a radiator, fan and thermostat. The coolant is circulated through the system by a belt driven centrifugal pump. The pump draws the coolant from the side of the radiator, circulates it through the cylinder block and head and returns it to the radiator. A thermostat mounted in the coolant outlet line from the cylinder head to the radiator automatically maintains coolant temperature within the specified temperature range.

All water cooled engines are shipped from the factory with a 50% permanent type antifreeze concentrate and 50% water mixture in the engine cooling system.

This provides the following:

1. Prevents freezing down to -30 F (-34 C).
2. Retards rust and mineral scale that can cause engine overheating.
3. Retards corrosion (acid) that can attack accumulator tanks, water tubes, radiators and core plugs.
4. Provides lubrication for the water pump seal.

NOTE: Do not operate this unit with less than a 50/50 antifreeze mixture because temperatures in the econmizer get low enough to freeze less concentrated antifreeze mixtures.

ELC (Extended Life Coolant)

ELC has been phased into all trailer units equipped with TK 486, engines. A nameplate on the coolant expansion tank identifies units with ELC.

NOTE: The new engine coolant, Texaco Extended Life Coolant, is RED in color instead of the current GREEN or BLUE-GREEN colored coolants.

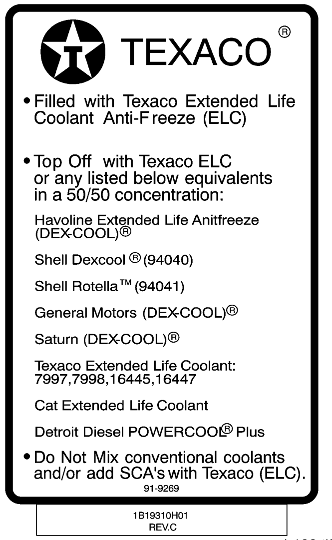


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Figure 20: ELC Nameplate Located On Expansion Tank

The following are the Extended Life Coolants currently approved by Thermo King for use in ELC units for five years or 12,000 hours:

- Texaco ELC #16445 (nitrite free) 100% concentrate.
- Texaco ELC #16447 (nitrite free) premixed 50/50% mixture.
- Havoline Dex-Cool #7994 (nitrite free) 100% concentrate, or #7997 (with nitrites) 100% concentrate.
- Havoline Dex-Cool #7995 (nitrite free) premixed 50/50% mixture, or #7998 (with nitrites) premixed 50/50% mixture.
- Shell Dexcool #94040.
- Shell Rotella #94041.
- Havoline XLC #30379 (Europe) 100% concentrate.
- Havoline XLC #33013 (Europe) premixed 50/50% mixture.
- Saturn/General Motors Dex-Cool.
- Caterpillar ELC.
- Detroit Diesel POWERCOOL Plus.

CAUTION: Do not add "GREEN" or "BLUE-GREEN" conventional coolant to cooling systems using "RED" Extended Life Coolant, except in an emergency. If conventional coolant is added to Extended Life Coolant, the coolant must be changed after 2 years instead of 5 years.

NOTE: The use of 50/50% pre-mixed Extended Life Coolant (ELC) is recommended to assure that de-ionized water is being used. If 100% full strength concentrate is used, de-ionized or distilled water is recommended over tap water to insure the integrity of the cooling system is maintained.

Antifreeze Maintenance Procedure

As with all equipment containing antifreeze, periodic inspection on a regular basis is required to verify the condition of the antifreeze. Inhibitors become worn out and must be replaced by changing the antifreeze. Change ELC (red) engine coolant every five years or 12,000 hours (whichever occurs first).

Do not mix green or blue-green engine coolant with ELC (red) engine coolant. See "ELC (Extended Life Coolant)" on page 61 for more information about ELC.

The factory recommends the use of a 50/50 antifreeze mixture in all units even if they are not exposed to freezing temperatures. This antifreeze mixture will provide the required corrosion protection and lubrication for the water pump.

Checking the Antifreeze

Check the solution concentration by using a temperature compensated antifreeze hydrometer or a refractometer (P/N 204-754) designed for testing antifreeze. Maintain a minimum of 50% permanent type antifreeze concentrate and 50% water solution to provide protection to -30 F (-34 C). Do not mix antifreeze stronger than 68% permanent type coolant concentrate and 32% water for use in extreme temperatures.

Changing the Antifreeze

1. Run the engine until it is up to its normal operating temperature. Stop the unit.
2. Use Service Test Mode [LS.H] to place the unit in low speed heat before the unit starts. This opens the water valve and allows the coolant to drain from the economizer and its hoses. Refer to the appropriate Diagnostic Manual for specific information about the Service Test Mode.
3. Open the engine block drain (located behind the starter) and completely drain the coolant. Observe the coolant color. If the coolant is dirty, proceed with a, b, and c. Otherwise go to 4.

   CAUTION: Avoid direct contact with hot coolant.

   a. Run clear water into the radiator and allow it to drain out of the block until it is clear.

   b. Close the block drain and install a commercially available radiator and block flushing agent, and operate the unit in accordance with instructions of the flushing agent manufacturer.

   c. Open the engine block drain to drain the water and flushing solution.

   CAUTION: Avoid direct contact with hot coolant.

4. Run clear water into the radiator, and allow it to drain out of the block until it is clear.
5. Inspect all hoses for deterioration and hose clamp tightness. Replace if necessary.
6. Loosen the water pump belt. Check the water pump bearing for looseness.
7. Inspect the radiator cap. Replace the cap if the gasket shows any signs of deterioration.
8. If using ELC concentrate, mix one gallon of ELC concentrate and one gallon of de-ionized or distilled water in a container to make a 50/50 mixture. (Do not add antifreeze and then add water to the unit. This procedure may not give a true 50/50 mixture because the exact cooling system capacity may not always be known.)
9. Refill the radiator with the 50/50 antifreeze mixture and make sure to bleed the air from the cooling system as needed.

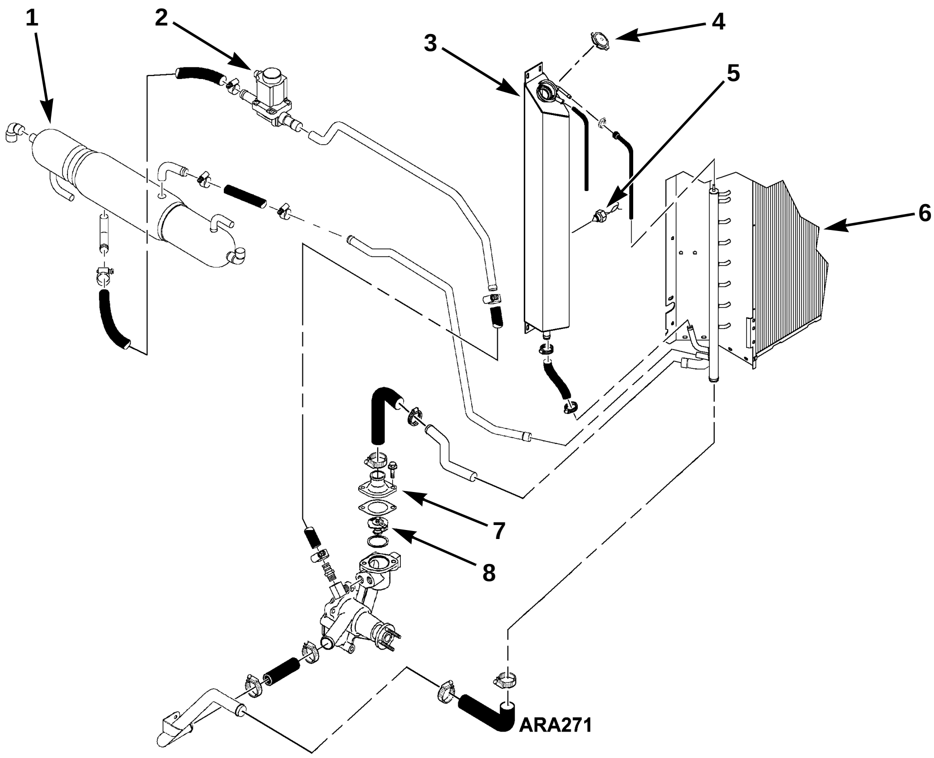
Bleeding Air From The Cooling System

Jiggle pin thermostats are original equipment on units that have TK 482/486 engines. Jiggle pin thermostats make it unnecessary to bleed the air out of the engine block because they keep air from being trapped in the engine block. Normally, all but about 1.5 qt (1.4 liters) of coolant drain out of the cooling system when it is drained. If approximately half of the Cooling System Capacity (see Specifications) seems to fill the cooling system after it has been drained, air has been trapped in the block. Bleed the air out of the block using the following procedure:

CAUTION: IF YOU SUSPECT THAT AIR IS TRAPPED IN THE BLOCK, DO NOT START THE ENGINE WITHOUT BLEEDING THE AIR OUT OF THE BLOCK.

NOTE: If an engine runs with air trapped in the block, the engine may be damaged. The high water temperature switch may not protect an engine that has air trapped in the block, because the high water temperature switch is designed to protect an engine from overheating due to failures in the cooling system.

1. Loosen the plug on the back of the water pump below the thermostat cover until coolant comes out of the plug fitting.
2. Tighten the plug.
3. Pour coolant into the system until it appears to be full.
4. Make sure that the amount of coolant that goes back into the system is approximately equal to the amount of coolant that came out of the system.
5. Start the unit on low speed heat, let it run for two minutes, and then shut it off.



1.	Economizer Heat Exchanger	5.	Coolant Level Sensor
2.	Water Valve Solenoid	6.	Radiator
3.	Expansion Tank	7.	Thermostat Housing
4.	Radiator Cap	8.	Thermostat

Figure 21: Engine Cooling System

6. Check the coolant level and add coolant if necessary.
7. Repeat steps 5 and 6 until the coolant level stabilizes.

Engine Thermostat

For the best engine operation, use a 180 F (82 C) thermostat year-round.

NOTE: If the thermostat sticks open, it can cause the unit to go into Bucking Heat or Bucking Defrost instead of Heat or Defrost in an attempt to raise the coolant temperature to 120 F (49 C).

Engine Fuel System

The TK 486 engine is a direct injection diesel that uses an in-line injection pump.

The components of the fuel system are:

1. Fuel tank
2. Inlet strainer (prefilter)
3. Fuel filter/water separator
4. Priming pump
5. Fuel transfer pump
6. Injection pump
7. Injection nozzles

The priming pump is used to manually draw fuel from the tank up to the fuel pump if the unit should run out of fuel.

Operation

Fuel is drawn from the fuel tank and through the prefilter by the fuel transfer pump. The fuel transfer pump delivers fuel to the fuel filter/water separator. Two orifices in the filter head control the pressure in the fuel system by allowing a certain amount of fuel to return to the tank. One orifice is located in the center of the filter head. It bleeds off water. The other orifice is located off-center on the filter head. It bleeds off air. Filtered fuel passes through a line from the outlet fitting on the filter base to the injection pump.

The injection pump plungers are activated by a gear driven injection pump camshaft. The governor sleeve and weight assembly is mounted on the end of the pump camshaft. The governor's speed requirements are relayed to the injection pump through a linkage arrangement located in the rear cover. The injection pump raises the pressure of the fuel and meters the correct amount of fuel to the nozzle at the correct time. The increased fuel pressure will lift the spring loaded nozzle to admit fuel into the combustion chamber.

Injection pump leakage, injection nozzle overflow and excess fuel from the fuel filter orifice are then all sent back to the fuel tank in the return line.

Maintenance

The injection pump and fuel transfer pump are relatively trouble-free and if properly maintained will usually not require major service repairs between engine overhauls.

Contamination is the most common cause of fuel system problems. Therefore, to ensure best operating results, the fuel must be clean and fuel tanks must be free of contaminants. Change the fuel filter/water separator regularly and clean the prefilter on the inlet side of the fuel transfer pump.

NOTE: The injection nozzles should be tested (and repaired if necessary) at 10,000 hour intervals when used in normal conditions. Normal conditions are considered to be the use of clean high quality fuel, no used oil blending, and regular maintenance of the fuel system according to the Maintenance Inspection Schedule. Refer to the TK 482 and TK 486 Overhaul Manual TK 50136 for injection nozzle testing and repair procedures.

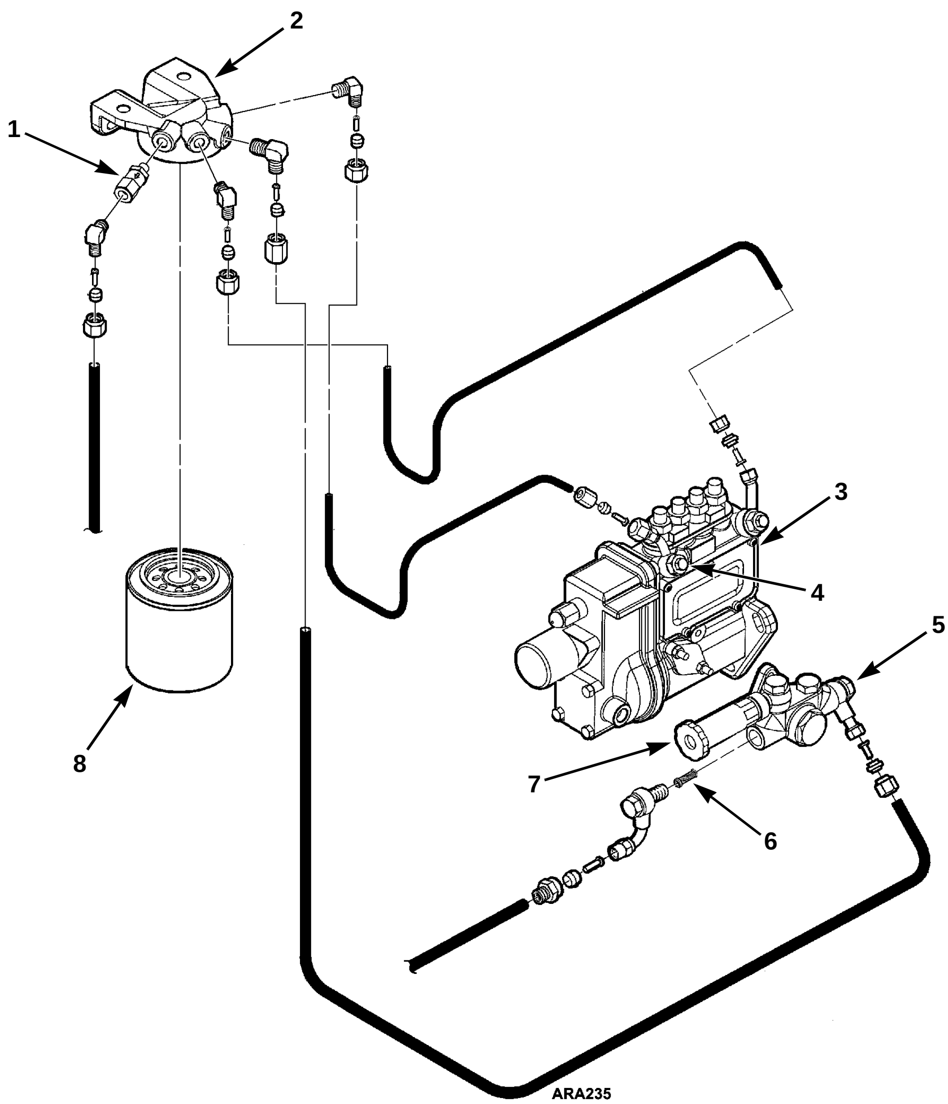
Whenever the fuel system is opened, take the following precautions to prevent dirt from entering the system:

1. Cap all fuel lines.
2. Work in a relatively clean area whenever possible.
3. Complete the work in the shortest possible time.

Any major injection pump or nozzle repairs should be done by a quality diesel injection service shop. The necessary service equipment and facilities are not found in most engine rebuild shops because of the large investment required.

The following procedures can be done under field conditions:

1. Bleeding air from the fuel system.
2. Fuel tank and filter system maintenance.
3. Priming pump (hand) replacement or repair.
4. Fuel pump replacement or repair.
5. Injection line replacement.
6. Injection pump and governor adjustments.
7. Injection pump timing.
8. Nozzle spray pattern testing and adjustment.
9. Minor rebuilding of nozzles.



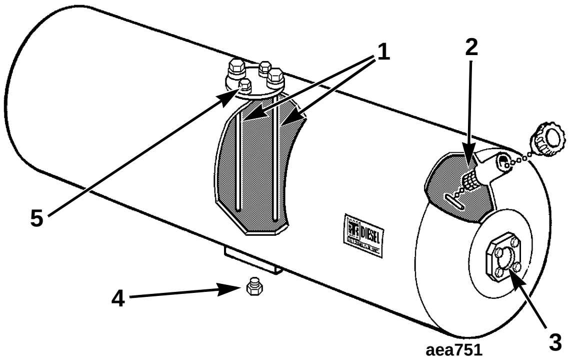
1.	Check Valve (Keeps air from entering fuel system when engine is not running.)	5.	Fuel Transfer Pump
2.	Filter Head	6.	Inlet Strainer (Prefilter)
3.	Injection Pump	7.	Priming Pump
4.	Bleed Screw	8.	Fuel Filter/Water Separator

Figure 22: Engine Fuel System

Bleeding The Fuel System

If the engine runs out of fuel, repairs are made to the fuel system, or if air gets into the system for any other reason, the air must be bled out of the fuel system.

NOTE: MAKE SURE the fuel tank vent is kept open. If the vent becomes clogged, a partial vacuum develops in the tank, and this increases the tendency for air to enter the system.

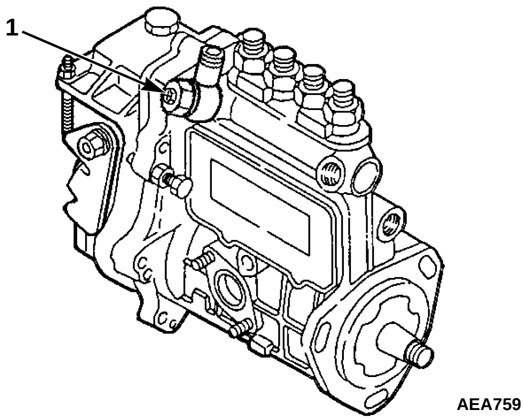


1.	Stand Pipes	4.	Drain Plug
2.	Anti-Siphon Screen	5.	Vent
3.	Fuel Gauge		

Figure 23: Fuel Tank

To bleed air from the fuel system:

1. Loosen the bleed screw in the inlet fitting on the injection pump.



1.	Bleed Screw

Figure 24: Injection Pump

2. Unscrew the priming pump handle and manually prime the fuel system until air bubbles are no longer visible in the fuel coming out of the bleed screw.
3. Tighten the bleed screw and screw the priming pump handle back in.
4. Loosen the injection lines at the injection nozzles.
5. Crank the engine until fuel appears at the nozzles.
6. Tighten the injection lines.
7. Start the engine and observe the engine run for a few minutes. If the engine fails to start, or starts but stops in a few minutes, repeat the procedure.

Draining Water from Fuel Tank

Water run through the system may damage the injection pump or nozzles. Damage to the fuel system will subsequently cause more expensive damage to the engine. A large accumulation of water in the bottom of the fuel tank will stop a diesel engine. Water should be drained off during scheduled maintenance inspections to prevent breakdowns. Drain the water off after the fuel tank and unit have remained idle for an hour.

1. Place a container under the fuel tank to catch the draining water and fuel.
2. Remove the drain plug from the bottom of the fuel tank.

NOTE: Some fuel tanks have a check valve in the drain plug fitting. Push the check valve open with a small screw driver to drain the tank.

3. Let the water and fuel drain into the container until no water is visible in the fuel draining from the tank. If the water and fuel do not drain freely, the vent may be plugged. If so, clean or replace the vent.
4. Install the drain plug.

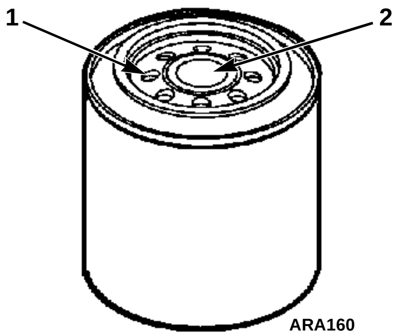
Fuel Filter/Water Separator

The fuel filter/water separator removes water from the fuel and returns it to the fuel tank.

Fuel Filter/Water Separator Replacement

Replace the fuel filter/water separator at intervals according to the Maintenance Inspection Schedule.

1. Unscrew the fuel filter/water separator canister with a strap wrench. Drain, and dispose of properly.
2. Clean the filter head seal surface.
3. Lubricate the canister seal with clean fuel.
4. Through one of the small openings in the top of the canister, fill the new fuel filter/water separator canister with clean fuel. This will purge the air from the canister. Do not fill canister through the center hole.
5. Screw the new canister on hand-tight. Using a strap wrench, tighten another 1/4 turn.



1.	Fill Through Small Opening
2.	Do Not Fill Through Center Hole

Figure 25: Filling Fuel Filter/Water Separator

Engine Speed Adjustments

When the diesel engine fails to maintain the correct engine speed, check the following before adjusting the speed:

1. Check the fuel inlet screen. Check the speed.
2. Bleed the air out of the fuel system. Check the speed.
3. Bleed the air out of the nozzles. Check the speed.

Make the engine speed adjustments with the engine fully warmed up.

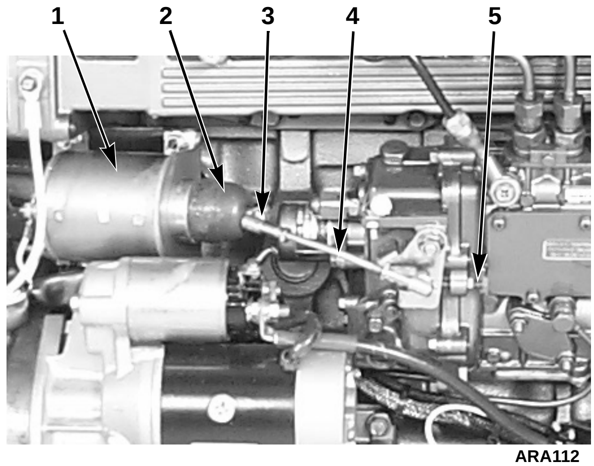
High Speed

1. Use the Service Test Mode to run the unit in high speed and check the high speed rpm. It should be 2200 ± 25 rpm.
2. Shut the unit off.
3. Remove the ball joint from the eye bolt in the high speed solenoid.
4. Remove the boot from the high speed solenoid.
5. Pull the plunger out of the solenoid enough to loosen the jam nut. An Allen wrench placed in the hex opening in the face of the plunger will keep the plunger from turning. Turn the plunger eye bolt clockwise to increase the speed and counterclockwise to decrease the speed.
6. Replace the ball joint, start the unit and check the speed. When the speed is correct, tighten the jam nut and replace the solenoid boot.

NOTE: If the correct speed cannot be set close enough with half turns of the eye bolt, use the Allen wrench to turn the plunger in smaller increments.

Low Speed

1. Loosen the jam nut on the low speed adjustment screw.
2. Use the Service Test Mode to run the unit in low speed. Adjust the screw to obtain the correct speed. It should be 1450 ± 25 rpm.
3. Tighten the jam nut and recheck the speed.



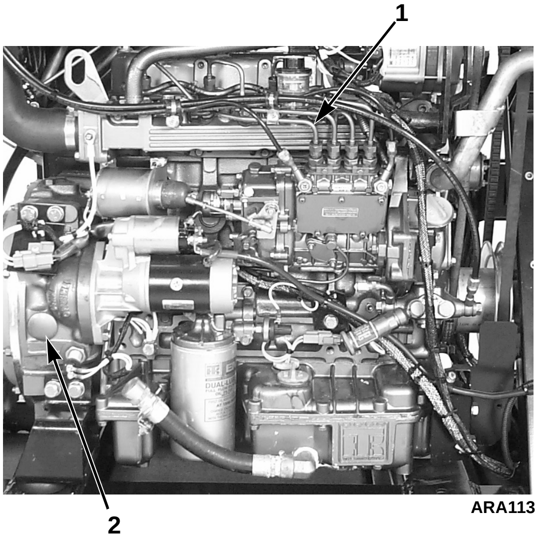
1.	High Speed Solenoid
2.	Boot
3.	Ball Joint
4.	Speed Control Rod
5.	Low Speed Adjustment Screw

Figure 26: Engine Speed Adjustments

Injection Pump Timing

This timing procedure requires fuel pressure at the injection pump inlet. This can be accomplished by pumping the priming pump by hand, or by using an electric fuel pump to supply fuel to the fuel pump inlet.

1. Place the On/Off switch in the Off position.
2. Remove the round cover (plug) from the timing mark access hole on the front of the bell housing. The index marks on either side of this hole and the timing marks on the flywheel are used to check the injection pump timing.



1.	Number One Cylinder Injection Line
2.	Timing Mark Access Hole

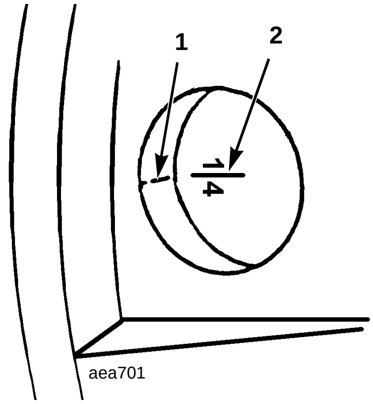
Figure 27: Component Location

CAUTION: Loosen all of the injection lines at the injection nozzles to prevent the possibility of the engine firing while it is being rotated.

3. Remove the injection line for the number one cylinder from the delivery valve on the injection pump and from the injection nozzle.

   NOTE: The number one cylinder is the cylinder at the flywheel end of the engine.

4. Remove the rocker arm cover.
5. Place the engine at top dead center of the compression stroke for the number one cylinder. Refer to steps a. through d.
   a. Rotate the engine in the normal direction of rotation (clockwise viewed from the water pump end) until the 1-4 timing mark on the flywheel lines up with the index mark in the timing mark access hole.



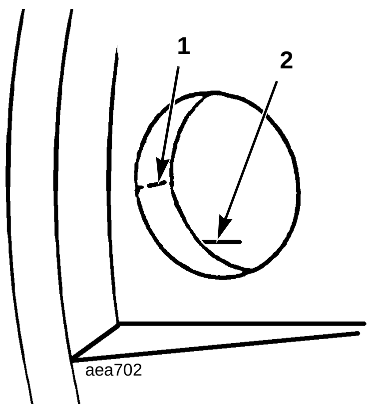
1.	Index Mark
2.	Top Dead Center Mark for 1 and 4

Figure 28: Top Dead Center One and Four

   b. Check the rocker arms on the number one cylinder to see if they are loose.
   c. If the rocker arms are loose, the engine is at top dead center of the compression stroke for the number one cylinder.
   d. If the rocker arms are tight, the engine is at top dead center of the exhaust stroke for the number one cylinder. Rotate the engine 360° to place the engine at top dead center of the compression stroke for the number one cylinder.
6. Disconnect the 8S wire from the starter solenoid to prevent the engine from cranking when the unit is turned On.
7. Place the On/Off switch in the On position.
8. Use the microprocessor keypad to enter the Relay Board Test Mode. Refer to the appropriate Microprocessor Diagnostic Manual for detailed information about the Relay Board Test Mode.

9. Energize the fuel solenoid by energizing the run relay [RUNR] with the Relay Board Test Mode.

10. Rotate the engine backwards (counterclockwise viewed from the water pump end) until the injection timing mark is positioned in the bottom of the timing mark access hole. The injection timing mark is a horizontal line stamped on the flywheel approximately 1.2 in. (30 mm) before the top dead center mark.



1.	Index Mark
2.	Injection Mark

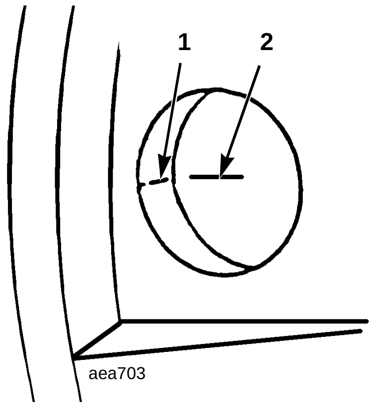
Figure 29: Timing Mark Alignment

11. Pump the priming pump by hand a few times, or energize the electric fuel pump if an electric fuel is being used.

12. Use a clean towel to remove the fuel from the top end of the delivery valve holder.

13. Slowly turn the engine in the normal direction of rotation until you see the fuel rise in the end of the delivery valve holder. Stop as soon as you see the fuel rise.

14. Check position of the timing marks. The injection timing mark on the flywheel should be aligned with the index mark on the side of the timing mark access hole. Repeat steps 10 through 14 to recheck the timing.



1.	Index Mark
2.	Injection Mark

Figure 30: Correct Injection Timing Mark Alignment

15. If the timing is off by more than 1 degree (0.1 in. [2.5 mm]), loosen the mounting nuts on the studs that fasten the injection pump to the engine and rotate the injection pump to change the timing.

    a. Pull the top of the injection pump away from the engine to advance the timing.

    b. Push the top of the injection pump toward the engine to retard the timing.

16. Tighten the injection pump mounting nuts and recheck the timing. Repeat steps 10 through 16 until the timing is correct.

17. Install the cover in the timing mark access hole, install the injection line for the number one cylinder, install the rocker arm cover, tighten the other injection lines and reconnect the 8S wire to the starter solenoid when finished with the procedure.

Injection Pump Removal

The injection pump drive gear will not fit through the gear housing when removing the pump, the gear must be separated from the pump. Using tool P/N 204-1011, it will not be necessary to remove the belts, fuel pump, crankshaft pulley, crankshaft seal or front plate.

1. Remove the starter for clearance, remove throttle linkage, fuel lines, harness and mounting hardware from injection pump.

2. Remove the cover plate from the gear case. Remove the nut and lock washer which secure the gear to the injection pump shaft. Use a shop rag to prevent the lock washer or nut from falling into the gear case.

3. Use the hardware from the cover plate to attach the tool plate (with the marked side pointing up and out) to the gear case.

4. Align the threaded holes in the injection pump gear with the two holes in the tool plate by rotating the engine crankshaft. Attach the gear to the tool plate with the screws provided with the tool plate.

5. Thread the long screw supplied with the tool plate into the small end of the adapter, also supplied with the tool plate. Insert the adapter into the tool plate and rotate to provide a solid position to force the injection pump shaft from the gear. Caution should be made to align the screw over the center of the injection pump shaft.

6. Remove the screw and adapter leaving the tool plate in place. This holds the gear in proper tooth alignment until the injection pump is re-installed.

Injection Pump Reinstallation

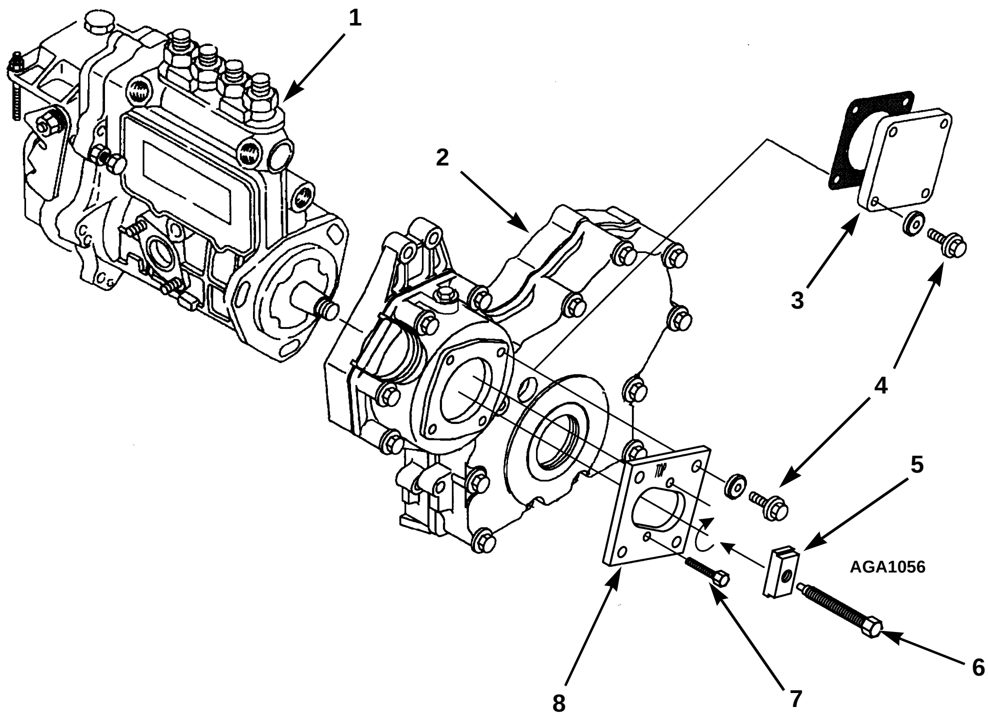
1. Position injection pump shaft into gear, rotating shaft to mate key with keyway in gear.

2. Secure injection pump to gear case with previously removed hardware.

3. Remove hardware holding gear to tool plate, then remove tool plate.

4. Secure gear to injection pump shaft with lock washer and nut, use a shop rag, as before, to prevent the lock washer or nut from falling into the gear case. Torque the nut to 84 to 90 ft-lb (113 to 122 N•m)

5. Fasten cover plate to gear case and reinstall all components removed previously to facilitate injection pump removal.



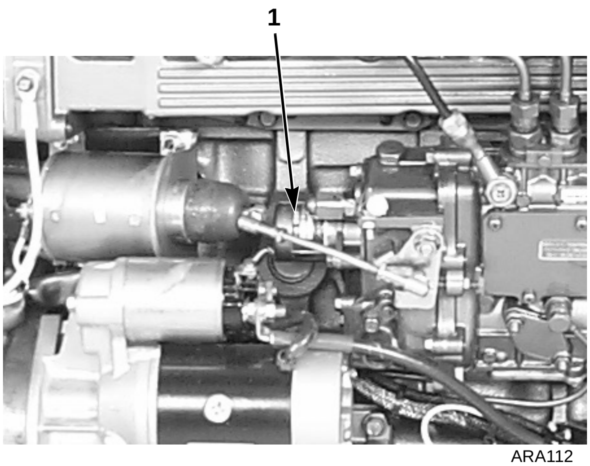
1.	Injection Pump	5.	Adapter
2.	Gear Case	6.	Tool Long Screw
3.	Cover Plate	7.	Tool Short Screw
4.	Cover Plate Bolt	8.	Tool Plate

Figure 31: Injection Pump Gear Tool

Fuel Solenoid

The fuel solenoid is located on the end of the injection pump. It contains two coils: the pull-in coil, and the hold-in coil. The pull-in coil draws approximately 35 to 45 amps at 12 volts. The hold-in coil draws approximately 1 amp at 12 volts.

The pull-in coil must be energized to move the injection pump governor linkage to the fuel on position. Once the injection pump governor linkage has been moved to the fuel on position, the hold-in coil will keep it in fuel on position until the 8D circuit is de-energized. The pull-in coil must be de-energized after a few seconds to keep it from being damaged. The pull-in coil is controlled by the microprocessor through the fuel solenoid relay (FSR).



1.	Fuel Solenoid

Figure 32: Fuel Solenoid Location

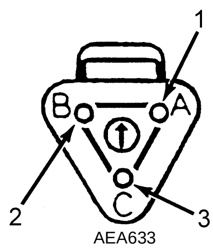
Testing The Fuel Solenoid

NOTE: The fuel solenoid pull-in coil will require 35 to 45 amps to turn on the fuel. The unit's battery must be in good condition. If the battery has enough power to crank the engine over, it has enough power to energize the fuel solenoid pull-in coil.

If you suspect that the engine does not run because the fuel solenoid is not operating correctly, use the following procedure:

1. Use the microprocessor keypad to enter the Relay Board Test Mode. Refer to the appropriate Microprocessor Diagnostic Manual for specific information about the Relay Board Test Mode.
2. Energize the run relay [RUNR] with the Relay Board Test Mode. The fuel solenoid relay is momentarily energized when the run relay is energized with the Relay Board Test Mode. This energizes the fuel solenoid, which makes a definite click when energized.
3. De-energize the run relay [RUNR] with the Relay Board Test Mode. This de-energizes the fuel solenoid, which makes a definite click when de-energized.
4. Repeat steps 2 and 3 a few times to check the operation of the fuel solenoid.

   NOTE: The fuel solenoid may be removed from the injection pump to visually check its operation. The fuel solenoid must be energized when it is re-installed in the injection pump. If it is not, the plunger and the linkage may not line up correctly and the fuel solenoid will not function properly.
5. If the fuel solenoid is not operating properly, check the run relay, the fuel solenoid relay, their fuses, and the associated circuits. If the relays, fuses and circuits are acceptable, use steps 6 through 9 to isolate and check the fuel solenoid.
6. Disconnect the fuel solenoid wire connector from the main wire harness.



1.	Red (8D)
2.	White (8DP)
3.	Black (CH)

Figure 33: Fuel Solenoid Connector Pin Identification

7. Place a jumper wire between the black wire (CH—pin C) in the fuel solenoid connector and a good chassis ground.

8. Test the pull-in coil by momentarily placing a jumper between the white wire (8DP—pin B) in the fuel solenoid connector and the positive battery terminal. The fuel solenoid should make a definite click when the pull-in coil is energized and should click again when the pull-in coil is de-energized.

   NOTE: The pull-in coil will draw 35 to 45 amps so do not leave the jumper connected to the white wire (8DP—pin B) for more than a few seconds.

   a. If the pull-in coil does not energize, check the resistance of the pull-in coil by placing an ohmmeter between the white wire (8DP—pin B) and the black wire (CH—pin C) in the fuel solenoid connector. The resistance of the pull-in coil should be 0.2 to 0.3 ohms. If the resistance of the pull-in coil is not in this range, replace the fuel solenoid.

   b. If the pull-in coil does energize, go to step 9.

9. Test the hold-in coil.

   a. Energize the hold-in coil by placing a jumper between the red wire (8D—pin A) in the fuel solenoid connector and the positive battery terminal.

   b. Momentarily energize the pull-in coil by placing a jumper between the white wire (8DP—pin B) in the fuel solenoid connector and the positive battery terminal. The fuel solenoid should make a definite click when the pull-in coil is energized, but should not click when the pull-in coil is de-energized.

   c. De-energize the hold-in coil by removing the jumper from the red wire (8D—pin A) and the 2 terminal. The fuel solenoid should make a definite click when the hold-in coil is de-energized.

   d. If the hold-in coil does not function properly, check the resistance of the hold-in coil by placing an ohmmeter between the red wire (8D—pin A) and the black wire (CH—pin C) in the fuel solenoid connector. The resistance of the hold-in coil should be 24 to 29 ohms. If the resistance of the hold-in coil is not in this range, replace the fuel solenoid.

Fuel Solenoid Replacement

1. Disconnect the fuel solenoid wire connector from the main wire harness and remove the old fuel solenoid.

2. Connect the new fuel solenoid wire connector to the main wire harness.

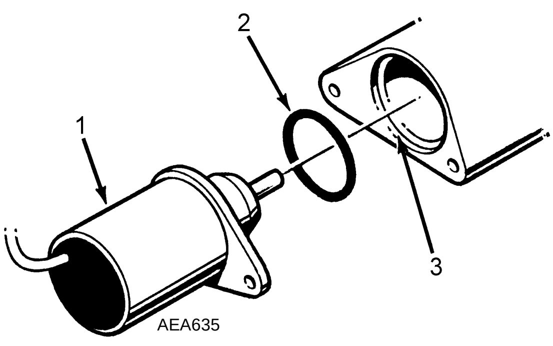
3. Place the On/Off switch in the On position.

4. Use the microprocessor keypad to enter the Relay Board Test Mode. Refer to the appropriate Microprocessor Diagnostic Manual for specific information about the Relay Test Mode.

5. Energize the fuel solenoid by energizing the run relay [RUNR] with the Relay Board Test Mode.

   NOTE: The fuel solenoid must be energized when it is installed. If not, the plunger and the linkage may not line up correctly and the fuel solenoid will not function properly.

6. Place the O-ring in the groove in the end of the fuel injection pump. Make sure that the O-ring is positioned correctly during installation to avoid damage and leaks.



1.	Fuel Solenoid
2.	O-ring
3.	Groove in Fuel Injection Pump

Figure 34: Fuel Solenoid Components

7. Install the new fuel solenoid.
8. Place the On/Off switch in the Off position after installing the fuel solenoid.

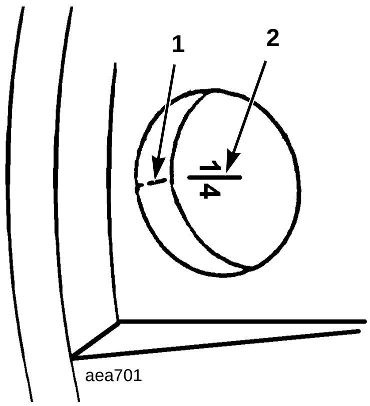
Engine Valve Clearance Adjustment

1. Remove the rocker arm cover.
2. Remove the round cover (plug) from the timing mark access hole on the front of the bell housing.

CAUTION: Loosen all of the injection lines at the injection nozzles to prevent the possibility of the engine firing while it is being rotated.

3. Place the engine at top dead center of the compression stroke for the number one cylinder. Refer to steps a. through d.

   a. Rotate the engine in the normal direction of rotation (clockwise viewed from the water pump end) until the 1-4 timing mark on the flywheel lines up with the index mark in the timing mark access hole.



1.	Index Mark
2.	Top Dead Center Mark for 1 and 4

Figure 35: Top Dead Center One and Four

   b. Check the rocker arms on the number one cylinder to see if they are loose.

   c. If the rocker arms are loose, the engine is at top dead center of the compression stroke for the number one cylinder.

   d. If the rocker arms are tight, the engine is at top dead center of the exhaust stroke for the number one cylinder. Rotate the engine 360° to place the engine at top dead center of the compression stroke for the number one cylinder.

Valve Adjustments and Cylinder Configurations

	Front						**Rear**	
Cylinder No.	**1**		**2**		**3**		**4**	
Valve arrangement	E	I	E	I	E	I	E	I
Piston in No. 1 cylinder is at TDC on compression stroke	○	○		○	○			
Piston in No. 4 cylinder is at TDC on compression stroke			◎			◎	◎	◎

4. Use a feeler gauge to check the valve clearance on both valves for the number one cylinder, the intake valve for the number two cylinder, and the exhaust valve for the number three cylinder. The valve clearance for both the intake valve and the exhaust valve should be 0.006 to 0.010 in. (0.15 to 0.25 mm).

   NOTE: Check to make sure that the valve stem cap is in good condition and is positioned squarely on the top of the valve stem. Replace the valve stem cap if it shows significant wear.

5. Adjust the valves if necessary by loosening the locknut and turning the adjustment screw until the valve clearance is correct.
6. Hold the adjustment screw in place and tighten the locknut.

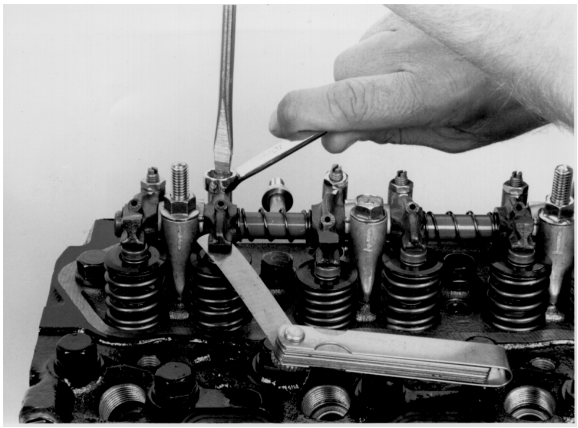


Figure 36: Adjusting the Valve Clearance

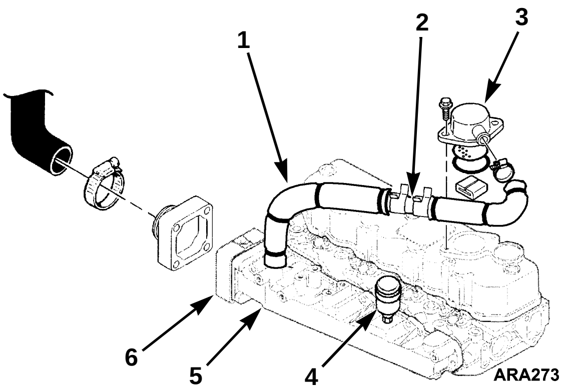
7. Recheck the valve clearance.
8. Rotate the engine one full turn (360°) in the normal direction of rotation (clockwise viewed from the water pump end), and align the 1-4 timing mark on the flywheel with the index mark in the timing mark access hole. This is top dead center of the compression stroke for the number four cylinder.
9. Check and adjust the exhaust valve for the number two cylinder, the intake valve for the number three cylinder, and both valves for the number four cylinder.
10. Replace the rocker arm cover, the cover for the timing mark access hole, and tighten the fuel injection lines when finished.

Crankcase Breather

The crankcase breather is located on top of the rocker arm cover. The crankcase breather system ducts crankcase gases formed in the crankcase directly to the air intake. Harmful vapors that would otherwise collect in the crankcase and contaminate the oil, or escape to the outside, are drawn back into the engine and burned. A restrictor is placed in the breather hose to limit the flow of gases from the crankcase to the air intake and keep the crankcase pressure from getting too low.

Normal crankcase pressures with a new air cleaner are 5 to 10 in. (127 to 254 mm) H_2O of vacuum at 1450 rpm and 7 to 11 in. (178 to 279 mm) H_2O of vacuum at 2200 rpm. The vacuum will increase as the air cleaner gets dirty and becomes more restrictive. The crankcase breather and the breather hose should be inspected when the air cleaner element is replaced to make sure they are not plugged or damaged.

NOTE: The breather hose must be routed so it slopes down from the crankcase breather to the intake manifold. This prevents condensation from collecting in the breather hose. The condensation can plug the breather hose if it collects and freezes in the hose.



1.	Insulation (Covers breather hose to prevent freezing.)
2.	Restrictor
3.	Crankcase Breather
4.	Air Restriction Indicator
5.	Intake Manifold
6.	Intake Air Heater

Figure 37: Crankcase Breather

EMI 3000 Air Cleaner

The EMI 3000 air cleaner is a dry element air cleaner used in late model units. Replace the EMI 3000 air cleaner element when the air restriction indicator reads 25 in. of vacuum, or at 3,000 hours or 2 years, whichever occurs first. The EMI 3000 air cleaner element has a nameplate that reads “EMI 3000.” It cannot be interchanged with air filters used on previous Thermo King trailer units, however it can be retrofit on previous units by using the EMI 3000 Air Cleaner Assembly.

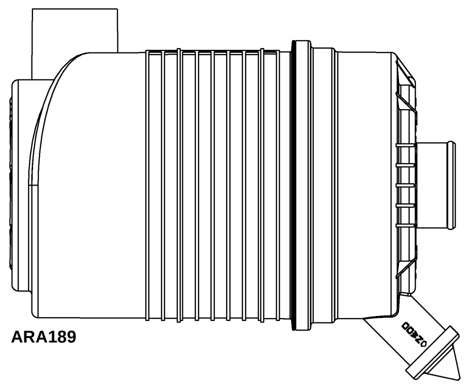
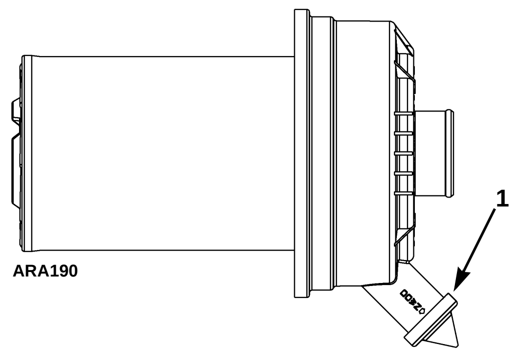


Figure 38: EMI 3000 Air Cleaner Assembly



1.	Dust Ejector Must Point Down When Installed

Figure 39: EMI 3000 Air Filter Element

Air Restriction Indicator

Excessive restriction of the air intake system reduces the flow of air to the engine affecting horsepower output, fuel consumption and engine life.

An air restriction indicator is installed in the air intake manifold. Visually inspect the restriction indicator periodically to assure the air filter is not restricted. Service the air filter when the yellow diaphragm indicates 25 in. of vacuum. Press the reset button on the bottom of the restriction indicator after servicing the air filter.

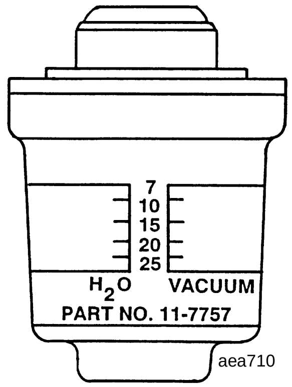


Figure 40: Air Restriction Indicator

Belts

Belts should be regularly inspected during unit pre-trip inspections for wear, scuffing or cracking. Belt tension should also be checked during scheduled maintenance inspections. Belts that are too loose will whip and belts that are too tight put too much strain on the belt fibers and bearings.

Using belt tension gauge, P/N 204-427, is the best method of checking belts for tightness. Install the belt gauge in the center of the longest belt span. Press the plunger so the hook will engage the belt. Make sure the hook is on the face of the belt, not in a notch. Release the plunger with a quick motion and without pulling on the belt. Then read the dial. Use an average of three readings.

NOTE: Do not attempt to remove or install belts without loosening adjustments. Belts that are installed by prying over pulleys will fail prematurely due to internal cord damage.

CAUTION: Do not attempt to adjust belts with the unit running.

CAUTION: With the unit On/Off switch in the On position, the unit may start operation at any time without prior warning. Switch the unit On/Off switch to the Off position before performing maintenance or repair procedures.

Alternator Belt Adjustment

The alternator belt tension should read 35 on the belt gauge.

1. Loosen the alternator pivot bolt and the adjusting arm bolt.
2. Move the alternator on the adjusting arm slots to adjust the belt to 35 on the belt tension gauge.
3. Tighten the adjusting arm bolt and alternator pivot bolt.

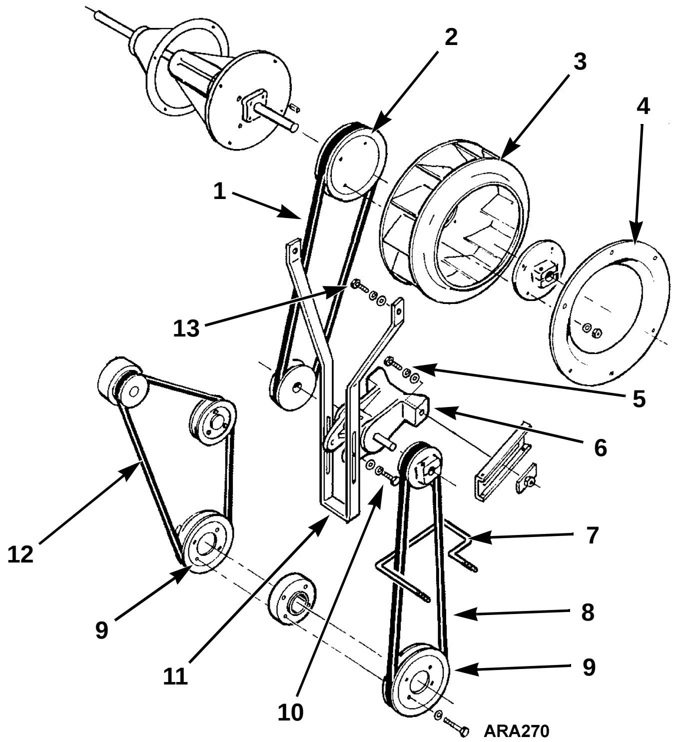
Upper And Lower Fan Belt Adjustment

The upper fan belt should read 74 and the lower fan belt should read 67 on the belt tension gauge.

NOTE: Both the upper and lower fan belts are adjusted at the same time in one procedure.

NOTE: If a fan belt is loose or damaged, replace the belt (see Fan Belt Removal and Installation procedure).

1. Loosen the idler assembly pivot bolts and the idler adjusting arm bolts.



1.	Upper Fan Belt	8.	Lower Fan Belt
2.	Condenser Fan Pulley	9.	Engine Pulley
3.	Condenser Fan	10.	Idler Adjusting Arm Bolt
4.	Condenser Inlet Ring	11.	Idler Adjusting Arm
5.	Idler Assembly Pivot Bolt	12.	Alternator Belt
6.	Idler Assembly	13	Idler Adjusting Arm Pivot Bolt
7.	Belt Guide		

Figure 41: Belt Arrangement

2. Push in or pull out on the idler adjusting arm to “center” the idler assembly between the belts and balance the tension equally between the upper and lower belts.
3. Tighten both idler adjusting arm bolts and both idler assembly pivot bolts.

NOTE: If the idler assembly binds when moving for belt adjustment, loosen the upper idler support bracket mounting bolts to free up the assembly. Check the main idler retainer nut assembly for proper alignment between the nut and the support bracket slots.

Fan Belt Removal and Installation

NOTE: Do not attempt to remove or install the belts without loosening the adjustments. Belts that are installed by prying over pulleys will fail prematurely due to internal cord damage.

Lower Fan Belt

Removal

1. Loosen both idler adjusting arm bolts and both idler assembly pivot bolts.
2. Push the idler adjusting arm IN. The lower fan belt will come off the engine pulley. Move the arm OUT far enough to clear the roadside idler mounting bracket.

Installation

1. Slip the belt into the groove of the idler pulley.
2. Push the idler adjusting arm back in toward the unit.
3. Slip the belt onto the pulley groove on the engine.
4. Pull the idler adjusting arm back OUT and adjust the belts to the proper tension.
5. Tighten the idler assembly pivot bolts and the idler adjusting arm bolts.

Upper Fan Belt

Removal

1. Loosen the idler adjusting arm bolts and remove the lower fan belt (see Lower Fan Belt Removal).
2. Push the idler adjusting arm in and the idler assembly up. The upper belt should become slack and slip down out of the idler pulley groove.
3. Pull the idler adjusting arm OUT. The upper fan belt should slip off the idler pulley as the idler pulley hub clears the curbside idler mounting bracket.
4. Loosen the two condenser fan hub to the shaft clamping bolts.
5. Tap the blower wheel with a soft hammer to drive the blower wheel up the fan shaft to provide 1/2 in. (13 mm) clearance between the blower wheel and the inlet ring.

NOTE: If the condenser fan does not slide on the fan shaft with light tapping, remove the small access panel located on the condenser coil header above the radiator tank. Thread a 1/4-20 x 1 in. diameter bolt into the end of the fan shaft. Tighten the bolt and washer down on the condenser fan hub to loosen the blower wheel. Drive the blower wheel back to provide 1/2 in. (13 mm) clearance between the blower wheel and condenser fan inlet ring.

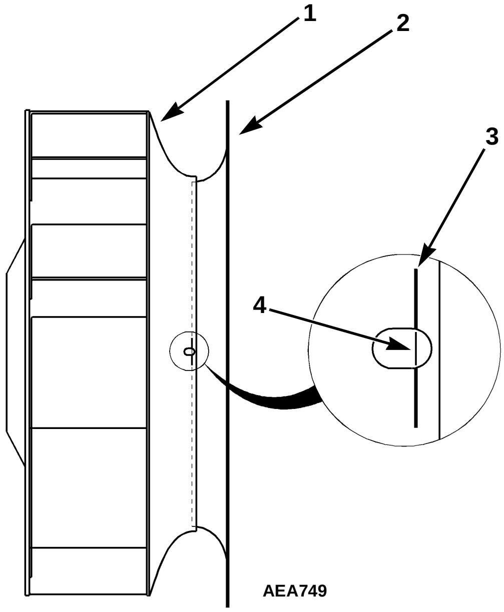
6. Lift the belt up over the condenser blower wheel and remove it from the unit.

Installation

1. Slip the belt over the condenser blower wheel and place it in the condenser fan pulley.
2. Drive the condenser blower wheel out toward the condenser fan inlet ring using a soft hammer.
3. Position the blower wheel so the edge of the inlet ring lines up with the alignment mark on the blower wheel.
4. Check the radial clearance between the blower wheel and inlet ring with a gauge wire. Check around the entire circumference to the inlet ring and blower wheel (see Condenser and Evaporator Fan Location under Structural Maintenance).
5. Torque the blower hub clamping bolts to 18 ft-lb (24 N•m).
6. Seat the upper belt in the blower wheel pulley groove.

7. Push inward on the idler adjusting arm and slip the belt into the idler pulley groove.

8. Pull the idler adjusting arm forward and install the lower fan belt.



1.	Blower Wheel
2.	Inlet Ring
3.	Alignment Mark
4.	Edge of Inlet Ring

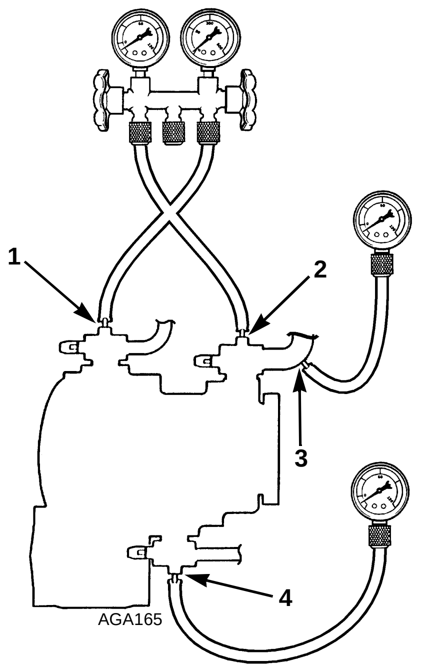
Figure 42: Condenser Blower Alignment

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 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.
2. Connect the high pressure gauge line to the discharge 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 42: Gauge Installation

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

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.

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 maximum outlet pressure from the MOP expansion valve is limited to approximately 50 psi (345 kPa), regardless of the inlet pressure.

The unit is also equipped with an electronic throttling valve. It is located in the suction line near outlet from the evaporator coil. The valve and the MOP expansion valve both limit the suction pressures at the compressor.

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 maximum economizer suction pressure at the economizer suction serviced valve is normally limited to 40 to 50 psi (276 to 345 kPa) by the MOP expansion valve.

When LV1 (economizer bypass solenoid) is open:

- The maximum economizer suction pressure at the economizer suction service valve is normally limited to approximately 40 to 50 psi (276 to 345 kPa) by the MOP expansion valve, but it may be lower when LV1 is open.
- The suction pressure at the main suction service valve will normally be approximately 5 to 10 psi (34 to 69 kPa) lower than the economizer suction pressure.

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.

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.
3. Use Service Test Mode [HS.C] to run the unit in High Speed Cool. Refer to the appropriate Diagnostic Manual for specific information about the Service Test Mode.
4. Use the microprocessor thermometer 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 psi (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.

Testing The Refrigerant Charge With A Loaded Trailer

1. Install a gauge manifold.
2. Use Service Test Mode [HS.C] to run the unit in High Speed Cool. Refer to the appropriate Diagnostic Manual 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 psi (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.

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.
2. Use Service Test Mode [HS.C] to run the unit in High Speed Cool. Refer to the appropriate Diagnostic Manual 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 psi (345 kPa) above the observed pressure. Do not allow the discharge pressure to go above 350 psi (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 psi (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.

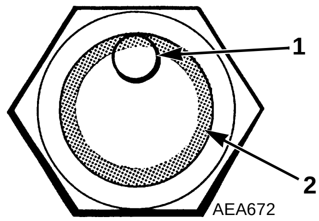
To adjust the refrigerant level:

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 psi (138 kPa).
    g. Maintain a discharge pressure of at least 275 psi (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.

Moisture Indicating Sight Glass

The receiver tank is equipped with a moisture indicating sight glass. The outer edge of the sight glass has a colored ring approximately 0.1 in. (2.5 mm) thick. The color of the ring indicates the moisture content of the refrigerant, but it may not be completely reliable.

- Green = Dry
- Chartreuse = Caution
- Yellow = Wet



1.	Floating Ball
2.	Colored Ring

Figure 43: Moisture Indicating Sight Glass

A system has to run for at least 15 minutes to change the color of the indicator ring after the moisture content of the system has been changed. For example, evacuating a system to remove the moisture will not change the color of the indicator ring until the system has been recharged and then operated for at least 15 minutes.

Refrigerant Leaks

Use a reliable leak detector that is suitable for R-404A to leak test the refrigeration system. Inspect for signs of oil leakage which is the first sign of a leak in the refrigeration system.

NOTE: A leak detector cannot be used to check the compressor shaft seal. The shaft seal in this screw compressor is designed so that if it leaks, it will leak oil not refrigerant (some refrigerant is dissolved in the oil). The entire shaft seal is submerged in oil, even when the compressor is not operating. See Compressor Shaft Seal Leak Test.

Compressor Shaft Seal Leak Check

Consider the following items before changing a compressor shaft seal:

- The presence of some oil around the seal cover is normal.
- The mechanic must be able to differentiate between normal oil seepage which is usually dirty or dusty, and a fresh stream of oil which will continue to appear and will flow until it drips.
- A seal can gradually leak enough refrigerant to cause a system failure with no evidence of heavy oil seepage.
- The compressor shaft seal on a unit that is not operated for extended periods of time may leak small amounts of refrigerant. However, the seal often recovers its normal sealing capability after the unit is operated and lubrication occurs.
- As with other refrigerant leaks, a shaft seal leak can be masked by the presence of oil in the leak passage. It can take as long as 30-45 minutes for the leak to appear in a large enough quantity to be measured.
- A high quality, very accurate leak detector such as P/N 204-712 (or an equivalent) and the discipline to follow the proper procedures are essential. A unit with a low refrigerant charge should be thoroughly leak checked.

Use the following procedure to leak check the compressor shaft seal:

1. Blow out the seal area to remove any residual refrigerant and remove excess oil with solvent.
2. Calibrate the leak detector P/N 204-712 for the medium setting (1/2 oz per year).
3. Starting from below the seal cover, slowly move the probe up towards the compressor shaft seal. Avoid getting dirt or oil in the probe.
4. If the leak detector senses a leak on the medium setting, withdraw the probe, allow the leak detector to stabilize, and check again.
5. Re-calibrate the leak detector for the large setting (5 oz per year) and repeat steps 3 and 4.
6. If the leak detector senses a leak on the large setting, the unit should be operated in high speed cool for 10 minutes or more. Stop the unit and blow out the seal cover area. Allow the unit to stand for 1/2 hour.

   NOTE: This time can be used to leak check the rest of the unit.

7. Repeat steps 2, 3, 4, and 5. If the leak detector does not sense a leak on the large setting, the shaft seal is okay unless a fresh stream of oil reappeared.

Checking Compressor Oil

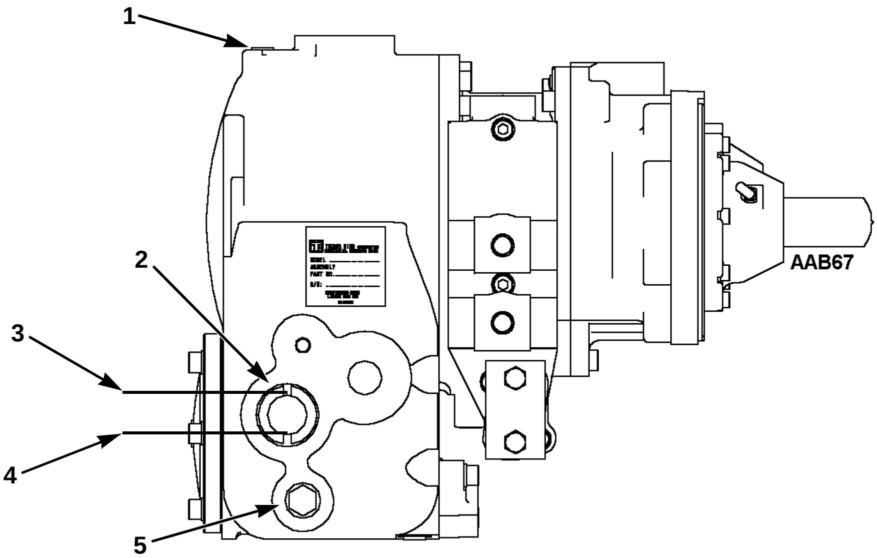
The compressor oil should be checked when there is evidence of oil loss (oil leaks) or when components in the refrigeration system have been removed for service or replacement. Note the following items:

- The unit must be running in high speed cool when checking the compressor oil level.
- The oil level in the compressor sump depends on the operating conditions. The oil should be visible in the sight glass. It is not abnormal for the oil level to be above the top of the sight glass. The compressor can handle losing up to about 0.6 qt (0.6 liters) of oil. The Oil Level Chart shows the relative compressor oil levels with a total oil charge of 2.8 qt (2.7 liters).
- DO NOT operate the unit if the compressor oil level is below the bottom of the sight glass.

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

Adding Compressor Oil

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 44: 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 Glasses**
-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

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. 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.
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:
   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.

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. 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.
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. Perform necessary repairs to low side component(s) using proper EPA procedures.
   b. Evacuate the low side through the suction access port. Evacuate the entire system if the refrigerant was recovered because of an external leak.
   c. Open the receiver tank outlet valve, main suction, and economizer suction service valves.
   d. Verify the proper refrigerant charge level in the unit.
   e. 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.

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 uses the input from the HPCI to protect the compressor from high discharge pressures. If the discharge pressure rises above 425 psi (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 psi (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:

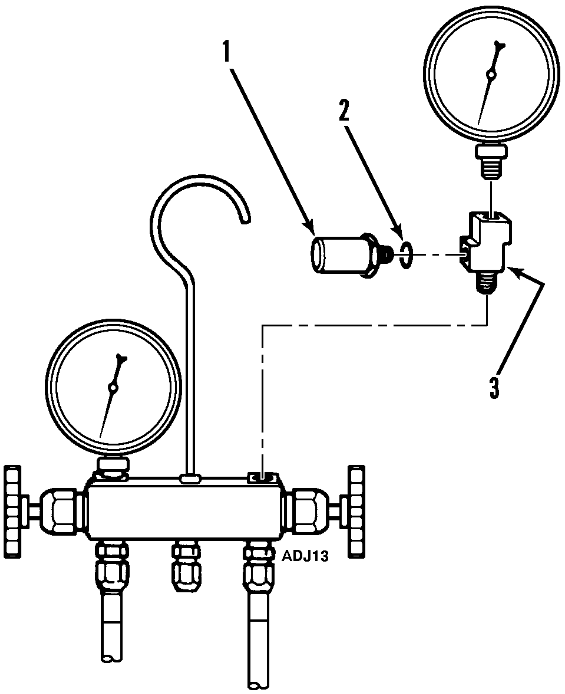
1. Install a gauge manifold on the compressor.
2. Disconnect the HPCI switch from the HPCI and CH wires in the main wire harness.
3. Check the HPCI for continuity. It should be open when the unit is not running.
4. Use Service Test Mode [HS.C] to run the unit in High Speed Cool. Refer to the appropriate Diagnostic Manual 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 psi (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 psi (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.

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 470 psi (3241 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 45: 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 psi (6204 kPa) working pressure rating.
2. Use Service Test Mode [HS.C] to run the unit in High Speed Cool. Refer to the appropriate Diagnostic Manual 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 470 ± 7 psi (3241 ± 48 kPa).

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

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

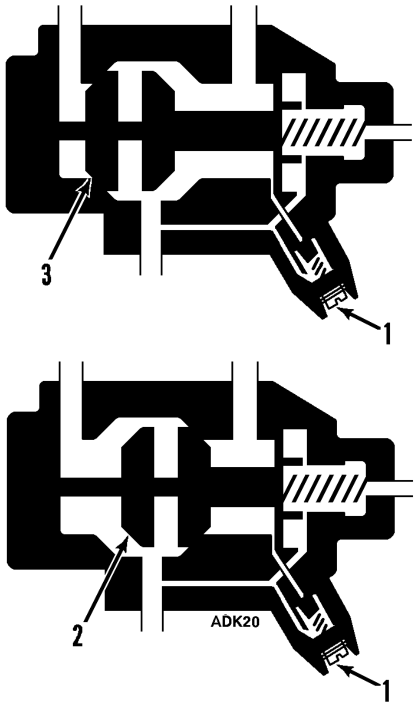
Three-Way Valve Condenser Pressure Bypass Check Valve

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” on page 106.



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

Figure 46: Three-way Valve 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. 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.
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, use Service Test Mode [LS.H] to place the unit in Low Speed Heat and shift the three-way valve to the heat position. 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 evaporator.
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 return outlet valve, the economizer suction service valve, the main suction service valve, remove the gauges and return the unit to normal operation.

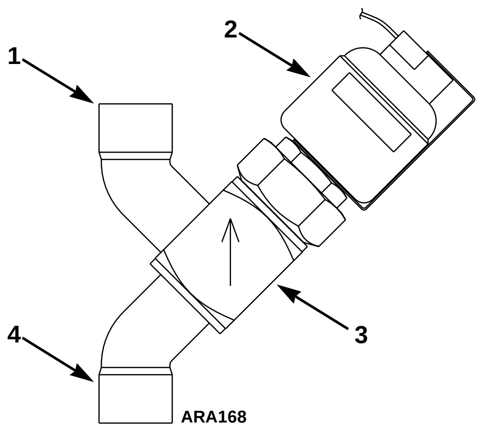
Electronic Throttling Valve (ETV)

The Electronic Throttling Valve (ETV) is a variable position valve operated by a stepper motor. The ETV is located in the suction line near the evaporator outlet. The ETV system also uses discharge and suction pressure transducers.

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 the Service Test Mode (Service Procedure A34A in TK 51329).

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.



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

Figure 47: Electronic Throttling Valve

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

Refer to “Electronic Throttling Valve (ETV)” on page 111 of this manual for removal and installation procedures.

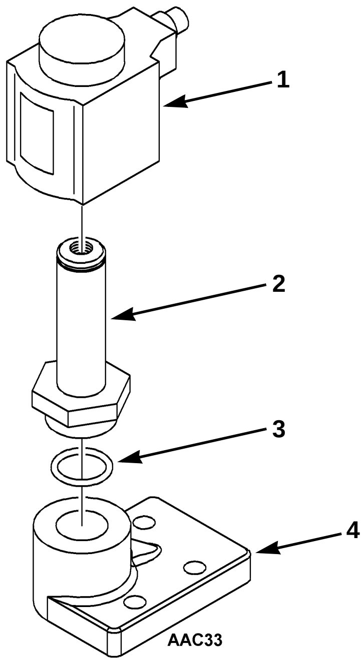
Pressure Transducers

The discharge pressure transducer and the suction pressure transducer supply pressure information to the microprocessor. These pressures can be monitored with the **GAUGE** key. [DIS.P] is the discharge pressure. [SUC.P] is the suction pressure. The readings can be checked by comparing them to the readings on a gauge manifold set attached to the compressor. Refer to Service Procedure D03A, the Pressure Sensor Test, and Alarm Codes 87 and 109 in the THERMOGUARD µP-VI Microprocessor for Screw Compressor Applications Diagnostic Manual TK 51329 for more information about the testing and operation of the pressure transducers.

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.

1. Install a gauge manifold on the compressor. 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. Refer to the appropriate Diagnostic Manual for specific information about the Service Test Mode.



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

Figure 48: Exploded View of LV1 and LV2

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 psi (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 resistance of the LV1 coil. It should be approximately 9.6 ohms. 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 psi (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 resistance of the LV2 coil. It should be approximately 9.6 ohms. If the coil is defective, replace it.

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

Liquid Line Solenoid Test

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

1. Install a gauge manifold on the compressor. 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. Refer to the appropriate Diagnostic Manual 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 -5 psi (-34 kPa), the test will continue. See step 5.

b. If the suction pressure is below -5 psi (-34 kPa), 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 -5 psi (-34 kPa), 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 -5 psi (-34 kPa), 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 resistance of the LLSV coil. It should be approximately 9.6 ohms. 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.

Liquid Injection Valve Test

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

1. Install a gauge manifold on the compressor. 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. Refer to the appropriate Diagnostic Manual 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.

   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 0.33 amps. If the LIV coil is defective, replace it.

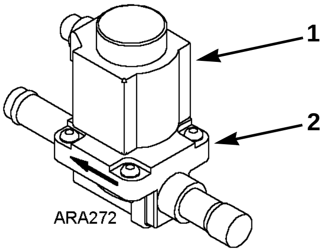
   c. If the LIV coil is not defective, replace the solenoid valve.

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 49: 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. Refer to the appropriate Diagnostic Manual 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 120 F (49 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. 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.
9. 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 0.33 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.

Heat Check Valve Test

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 orifice between the hot gas line and the suction line. This causes heavy frost accumulation on the main suction line between the 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.

There is no absolute test for the heat check valve. Instead, look for a pattern of symptoms using the following procedure:

1. Install a gauge manifold on the compressor. 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. Refer to the appropriate Diagnostic Manual 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 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 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 orifice and the compressor, but not between the evaporator and the orifice.

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.

Use the following procedure, and refer to the Compressor Test Flowchart on pages 95 and 96, to test the compressor:

1. Download the DAS 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, 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 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. Refer to the appropriate Diagnostic Manual 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. If the compressor oil is clear to light brown, go to step 5.
    c. Gray compressor oil indicates metal contamination. Dark brown compressor oil indicates high compressor temperatures. The compressor is probably defective if the oil is gray or dark brown. Go to step 6.
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 psi (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 psi (2758 kPa).
8. Close the main suction service valve slowly to reduce the main suction pressure to 16 psi (110 kPa).

    NOTE: If you cannot raise the discharge pressure to 400 psi (2758 kPa), make sure you have at least 16 psi (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 psi (2758 kPa) with a main suction pressure of 16 psi (110 kPa) or higher, the compressor is probably defective.

9. With the discharge pressure at 400 psi (2758 kPa) and the main suction pressure at 16 psi (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 psi (138 kPa) or less indicates the compressor is good and you can stop the test.
    b. A pressure of 20 to 23 psi (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 psi (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 psi (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 psi (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.

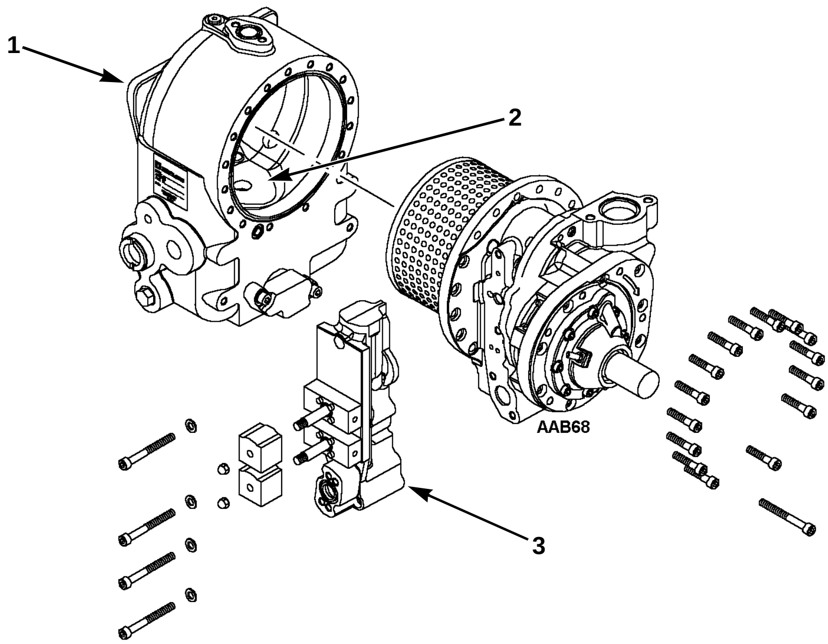
    c. Recover the refrigerant from the compressor.

    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.

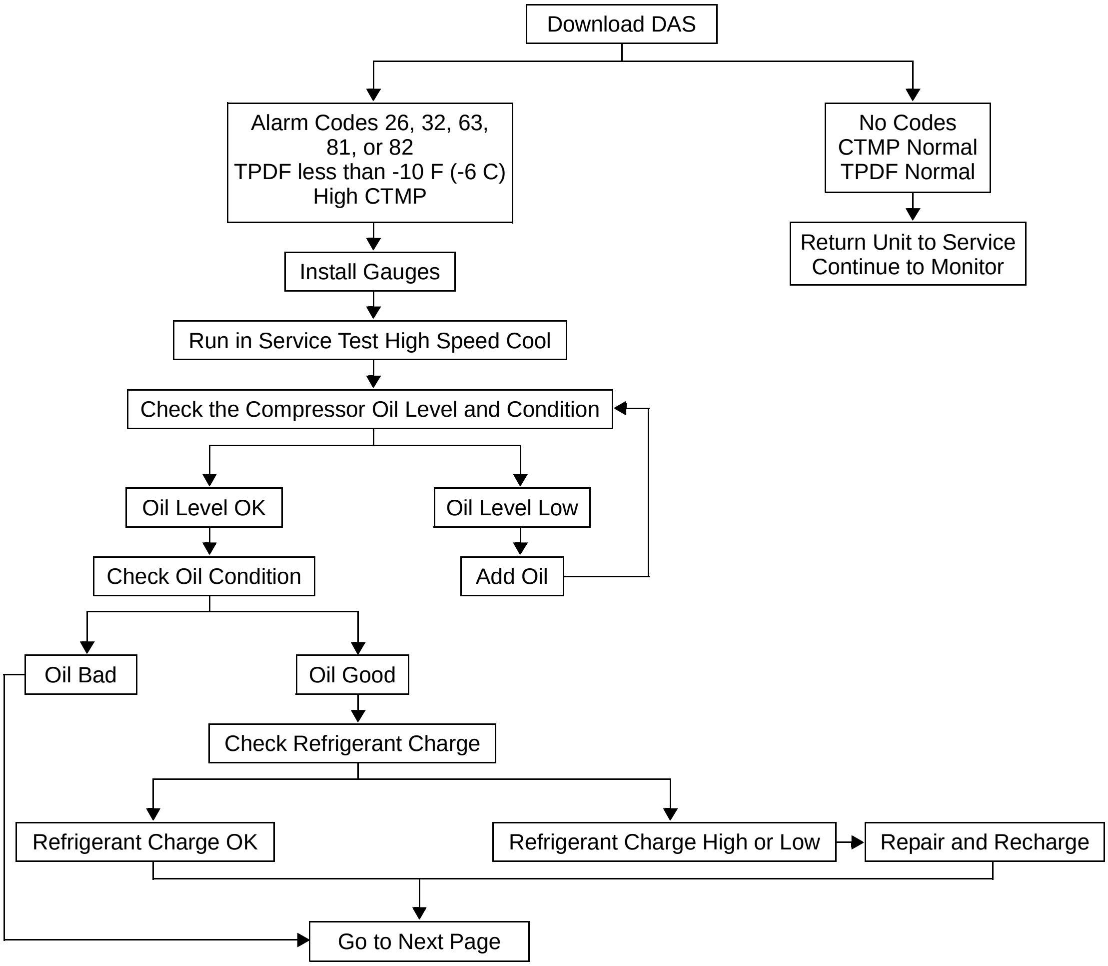
    g. Remove the sump and check it for metal shavings. Shavings tend to accumulate on the shelf in the lower part of the sump between the oil separator and the oil filter. Some shavings are usually present. If there are enough shavings to cover a finger size magnet passed around the shelf, the compressor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



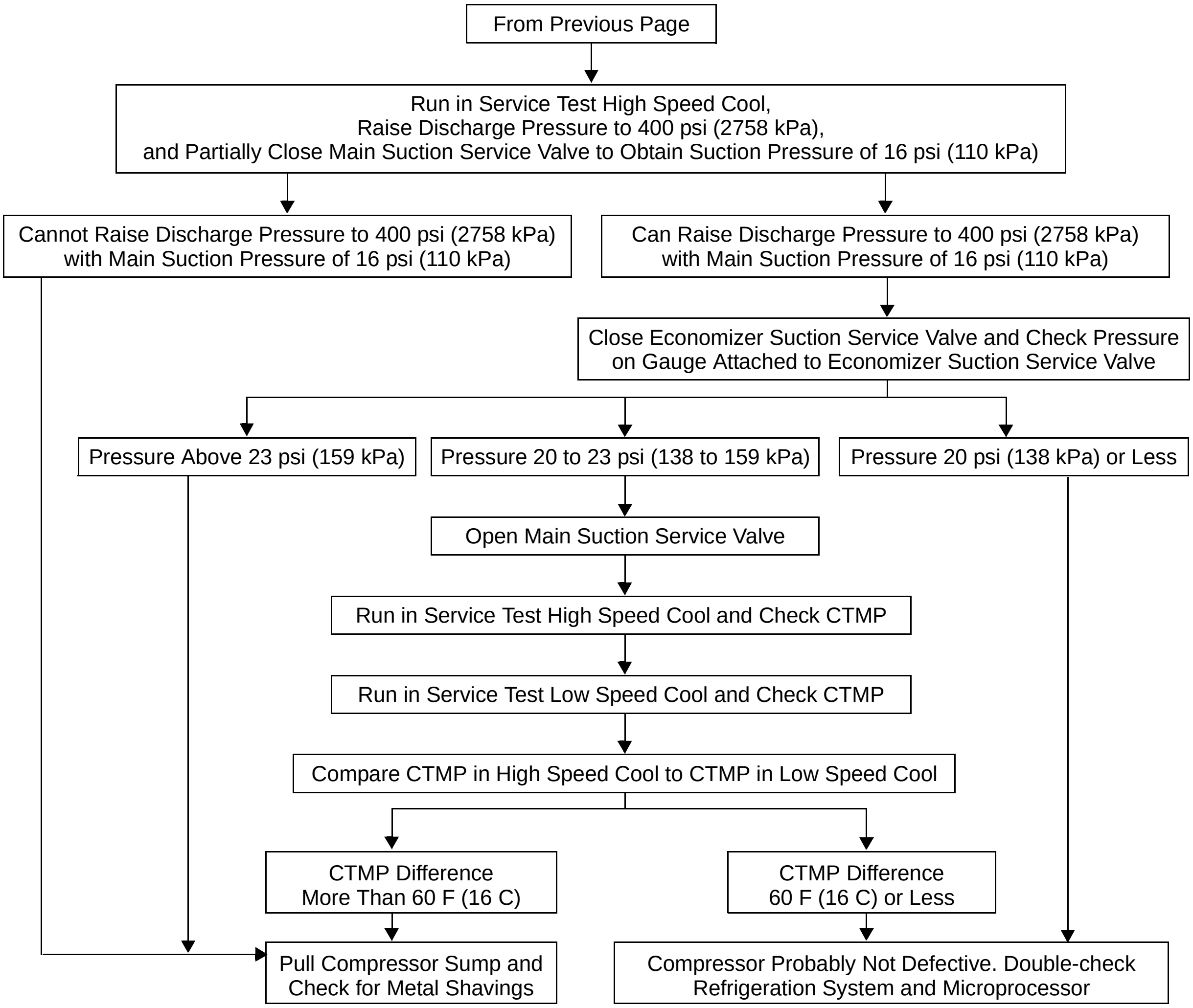
1.	Sump
2.	Check Shelf for Metal Shavings
3.	Valve Holder

Figure 50: Remove Sump

Compressor Test Flow Chart



Compressor Test Flow Chart (Continued)



NOTE: It is generally good practice to replace the filter drier whenever the high side is opened or when the low side is opened for an extended period of time.

Compressor

Removal

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 and suction service valves from the compressor.
4. Support the compressor and remove the compressor mounting hardware and the top three studs from the flywheel housing.
5. Remove the curbside main frame support brace.
6. Lift the service valves out of the way.
7. Slide the compressor to the left until coupling pins are clear.
8. Remove the compressor from the front of the unit. Keep the compressor ports covered to prevent dust, dirt, etc., from falling into the compressor.

NOTE: When the compressor is removed from the unit, oil level should be noted, or the oil removed from the compressor should be measured so that the same amount of oil can be added before placing the replacement compressor in the unit.

CAUTION: Do not use a hammer to pound the coupler off the compressor shaft. This will damage the compressor. Use drive coupling puller (P/N 204-139 or P/N 204-991) to remove the coupler.

Installation

1. Slide the compressor into the unit.
2. Place the compressor in position and install mounting bolts.

NOTE: The compressor drive coupling will only side onto the coupling pins in either of two positions, which are 180 degrees apart.

3. Install the service valves using new O-rings soaked in compressor oil.
4. Pressurize the compressor with a test gas and test for refrigerant leaks.
5. If no leaks are found, evacuate the compressor.
6. Back seat the suction and discharge service valves.
7. Operate the unit at least 30 minutes and then inspect the oil level in the compressor. Add or remove oil if necessary.
8. Check the refrigerant charge and add refrigerant if needed.

Compressor Coupling Removal

NOTE: The illustration on page 98 shows the compressor coupling removal tool P/N 204-991 being used on a reciprocating compressor. The same procedure applies to the screw compressor.

1. After the compressor has been removed from the unit, use the appropriate Allen tool provided with removal tool P/N 204-991 to loosen the center bolt which holds the coupling to the compressor shaft.
2. Attach the tool to the coupling with the provided socket head screws and spacers. 2 sets of spacers are provided with the tool, use the short spacers with shallow compressor mounting flanges and the longer set for deeper flanges. The side with the countersunk holes should be toward the coupling.
3. To prevent the tool and crankshaft from rotating, use one of the compressor to engine mounting screws to pin the tool to the flange. If a nut is used to prevent the bolt from falling out, the nut should not be tightened.

4. Use the appropriate Allen tool to loosen the coupling mounting screw.
5. Once the center screw has been loosened, back the head against the tool and it should push the coupling off the crankshaft as you continuing turning the center screw in a counter-clockwise direction. Using this tool will prevent the coupling from popping off because the center bolt and flatwasher will hold it in place.

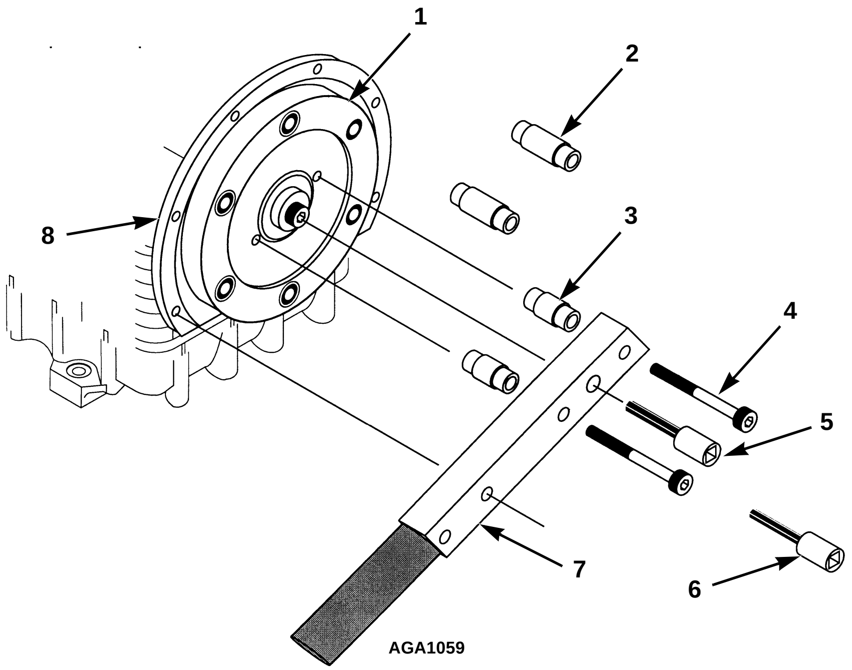
Compressor Coupling Installation

In a tapered fit joint the entire twisting load should be handled by the friction fit between the two tapered parts. The key is only a backup and is used to index the parts correctly. When a taper fit is machined and assembled properly a key is not needed. In fact, if the key is not installed correctly it may be worse than no key at all! If the key does not fit easily into the keyway, it will push the tapered components apart and the reduced friction could lead to slippage and premature failure.

The following procedure requires the key to be fitted after the tapers are pulled together with 20 ft-lb (27 N•m) torque. This insures that the key cannot hold the tapers apart when the final bolt torque is applied.

Use the following procedure to install a compressor coupling on the compressor crankshaft.

1. Clean the compressor shaft taper and coupling bore taper with a solvent that leaves no oily residue (such as naphtha, lacquer thinner, brake cleaner or the like).
2. Inspect both mating surfaces for burrs, oxidation and other surface imperfections. Dress with crocus cloth if necessary and re-clean as required.



1.	Coupling	5.	10 mm Allen Tool (for large shaft compressor)
2.	Long Spacers (supplied with tool)	6.	5/16 Allen Tool (for small shaft compressors)
3.	Short Spacers (supplied with tool)	7.	Coupling Removal Tool (P/N 204-991)
4.	Socket Head Bolts (supplied with Tool)	8.	Engine Mounting Flange

Figure 51: Compressor Coupling Removal Tool

3. **Using no lubricants**, set the coupling on the crankshaft and align the keyways using the Keyway Tool (P/N 204-972). Insert the tapered end of the tool into the keyway and gently move the coupling on the shaft while pressing the tool into the keyway. This will align the keyway in the crankshaft with the keyway in the coupler.

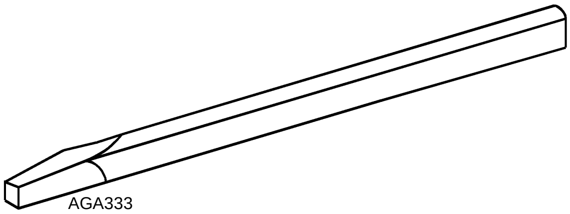


Figure 52: Keyway Tool P/N 204-972

CAUTION: If you are assembling a used coupler or crankshaft and the tool does not fit easily there is a problem with one of the keyways! Do not remove the coupler and place the key in the crankshaft keyway and then drop the coupler on. If the tool does not fit, the key will not fit, and it will hold the taper in the coupler off the taper on the shaft. Check both keyways for burrs or corrosion. A key can be coated with fine lapping compound and used as a lapping tool to clean the keyways.

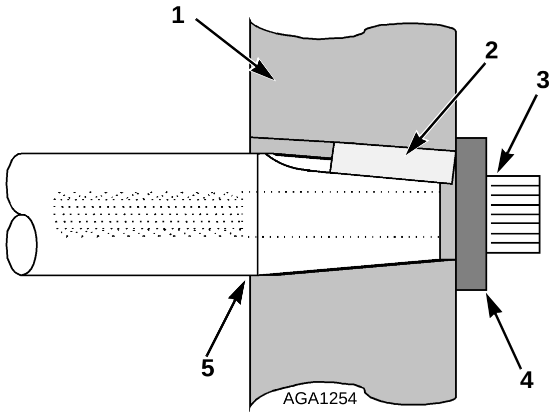
4. Remove the Keyway Tool and check the fit of the key (P/N 55-9024). It should fit into the keyway with a light press fit requiring only a minimum of light tapping. If the key does not fit properly, remove the coupler and inspect the keyways and key for burrs or other problems. Recheck the fit as shown above.

5. When the key fits properly, remove the coupling and key from the shaft.

6. Re-install the coupling and align the keyways with the Keyway Tool.

7. **Do not install the key at this time.** Install the flat washer and bolt and pre-torque to 20 ft-lb (27 N•m). Remove the bolt and washer.

8. Install the key in the keyway. As above, it should fit with a light press fit requiring only a minimum of light tapping. **Do not install the key into the keyway beyond the front face of the coupling.** If tapped in farther it may cause the coupling to move off center on the shaft.



1.	Compressor Coupling or Clutch
2.	Key tapped flush with outside face of coupling. Do not tap key any farther into keyway.
3.	Torque bolt to 90 ft-lb (122 N•m)
4.	Washer
5.	Spray this area with corrosion inhibitor after assembling.

Figure 53: Compressor Coupling Installation

9. Re-install the bolt and heavy flat washer and snug the bolt down by hand. Torque the bolt to 90 ft-lb (122 N•m).

10. Spray a corrosion inhibitor (such as spray paint) on the exposed part of the shaft and the joint between the shaft and the coupling. This prevents moisture from wicking into the joint and causing corrosion.

Compressor Repair

Refer to the S391 Screw Compressor Overhaul Manual (TK 50567) for compressor repair procedures.

System Clean-up Procedures

If a compressor fails, contaminants can spread throughout the system via the compressor oil. In order to effectively clean the system, the contaminants must be removed and/or diluted. Brown oil indicates slight acidity, but low contamination levels. Gray oil, however, indicates possible metal contamination and will require flushing and oil filter changes.

If the oil in the failed compressor is fairly clear and contains only a few metal chips, use the System Clean-Up Procedure Using Internal Oil Filter Replacement.

If the oil in the failed compressor is brown or gray, use the System Clean-Up Procedure Using Screw Compressor Clean-Up Kit P/N 204-920.

System Clean-Up Procedure Using Internal Oil Filter Replacement

1. Install a new compressor and dehydrator in the system.

   NOTE: The new compressor will contain a full charge of oil.

2. Run the unit for at least 1/2 to 1 hour in both the heat and cool cycles. This will loosen any oil trapped in the system.

3. Use this step to move most of the oil into the compressor and isolate the compressor.

   a. Change the setpoint to 70 F (21 C) and run the unit for 1/2 hour.

   b. Use the Service Test Mode [LS.C] to run the unit in low speed cool. Refer to the appropriate Diagnostic manual for specific information about the Service Test Mode.

   c. Close the main suction service valve and the economizer suction service valve while the unit is running.

   d. Turn the unit off and close the discharge service valve.

   e. Recover the refrigerant remaining in the compressor.

4. Remove the compressor drain plug and drain the compressor oil. Measure the amount of oil drained from the compressor and check the condition of the oil.

5. Replace the internal compressor oil filter and the dehydrator.

System Clean-Up Procedure Using Screw Compressor Clean-Up Kit P/N 204-920

Besides the Screw Compressor Clean-up Kit P/N 204-920, the following replacement items will be needed during the procedure:

- Dehydrator P/N 66-5750
- External Oil Filter P/N 66-4917
- POE Compressor Oil P/N 203-515
- Compressor Oil Filter (Internal) P/N 22-998
- O-ring (Sump Cover) P/N 33-2347

Procedure

1. Install a new compressor and dehydrator in the system.

   NOTE: The new compressor will contain a full charge of oil.

2. Install the Screw Compressor Clean-up Kit as shown in the illustration on page 101.

   a. Mount the oil filter bracket on the compressor mounting flange. Position the studs (P/N 55-1487) at one and two o'clock. This places the oil filter at an angle to provide clearance.

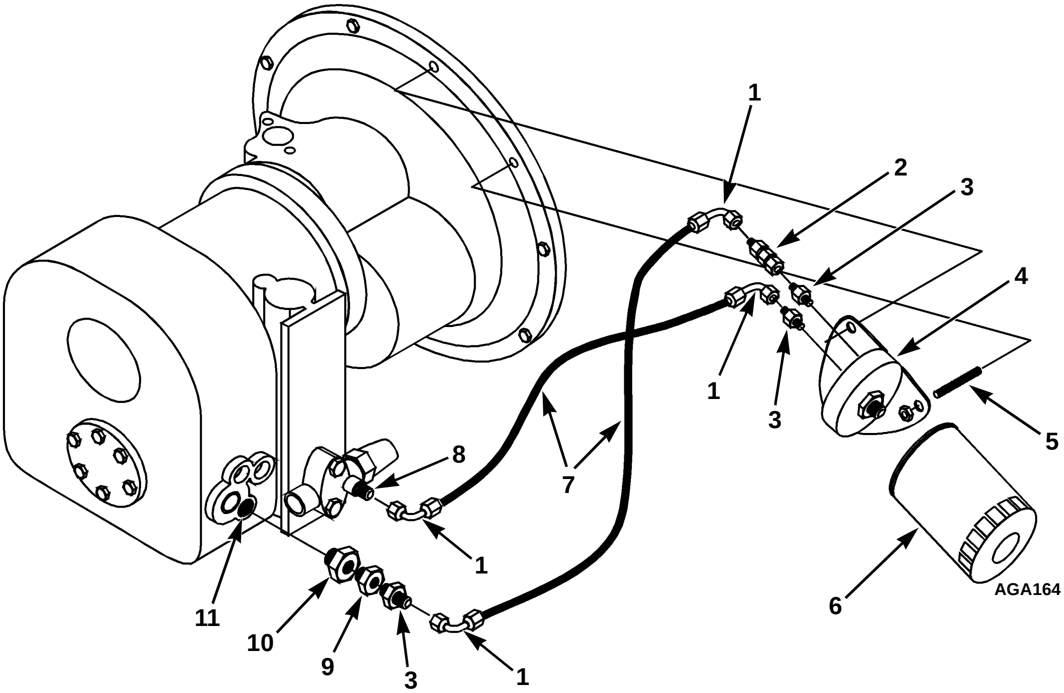
   b. The inlet hose to the oil filter goes from the compressor drain plug adapters to the check valve at the inlet hole to the side of the oil filter bracket.

   c. The outlet hose from the oil filter goes from the outlet hole in the center of the oil filter bracket to the service port on the economizer suction service valve.

   d. Fill the external oil filter with compressor oil before installing it.

3. Evacuate the air from the compressor and the external filter.

4. Mid-seat the economizer suction service valve. Open the main suction and discharge service valves.
5. Run the unit for at least 1/2 to 1 hour in both the heat and cool cycles.
6. Change the external oil filter when the oil becomes discolored. This removes the contaminants.
   a. Close the service valves to isolate the compressor.
   b. Recover the refrigerant remaining in the compressor.
   c. Change the external oil filter.
   d. Evacuate the air from the compressor and the external filter.
   e. Mid-seat the economizer suction service valve. Open the main suction and discharge service valves.
7. Run the unit in high speed cool and check the compressor oil level. Add oil if necessary.
8. Repeat steps 5 through 7 until the compressor oil does not become discolored. This indicates the system is clean.
9. When system is clean replace the internal oil filter and dehydrator, remove the clean-up kit, and replace the studs with the original bolts.

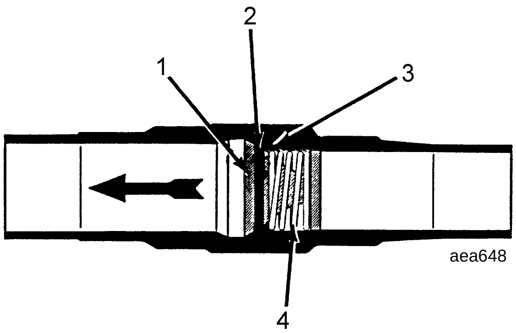


1.	Hose Fitting P/N 66-5076
2.	Check Valve P/N 66-5501
3.	Adapter P/N 55-459 (Use Sealant P/N 203-393)
4.	Oil Filter Bracket P/N 66-7490
5.	Mounting Stud P/N 55-1487
6.	Oil Filter P/N 66-4917 (Not Included in Kit)
7.	Refrigeration Hose P/N 67-942
8.	Economizer Suction Service Valve Service Port—From Filter Outlet (Center Hole)
9.	Bushing P/N 55-1786 (Use Sealant P/N 203-393)
10.	Drain Plug Adapter P/N 55-8817
11.	Drain Plug Opening—To Filter Inlet (Side Hole)

Figure 54: Screw Compressor Clean-Up Kit (P/N 204-920) Installation

In-line Condenser Check Valve

This unit uses an in-line condenser check valve. The in-line check valve is not repairable and must be replaced if it fails. A heat sink must be used on the in-line check valve when it is being soldered in place to prevent damage to the neoprene seal.



1.	Valve
2.	Neoprene Seal
3.	Valve Seat
4.	Spring

Figure 55: Cross Section of In-line Condenser Check Valve

Condenser Check Valve Replacement

Removal

1. Recover the refrigerant charge.
2. Place a heat sink on the check valve.
3. Unsolder the lines and remove the check valve.

Installation

NOTE: A heat sink must be used on the in-line check valve when it is being soldered in place to prevent damage to the neoprene seal.

1. Clean the tubes for soldering.
2. Place the check valve in position. The arrow on the valve body indicates the direction of refrigerant flow through the valve.
3. Place a heat sink on the check valve.
4. Solder the inlet and outlet connections.
5. Pressurize the refrigeration system and test for leaks.
6. If no leaks are found, evacuate the system.
7. Recharge the unit with proper refrigerant and check the compressor oil.

Discharge Vibrasorber

Removal

1. Recover the refrigerant charge.
2. Heat the connections on the vibrasorber until the vibrasorber can be removed.

CAUTION: Use a heat sink, P/N 204-584 or wrap the vibrasorber with wet rags to prevent damaging the vibrasorber.

Installation

1. Prepare the vibrasorber and tubing fittings by cleaning thoroughly.
2. Solder the vibrasorber connections.

CAUTION: Use a heat sink, P/N 204-584 or wrap the vibrasorber with wet rags to prevent damaging the vibrasorber.

3. Pressurize the system and test for leaks. If no leaks are found, evacuate the system.
4. Charge the unit with the proper refrigerant and check the compressor oil level.

Receiver Tank

Removal

1. Recover the refrigerant charge.
2. Unsolder the inlet and outlet lines from the receiver tank.
3. Remove the high pressure relief valve from the receiver tank.
4. Unbolt the mounting brackets and remove the receiver tank from the unit.

Installation

1. Install the high pressure relief valve in the receiver tank.

2. Place the receiver tank in the unit and install the mounting bolts and nuts loosely. Position the receiver tank so that the sight glass is clearly visible through the viewing hole in the mounting bracket.
3. Solder the inlet and outlet lines to the receiver tank. Use a heat sink on the bypass check valve.
4. Tighten the receiver tank mounting hardware securely.
5. Pressurize the refrigeration system and check for leaks. If no leaks are found, evacuate the system.
6. Recharge the unit with proper refrigerant and check the compressor oil level.

Filter Drier

Removal

1. Pump down and isolate the low side. Equalize the pressure to slightly positive.
2. Disconnect the ORS nuts at the ends of the drier.
3. Loosen the mounting hardware and remove the drier.

Installation

1. Place the new O-rings in the ORS fittings on the ends of the drier.
2. Install the new drier and tighten the mounting hardware.
3. Install and tighten the inlet ORS nut. Hold the drier with a back-up wrench on the hex behind the ORS fitting.
4. Release a small amount of refrigerant to purge the air through the drier. Then tighten the outlet ORS nut.
5. Pressurize the system and inspect for leaks. If no leaks are found, open the refrigeration valves and place the unit in operation.

Evaporator Expansion Valve

NOTE: The evaporator expansion valve and the economizer expansion valve are made by the same manufacturer. It is easy to get them mixed up. The evaporator expansion valve has the numbers 3A86277G51 and possibly 66-9430 stamped on the power head. The economizer expansion valve has the number 3A86277G59 stamped on the power head.

Removal

1. Pump down and isolate the low side and the liquid line. Equalize the pressure to slightly positive.
2. Remove the upper and lower evaporator access panels. Remove the roadside evaporator access panel mounting channel.
3. Remove the feeler bulb from the clamp. Note the position of the feeler bulb on the suction line.
4. Unsolder the equalizer line, the inlet liquid line, and distributor from expansion valve. Make sure to use a heat sink.
5. Remove the expansion valve mounting bolt and remove the expansion valve from the unit.

Installation

1. Install and bolt the expansion valve assembly in the unit.
2. Solder the inlet liquid line, distributor, and equalizer line to the expansion valve. Use low temperature solder and place a heat sink on the expansion valve.
3. Clean the suction line to a bright polished condition. Install the feeler bulb clamps and feeler bulb on the side of the suction line in former position. The feeler bulb must make good contact with the suction line or operation will be faulty. Wrap with insulating tape.
4. Pressurize the low side and test for leaks. If no leaks are found, evacuate the low side.
5. Replace the evaporator access mounting channel and the upper and lower access panels on the evaporator.

6. Open the refrigeration valves and place the unit in operation.
7. Test the unit to see that the expansion valve is properly installed and check the expansion valve superheat.

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.
- Check the bypass solenoid, (LV1). It must be closed.
- Inspect the evaporator and condenser coils.

Check/Adjustment Procedure

1. Install a gauge manifold on the compressor. 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. Refer to the appropriate Diagnostic Manual for specific information about the Service Test Mode.
6. Cover the condenser as needed to maintain a discharge pressure of 275 to 300 psi (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.
    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 psi (34 kPa)
Convert to Temperature =	5 psi = -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).
11. Adjust the superheat setting by turning the adjustment screw located under the hex cap nut on the expansion valve. Turn the adjustment screw clockwise to increase the superheat. Turn the adjustment screw counterclockwise to decrease the superheat.
12. Repeat the Check/Adjustment procedure as necessary to obtain an acceptable superheat value.

Evaporator Coil

Removal

1. Pump down the low side and equalize the pressure to slightly positive.
2. Remove the upper and lower evaporator access panels.
3. Remove the roadside and curbside evaporator access panel mounting channels.
4. Disconnect the sensors.

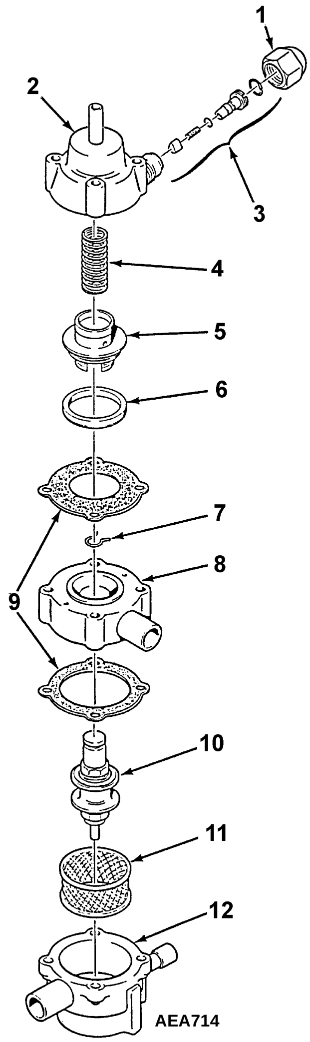
5. Remove the feeler bulb from the suction line clamp. Note the position of the feeler bulb on the suction line.
6. Unsolder the distributor from the expansion valve.
7. Unsolder the suction line from the evaporator circuit.
8. Unsolder the hot gas inlet line and the outlet line from the heat circuit.
9. Remove the mounting bolts, lift and slide the coil from the housing.

Installation

1. Place the evaporator coil in the evaporator housing and install the mounting bolts.
2. Solder the hot gas inlet line and the outlet line to the heat circuit.
3. Solder the suction line connection to the evaporator circuit.
4. Solder the distributor to the expansion valve.
5. Replace and connect the sensors.
6. Pressurize the low side and test for leaks. If no leaks are found, evacuate the low side.
7. Clean the suction line to a bright polished condition. Install the feeler bulb on the side of the suction line in its former position. The feeler bulb must make good contact with the suction line or operation will be faulty. Wrap with insulating tape.
8. Replace the evaporator access panel mounting channels.
9. Replace the evaporator access panels.
10. Open the refrigeration valves and place the unit in operation. Check the refrigerant charge and compressor oil. Add as required.

Three-way Valve Repair

NOTE: The three-way valve can be repaired in the unit if leakage or damage to the Teflon seals should occur. There is usually enough give in the copper tubing to separate the three sections of the valve without unsoldering any tubes.



1.	Cap	7.	Clip
2.	End Cap	8.	Seat
3.	Check Valve	9.	Gaskets
4.	Spring	10.	Stem Assembly
5.	Piston	11.	Screen
6.	Seal	12.	Bottom Cap

Figure 56: Three-Way Valve

Removal/Disassembly

1. Recover the refrigerant charge.
2. Clean the exterior surface of the valve.
3. Remove the line from the three-way valve to the pilot solenoid.

4. Loosen the four 1/4 in. Allen head screws (DO NOT REMOVE OR CAP MAY POP OFF); use tool P/N 204-424 to break the gasket at each side of the center section.

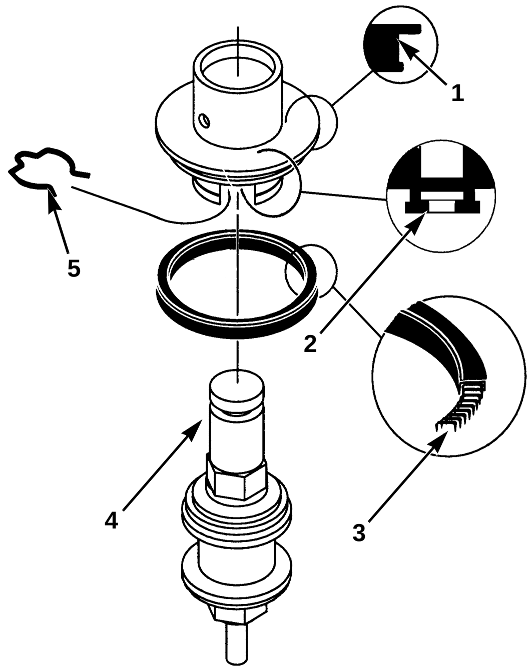
CAUTION: Do not force the tool into the brass or against the bolts.

Figure 57: Gasket Tool P/N 204-424

5. Remove the four bolts from the valve.
6. Remove the end cap and spring.
7. Remove the spring clip which secures the stem to the piston. Slide piston off the stem.
8. Remove the seat and stem assembly.
9. Inspect the following parts for wear or damage:
   a. Bottom cap, sealing and support area.
   b. Seat, sealing surface.
   c. End cap, sealing and support surface.

   The following parts will be discarded:
   a. Stem assembly.
   b. All gaskets.
   c. Piston seal.
10. Remove the screen. If any particles drop from the screen into the discharge line, the discharge line must be removed at the compressor.

    NOTE: The valve body cannot be reconditioned. Seat positions change and improper sealing will result.



1.	Seal Groove in Piston
2.	Connecting Notch in Piston
3.	Internal Spring in Seal
4.	Connecting Groove in Stem
5.	Retaining Clip

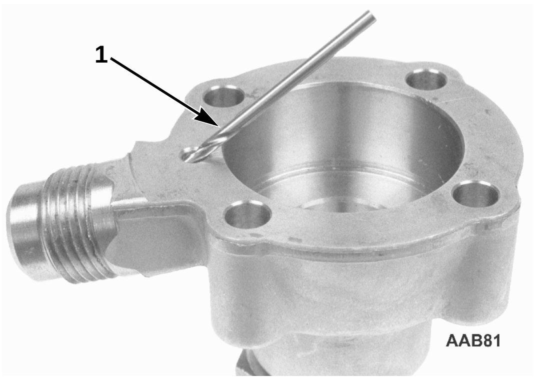
Figure 58: Piston and Stem Parts

End Cap Checks

All end caps, even new ones, should be checked as follows. See Service Bulletin T&T 260 for more information.

Check Valve Bleed Hole Diameter

1. Remove the condenser pressure bypass check valve snap ring, stem, spring, and piston from the end cap.
2. Use a number 43 (0.089 in. [2.26 mm]) drill bit to check the size of the hole from the end cap gasket face to the check valve piston bore as shown.
3. If the drill does not go all the way into the bore, drill the hole completely through.
4. Deburr the hole in the check valve piston bore. A used drill bit can be modified to use as a deburring tool.

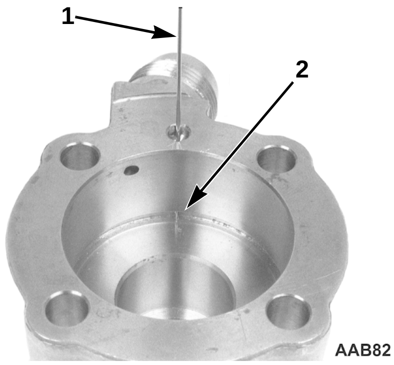


1.	Number 43 Drill

Figure 59: Check Bleed Hole Diameter

Piston Bleed Orifice Check

1. Use a number 66 (0.033 inch [0.84 mm]) drill bit to check the orifice in the bleed hole from the gasket surface to the groove in the bottom of the piston bore.
2. Carefully check to see that the drill projects down into the groove and that there are no burrs at the end of the hole in the groove. Do not enlarge this hole.



1.	Number 66 Drill
2.	Check for Burr Here

Figure 60: Check Piston Bleed Orifice

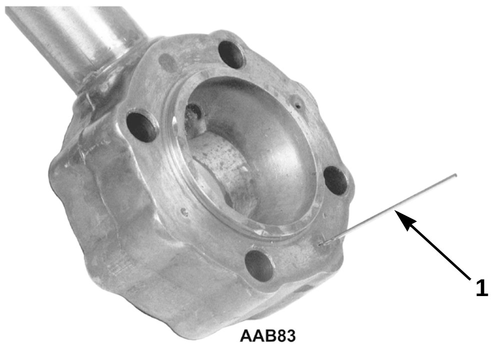
Check Valve Piston Check

1. Reassemble the end cap using a new check valve piston, spring, stem, and snap ring (Kit P/N 60-163).
2. Leave the stem back seated against the snap ring. Use a paper clip bent into a 90 degree angle to push the check valve piston back in its bore. Make sure you can feel the piston working against the spring.
3. With the piston pushed all the way back in its bore, use a strong light to look down the 0.089 in. (2.26 mm) hole towards the back of the piston and determine how much of the end of the hole is covered by the piston. If the piston covers more than three-quarters of the hole replace the end cap.

NOTE: When front seating a condenser bypass check valve DO NOT over-tighten the stem! Excessive torque will deform the piston and the deformed piston can increase the hole blockage.

Seat (Center Section) Orifice Check

There are three 0.033 inch (0.84 mm) holes located in the three-way valve seat (center section). Only one is used depending on how the valve is configured. If the hole is too large the valve will be slow to shift from heat to cool when the condenser pressure is higher than discharge pressure because gas will flow to the discharge line instead of behind the piston. If the hole is too small the valve will be slow to shift from heat to cool when discharge pressure is higher than condenser pressure because the flow is restricted. **Do not enlarge this hole larger than 0.033 inch (0.84 mm)!** Whenever you disassemble a three-way valve you should check that all three of the holes are drilled cleanly.



1.	Number 66 Drill

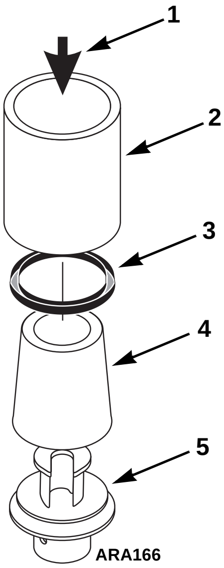
Figure 61: Check Seat Orifice

Assembly/Installation

After cleaning and inspecting all parts, reassemble the valve.

1. Install the screen in the bottom cap.
2. Install the new stem in the bottom cap.

3. Install new gaskets on both sides of the seat. Oil the gaskets in compressor oil before installing.
4. Use the three-way valve seal installation tool P/N 204-1008 to install a new seal on the piston. This prevents the seal from being stretched and damaged.
   a. Place the tapered tool over the piston.
   b. Lubricate the seal with refrigeration oil.
   c. Slide the seal onto the tapered tool with the spring side facing away from the piston.
   d. Use the pipe to hand press the seal onto the piston.



1.	Press by Hand	4.	Tapered Tool
2.	Pipe	5.	Piston
3.	Seal		

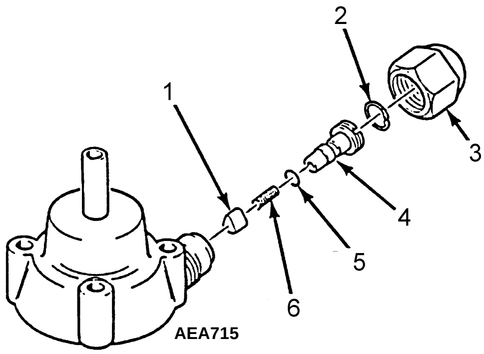
Figure 62: Seal Installation with Tool P/N 204-1008

5. Place the piston slot on the stem and secure with spring clip. The open part of the clip should be on the opposite side of the piston slot.
6. Install the spring and end cap.
7. Line up the passageways in the cap and body. Failure to line up the holes will result in improper operation of the valve.
8. Install the bolts and tighten in rotating sequence. Torque to 160 in-lb (18 N•m).
9. Install the pilot solenoid line and pressurize the system with refrigerant to check for leaks.
10. If there are no leaks, evacuate the system and recharge with the proper refrigerant.
11. Run the unit to check for proper three-way valve operation.

Three-Way Valve Condenser Pressure Bypass Check Valve Repair

Removal

1. Recover the refrigerant charge.
2. Unscrew the condenser pressure bypass check valve cap from the three-way valve.
3. Remove the snap ring.



1.	Piston	4.	Stem
2.	Snap Ring	5.	O-ring
3.	Cap	6.	Spring

Figure 63: Teflon Check Valve Assembly

4. Unscrew the check valve stem by using a screwdriver in the slot provided.

   NOTE: The spring and piston are held in by the stem. While removing the stem, use care so the spring and piston are not lost.

5. Remove the spring and piston.
6. Inspect the check valve seat in the three-way valve.
7. If replacement parts are needed, a kit P/N 60-163 must be used which includes the piston, spring, O-ring, valve stem and snap ring.

Installation

1. Coat the O-ring with compressor oil and install it on the check valve stem.
2. Insert the spring into the hole in the check valve stem and then install the piston on the other end of the spring with the hole in the piston towards the spring.
3. Coat the entire assembly with compressor oil and install the assembly into the check valve seat in the three-way valve.

CAUTION: The piston must be inserted with the flat side against the valve seat to ensure proper sealing.

4. Screw the check valve stem into the three-way valve until the snap ring can be installed.
5. Install the snap ring.
6. Unscrew (back seat) the check valve stem against the snap ring.

   NOTE: The valve stem must be back seated during normal unit operation.

7. Coat sealing area in the cap with compressor oil, install and tighten the cap on the three-way valve.
8. Pressurize the refrigeration system and test for leaks. If no leaks are found, evacuate the system.
9. Recharge the unit.

Pilot Solenoid

Removal

1. Recover the refrigerant charge.
2. Disconnect the wires and remove the coil from the valve.
3. Unsolder the refrigeration lines.
4. Remove the mounting bolts and remove the valve.

Installation

1. Remove the coil from the valve.
2. Place the valve in the unit and install the mounting bolts. The arrow on the valve indicates the direction of flow through the valve. Make sure that the arrow points in the proper direction.
3. Solder the refrigeration lines to the valve.
4. Install the coil and connect the wires.
5. Pressurize the refrigeration system and test for leaks. If no leaks are found, evacuate the system.
6. Recharge the unit with the proper refrigerant and check the compressor oil.

Suction Vibrasorbers

Removal

1. Pump down and isolate the low side. Equalize pressure to slightly positive.
2. Unsolder the end of the suction vibrasorber that is not connected to the suction service valve first, then unsolder the service valve connection. Make sure to use a heat sink on the vibrasorber.

Installation

1. Prepare the suction hose and tube fittings for soldering by cleaning thoroughly.
2. Solder the vibrasorber to the suction service valve.
3. Solder the other vibrasorber connection.

CAUTION: Use a heat sink or wrap vibrasorber with wet rags to prevent damaging the vibrasorber.

4. Pressurize the low side and check for leaks. If no leaks are found, evacuate the system.
5. Open the refrigeration valves and place the unit in operation.

High Pressure Cutout And High Pressure Cut In Switches

Removal

1. Use the compressor pump down procedure to pump down and isolate the compressor.

2. Recover the refrigerant remaining in the compressor.
3. Disconnect the switch wire connector from the main wire harness, and remove the switch from the discharge service valve.

Installation

1. Apply a refrigerant Loctite to the threads of the switch.
2. Install and tighten the switch and reconnect the wires.
3. Pressurize the compressor and test for leaks.
4. If no leaks are found, open the refrigeration service valves and place the unit in operation.

High Pressure Relief Valve

Removal

1. Recover the refrigerant charge.
2. Unscrew and remove the high pressure relief valve.

Installation

1. Apply a refrigerant oil to the O-ring of the high pressure relief valve.
2. Install and tighten the high pressure relief valve.
3. Pressurize the refrigeration system and test for leaks. If no leaks are found, evacuate the system.
4. Recharge the unit with the proper refrigerant and check the compressor oil.

Liquid Line Solenoid

Removal

1. Pump down and isolate the low side. Equalize the pressure to slightly positive.
2. Disconnect the solenoid coil wires from the main wire harness and remove the solenoid coil from the solenoid valve.
3. Unsolder the inlet and outlet lines from the solenoid valve and remove it from the unit.

Installation

1. Clean the tubes for soldering.
2. Remove the solenoid coil from the solenoid valve.
3. Place the valve in position. The arrow on the valve indicates the direction of flow through the valve. Make sure that the arrow points in the proper direction.
4. Solder the inlet and outlet connections. After the valve cools, install the solenoid coil and connect the wire connector to the main wire harness.

CAUTION: Use a heat sink or wrap the valve in wet rags to prevent damaging the valve while doing the soldering.

5. Pressure the low side and test it for leaks.
6. If no leaks are found, evacuate the low side.
7. Open the service valves, run the unit, and check the operation.

Subcooler/Condenser/Radiator

Removal

1. Recover the refrigerant charge.
2. Open the roadside condenser fan grille.
3. Drain the engine coolant.
4. Disconnect the coolant hoses from the expansion tank and the subcooler/condenser/radiator.
5. Remove the expansion tank mounting hardware and remove the expansion tank.
6. Remove the subcooler/condenser/radiator mounting hardware.
7. Unsolder the refrigeration line connections and remove the subcooler/condenser/radiator from the unit.

Installation

1. Clean the fittings for soldering.
2. Place the subcooler/condenser/radiator in the unit and install the mounting hardware.

3. Solder the refrigeration connections.
4. Pressurize the refrigeration system and test for leaks. If no leaks are found, evacuate the system.
5. Install the expansion tank and tighten the mounting hardware.
6. Attach the coolant hoses to the expansion tank and the subcooler/condenser/radiator.
7. Fill the cooling system with coolant.
8. Close the roadside condenser fan grille.
9. Recharge the unit with proper refrigerant and check compressor oil.

Discharge Pressure Transducer

Removal

1. Recover the refrigerant charge.
2. Disconnect the wires and remove the discharge pressure transducer.

Installation

1. Apply a refrigerant Loctite to the threads of the discharge pressure transducer.
2. Install and tighten the discharge pressure transducer and reconnect the wires.
3. Pressurize the refrigeration system and test for leaks. If no leaks are found, evacuate the system.
4. Recharge the unit with the proper refrigerant and check the compressor oil.

Suction Pressure Transducer

Removal

1. Pump down the low side and equalize pressure to slightly positive.
2. Disconnect the wires and remove the suction pressure transducer.

Installation

1. Apply a refrigerant Loctite to the threads of the suction pressure transducer.
2. Install and tighten the suction pressure transducer and reconnect the wires.
3. Pressurize the low side and check for leaks. If no leaks are found, evacuate the low side.
4. Open the refrigeration valves and place the unit in operation.

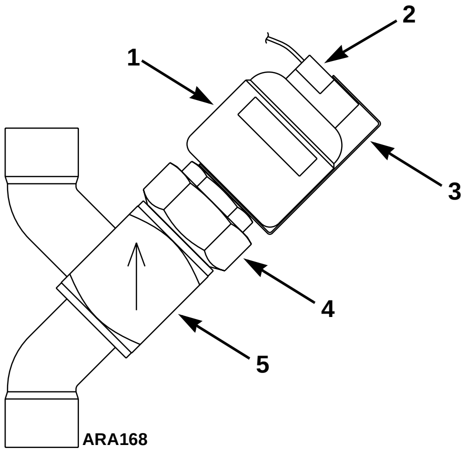
Electronic Throttling Valve (ETV)

Removal

1. Pump down the low side and equalize the pressure to slightly positive.
2. Remove the evaporator access panels.
3. Remove the clip and disconnect the ETV harness connector from the stepper motor.
4. Unscrew the large nut that attaches the stepper motor and piston assembly to the valve body. The torque on the nut is approximately 100 ft-lb (136 N•m). Hold the valve body with backup wrench to prevent damage to the refrigeration tubing.

CAUTION: Unscrew the large nut. Do not unscrew the small nut.

WARNING: If the ETV is stuck in the closed position, much of the refrigerant charge may be trapped in the evaporator. If you hear refrigerant begin to flow through the valve when the stepper motor and piston assembly are loosened, unscrew the stepper motor and piston assembly no more than four turns and check the suction (low side) pressure on the gauge manifold. If the suction pressure has increased from the pressure to which it was equalized after the low side pump down, refrigerant is trapped and must be recovered. Screw the stepper motor and piston assembly back into the valve body. Attach a refrigerant recovery device to the service port on the receiver tank outlet valve. Midseat the receiver tank outlet valve, and recover the refrigerant charge. The stepper motor and piston assembly may then be removed.



1.	Stepper Motor	4.	Large Nut
2.	Harness Connector	5.	Valve Body
3.	Clip		

Figure 64: Electronic Throttling Valve

5. If the complete ETV assembly is being replaced, unsolder and remove the valve body. It may be necessary to unsolder the tubes above or below the valve body to obtain enough clearance to remove the valve body. Note the position of the valve body so the new one will be placed in the same position. The new ETV could interfere with the evaporator access panel if it is not placed in the same position as the old one.

Installation

1. If an ETV service kit (stepper motor and piston assembly) is being installed, go to step 2. If a complete ETV assembly is being installed, proceed as follows:

    a. Remove the stepper motor and piston assembly from the valve body on the new ETV assembly.

    b. Clean the tubes for soldering.

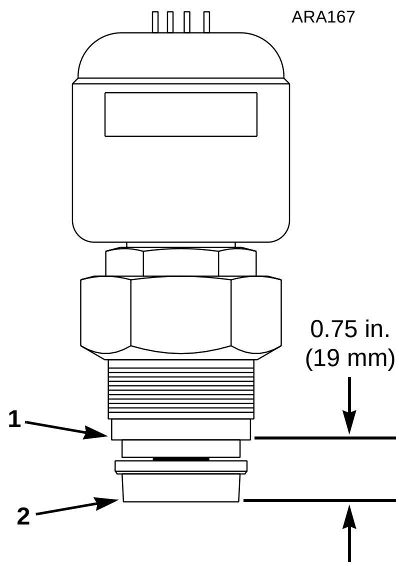
    c. Place the new valve body (and any tubes that were removed) in the same position from which the old one was removed. The new ETV could interfere with the evaporator access panel if it is not placed in the same position as the old one. The arrow on the valve body must point up, which is the direction of refrigerant flow from the evaporator to the heat exchanger.

    d. Solder the tubing connections. Use a heat sink on the valve body to prevent damage.

    e. Allow the valve body to cool before installing the stepper motor and piston assembly.

2. Check the stepper motor and piston assembly to make sure the piston is an open position. In an open position the bottom edge of the piston is 0.75 to 1.25 in. (19 to 32 mm) from the bottom edge of the brass nut. The piston retracts to open and extends to close.

NOTE: The ETV cannot be opened manually. See the following CAUTION.



1.	Bottom Edge of Brass Nut
2.	Bottom Edge of Piston

Figure 65: Stepper Motor and Piston Assembly with Piston in Fully Open Position

CAUTION: The ETV may stick in the closed position if the stepper motor and piston assembly is installed with the piston in the closed position. In the closed position the bottom edge of the piston is 1.5 in. (38 mm) from the bottom edge of the brass nut. If there is any doubt about the position of the piston, connect the ETV harness to the stepper motor and piston assembly and use the evacuation [EVAC] mode in the Service Test Mode to place the piston in the fully open position. Refer to Service Procedure A34A, the Service Test Mode, in the THERMOGUARD μP-VI Microprocessor Controller Diagnostic Manual TK 51329 for information about placing the unit in the evacuation [EVAC] mode. After placing the piston in the fully open position, disconnect the ETV harness from the stepper motor and piston assembly.

3. Lubricate the piston and threads on the new stepper motor and piston assembly with refrigeration oil.
4. Screw the new stepper motor and piston assembly into the valve body.
5. Torque the nut to approximately 100 ft-lb (136 N•m). Hold the valve body with backup wrench to prevent damage to the refrigeration tubing.

CAUTION: Tighten the large nut. Do not tighten the small nut.

6. Connect the ETV harness connector to the stepper motor. Take care when making the connection. The connector attaches to the ETV in only one position.
7. Install the clip and secure it with a band wrap.
8. Pressurize the low side and test for leaks.
9. If no leaks are found, evacuate the low side.
10. Install the evaporator access panels.
11. Open the refrigeration valves and place the unit in operation. Check the operation of the ETV.

Economizer Heat Exchanger

Removal

1. Pump down and isolate the low side. Equalize the pressure to slightly positive and recover the refrigerant remaining in the low side.
2. Drain the coolant from the cooling system.
3. Disconnect the coolant hoses from the economizer.
4. Unsolder the refrigeration lines from the economizer.
5. Remove the economizer mounting hardware and remove the economizer from the unit.

Installation

1. Place the economizer in the unit and loosely fasten it in place with the mounting hardware.
2. Solder the refrigeration lines to the economizer.
3. Tighten the mounting hardware.
4. Connect the coolant hoses to the economizer.
5. Fill the cooling system with antifreeze.
6. Pressurize the low side and test for leaks. If no leaks are found, evacuate the low side.
7. Open the refrigeration valves and place the unit in operation. Check refrigerant charge and compressor oil. Add as required.

Economizer Expansion Valve

NOTE: The evaporator expansion valve and the economizer expansion valve are made by the same manufacturer. It is easy to get them mixed up. The evaporator expansion valve has the numbers 3A86277G51 and possibly 66-9430 stamped on the power head. The economizer expansion valve has the number 3A86277G59 stamped on the power head.

Removal

1. Pump down and isolate the low side. Equalize the pressure to slightly positive.

2. Remove the feeler bulb from the clamp on the suction line. Note the position of the feeler bulb on the suction line.
3. Unsolder the inlet, outlet, and equalizer line connections, and remove the expansion valve.

Installation

1. Place the expansion valve in position on the economizer. Make sure that all of the refrigeration lines are aligned properly.
2. Solder the inlet, outlet, and equalizer line connections.
3. Clean the suction line to a bright polished condition. Install the feeler bulb clamps and feeler bulb on the side of the suction line in former position. The feeler bulb must make good contact with the suction line or operation will be faulty. Wrap with insulating tape.
4. Pressurize the low side and test for leaks. If no leaks are found, evacuate the low side.
5. Open the refrigeration valves and place the unit in operation. Check refrigerant charge and compressor oil. Add as required.
6. Check the economizer expansion valve superheat and maximum operating pressure.

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.
- Check LV1 (economizer bypass solenoid). It must be closed.
- Inspect the evaporator and condenser coils.

Check/Adjustment Procedure

1. Install a gauge manifold on the compressor. 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.C] to run the unit in high speed cool. Refer to the appropriate Diagnostic Manual for specific information about the Service Test Mode.
5. Check the suction pressure at the economizer suction service valve when the return air temperature (check with the microprocessor) is above 35 F (1.7 C). The economizer expansion valve should have a maximum operating pressure (MOP) of 50 psi (345 kPa). If the economizer suction line pressure is higher than 60 psi (414 kPa), the economizer expansion valve is defective.
6. After checking the MOP of the economizer expansion valve, take the unit out of the service test mode.
7. 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).
8. Defrost the evaporator and allow the return air temperature to stabilize near -20 F (-29 C).
9. Use the Service Test Mode [HS.C] to run the unit in high speed cool.
10. Cover the condenser as needed to maintain a discharge pressure of 275 to 300 psi (1896 to 2068 kPa).

11. Check and record the economizer suction service valve pressure and the suction line temperature simultaneously. Take four readings at 2 minute intervals.
12. 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 =	30 psi (207 kPa)
Convert to Temperature =	30 psi = -3 F (207 kPa = -19.4C)
Feeler Bulb Temperature =	14 F (-10 C)
Converted Temperature =	-3 F (-19.4 C)
Superheat =	14 F - (-3 F) = 17 F (-10 C - [-19.4 C] = 9.4 C)

13. Average the four superheat values by adding them together and dividing the sum by four.
14. The average superheat value should be 10 to 20 F (5.6 to 11.1 C) at a return air temperature of approximately -20 F (-29 C).

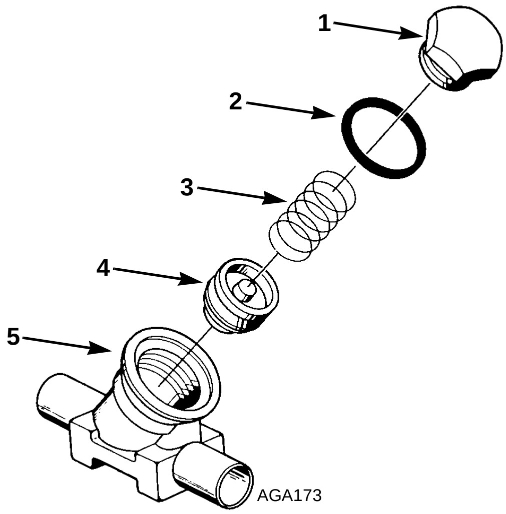
    NOTE: The temperature at the tube between the economizer expansion valve and the economizer should be at least 10 F (5.6 C) above the feeler bulb temperature. If the temperatures are nearly the same, the expansion valve is flooding. If the temperature at the tube between the expansion valve and the economizer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

15. Adjust the superheat setting by turning the adjustment screw located under the hex cap nut on the expansion valve. Turn the adjustment screw clockwise to increase the superheat. Turn the adjustment screw counterclockwise to decrease the superheat.
16. Repeat the Check/Adjustment procedure as necessary to obtain an acceptable superheat value.

Heat Check Valve Repair

Disassembly

1. Recover the refrigerant charge.
2. Remove the cap nut from the check valve and remove the spring and seat.



1.	Cap
2.	Gasket
3.	Spring
4.	Seat
5.	Body

Figure 66: Check Valve with Cap Nut

Reassembly

1. Inspect the inside of the check valve body for damage or foreign particles which might adhere to the seat and damage the new seat. If the body is damaged, replace the check valve.
2. Install the new seat and spring. Place a new gasket on the cap and tighten the cap.
3. Pressurize the system and test for leaks.
4. If no leaks are found, evacuate the system.
5. Recharge the unit with proper refrigerant and check compressor oil.

Heat Check Valve Replacement

Removal

1. Recover the refrigerant charge.

2. Disassemble the check valve.
3. Unsolder the lines and remove the check valve.

Installation

1. Clean the tubes for soldering.
2. Place the disassembled check valve in position. The arrow on the valve body indicates the direction of refrigerant flow through the valve.
3. Solder the inlet and outlet connections. After the valve cools, reassemble the valve.
4. Pressurize the low side and test for leaks.
5. If no leaks are found, evacuate the system.
6. Recharge the unit with proper refrigerant and check compressor oil.

Liquid Injection Valve

The liquid injection valve has a screen in the inlet tube. If the valve acts like it is stuck closed, check the screen to see if it is plugged before replacing the valve. The valve must be removed to check the screen.

Removal

1. Pump down and isolate the low side. Equalize the pressure to slightly positive.
2. Disconnect the coil wires from the main wire harness and remove the coil from the valve.
3. Unsolder the inlet and outlet lines from the valve and remove it from the unit.

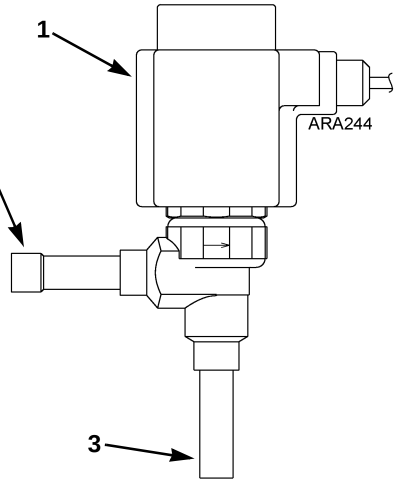
CAUTION: Use a heat sink or wrap the valve in wet rags to prevent damaging the valve while doing the soldering.

Installation

1. Clean the tubes for soldering.
2. Remove the coil from the valve.
3. Place the valve in position. The arrow on the valve indicates the direction of flow through the valve. Make sure that the arrow points in the proper direction.
4. Solder the inlet and outlet connections. After the valve cools, install the coil and connect the wire connector to the main wire harness.

CAUTION: Use a heat sink or wrap the valve in wet rags to prevent damaging the valve while doing the soldering.

5. Pressure the low side and test it for leaks.
6. If no leaks are found, evacuate the low side.
7. Open the service valves, run the unit, and check the operation.



1.	Solenoid Coil
2.	Inlet Tube
3.	Outlet Tube

Figure 67: Liquid Injection Valve

Structural Maintenance

Unit and Engine Mounting Bolts

Check and tighten all unit and engine mounting bolts during scheduled maintenance inspections. Torque the unit mounting bolts to 60 ft-lb (81 N•m). Torque the engine mounting bolts to 150 ft-lb (203 N•m).

Unit Inspection

Inspect the unit during pre-trip inspection and scheduled maintenance inspections for loose or broken wires or hardware, compressor oil leaks, or other physical damage which might affect unit performance and require repair or replacement of parts.

Condenser, Evaporator, And Radiator Coils

Clean the coils during scheduled maintenance inspections. Remove any debris (e.g., leaves or plastic wrap) that reduces the air flow. Clean dirty coils with compressed air or a pressure washer. Be careful not to bend the fins when cleaning a coil. If possible, blow the air or water through the coil in the direction opposite the normal airflow. Repair bent fins and any other noticeable damage.

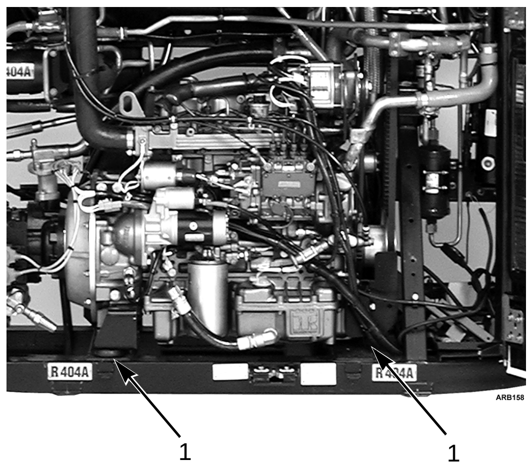
Defrost Drains

Clean the defrost drains during scheduled maintenance inspections to be sure the lines remain open.

Unit Installation

All nuts that hold the unit to the trailer are accessible using an impact wrench with a 10 in. extension, ball-type swivel and a deep-well socket.

NOTE: The nuts for mounting the unit should be elastic stop nuts (Nylock type).



1.	Check Bolts for Tightness

Figure 68: Unit and Engine Mounting Bolts

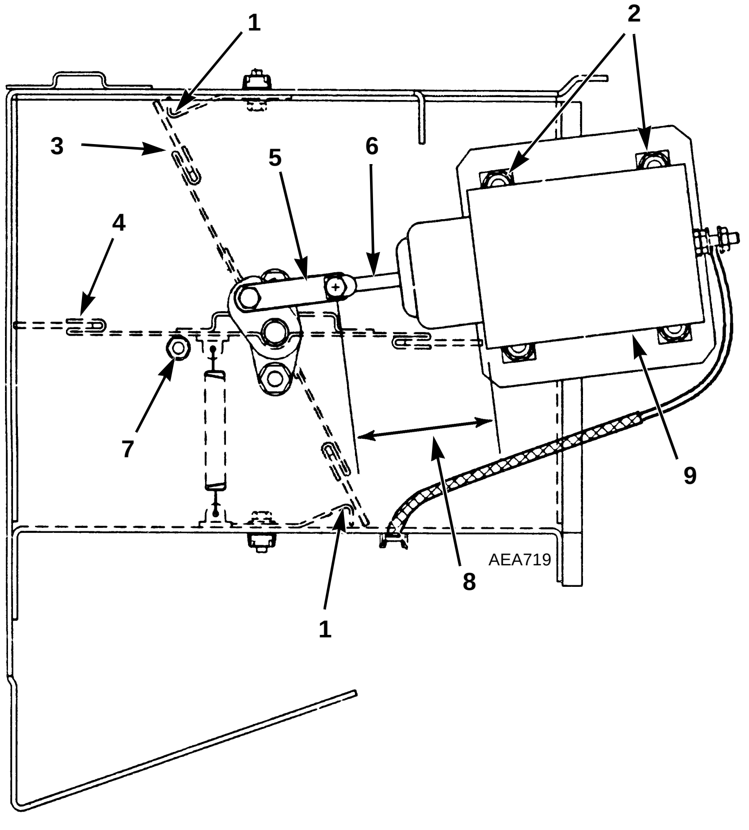
Defrost Damper

Check the damper during scheduled maintenance inspections for shaft wear, end play, and the ability to stop the air flow.

Position the damper so that air flow is stopped on the top and bottom edges with the solenoid plunger bottomed out.

To adjust the damper:

1. Remove the damper assembly from the evaporator.
2. Disconnect the damper link from the eye bolt.
3. Check Distance A, the distance from the shoulder on the solenoid to the center of the hole in the eye bolt. Distance A should be 2.75 in. (69.85 mm) with the solenoid de-energized.
4. If necessary, adjust Distance A to the proper dimension by loosening the locknut on the end of the solenoid plunger and turning the eye bolt. Tighten the locknut when Distance A is correct.
5. Connect the damper link to the eye bolt.
6. Energize the solenoid (apply 12 volts dc) and check the damper blade to make sure that both edges contact the damper housing. If necessary, adjust this by loosening the solenoid mounting bolts and moving the solenoid. Tighten the solenoid mounting bolts when both edges of the damper blade contact the damper housing.
7. Adjust the damper blade stops so they contact the edges of the damper blade. This keeps the damper from sticking closed.



1.	Stop	6.	Eye Bolt
2.	Mounting Bolts	7.	Round Stop
3.	Closed Position	8.	Distance A 2.75 in. (69.85 mm)
4.	Open Position	9.	Solenoid
5.	Damper Link		

Figure 69: Defrost Damper Adjustment

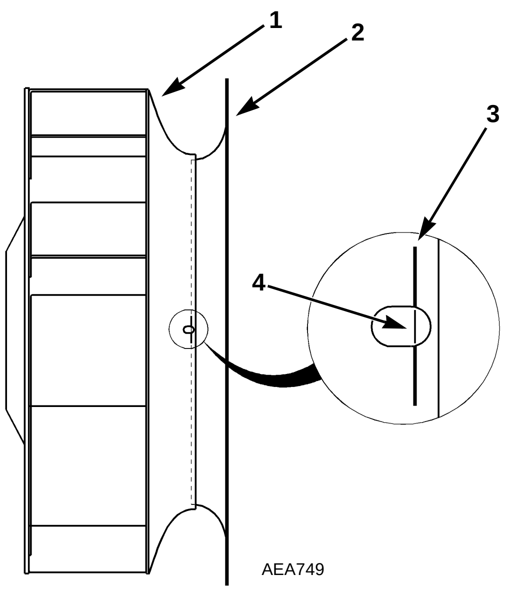
8. De-energize and energize the damper several times to make sure that the damper operates correctly and seals properly.
9. Make sure the damper blade rests on the round stops when the damper is open. Adjust the round stops if necessary.
10. Install the damper assembly in the evaporator.

Condenser and Evaporator Fan Location

When mounting the condenser or evaporator fan and hub assembly on the fanshaft, the blowers and inlet orifices must be properly aligned for proper air flow and to prevent damage to the blower.

Condenser Fan Blower

1. Loosen the condenser inlet ring (spinning) on the condenser coil bulkhead.
2. Slide the blower towards the inlet ring until it contacts the inlet ring. This centers the inlet ring in the blower orifice.
3. Tighten the inlet ring securely.
4. Slide the blower away from the inlet ring.



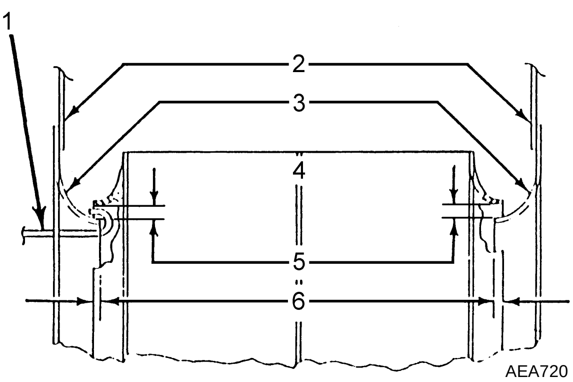
1.	Blower Wheel	3.	Alignment Mark
2.	Inlet Ring	4.	Edge of Inlet Ring

Figure 70: Condenser Blower Alignment

5. Pass a gauge wire completely around the blower orifice to check for uniform clearance.
6. Spin the blower by hand to check for blower distortion.
7. Position the blower so the edge of the inlet ring lines up with the alignment mark on the blower.
8. Torque blower hub bolts to 18 ft-lb (24 N•m).

Evaporator Fan Blower

1. Loosen the inlet rings on the sides of the blower housing.
2. Center the blower wheel in the blower housing with equal overlap on both inlet rings. The overlap on each ring should be approximately 0.15 in. (3.8 mm).
3. Tighten the hub bolts that hold the blower wheel on the fanshaft.
4. Center the inlet rings in the blower orifices. Tighten the inlet rings securely.
5. Check the radial clearance by passing a wire completely around the circumference of the inlet rings and the blower wheel.
6. Torque the blower hub bolts to 18 ft-lb (24 N•m).



1.	Check Clearance with a Wire
2.	Blower Housing Sides
3.	Inlet Rings
4.	Evaporator Blower
5.	Radial Clearance
6.	Equalize Blower Inlet Overlap

Figure 71: Evaporator Fan Location

Fan Shaft Assembly

The unit is equipped with a one-piece fan shaft assembly that contains tapered roller bearings in a sealed oil reservoir.

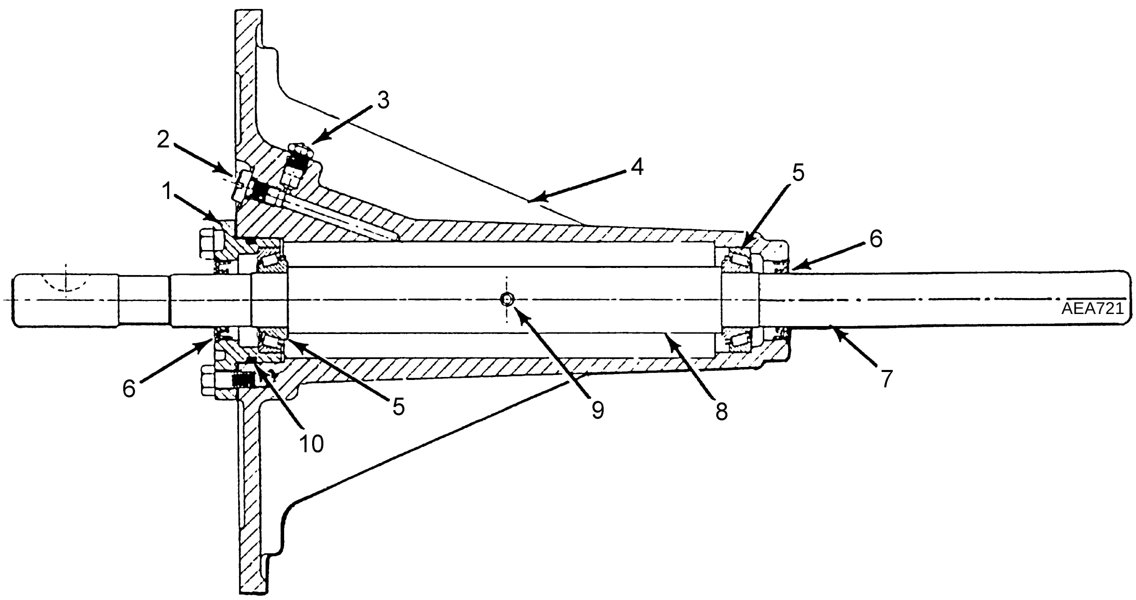
This assembly does not require any maintenance. There is a level plug and a fill plug, but they are not normally used except after removal and repair of the fan shaft assembly. The condenser and evaporator end oil seals should be checked during the pre-trip inspection for oil leakage. If there is any sign of leakage, the fan shaft assembly should be removed and repaired.

NOTE: The fan shaft assembly requires a special lubricant, Thermo King P/N 203-278.

Fan Shaft Assembly Overhaul

Disassembly

1. Remove the fan shaft assembly from the unit. Remove both oil plugs and drain the oil from the housing.
2. After draining the oil from the housing, remove the four retaining bolts from the condenser end of the assembly.
3. To remove the shaft from the assembly, tap the opposite end of the shaft with a soft hammer. After the shaft has been removed, clean all parts in clean solvent.
4. Using a punch, remove the oil seal from the evaporator end of the assembly. With the seal removed, clean the housing in clean solvent.
5. Check the condition of the vent. If it is loose or damaged, it must be repaired or replaced.
6. After all the parts are cleaned, inspect the bearings and bearing races for wear or damage.
7. If necessary, remove the bearings by tapping them off the shaft with a hammer and a punch. Be careful not to damage the shaft with the punch.
8. The bearing races can now be driven out with a punch and replaced in the same manner.



1.	Cap and Shims	6.	Oil Seal
2.	Oil Plug Screw (Use Oil P/N 203-278)	7.	Shaft
3.	Breather Vent	8.	Sleeve
4.	Housing	9.	Pin
5.	Roller Bearing	10.	O-ring

Figure 72: Fan Shaft Assembly

Reassembly

1. Tap the new bearings on the shaft with a pipe.
2. Install new oil seals after replacing the bearing races.
3. Replace the shaft in the housing. Install a new seal in the retainer cap. Use the original shims and replace the O-ring if needed.
4. Install the retainer cap assembly over the shaft, then install the bolts.
5. Torque the bolts in a criss-cross pattern in equal steps to 80 in-lb (9.04 N•m).
6. Lock the assembly in a vise and set up a dial indicator to read end-play. To measure the end-play, rotate the shaft while pushing in one direction and set the dial indicator to ‘0’. Now rotate the shaft and pull in the opposite direction while reading the dial indicator. End-play should be 0.001 to 0.005 in. (0.025 to 0.127 mm). If end-play is incorrect, use different shims to obtain correct end-play.

Shims available from the Service Parts Department	
0.020 in. (0.500 mm)	Thermo King P/N 99-4231
0.007 in. (0.177 mm)	Thermo King P/N 99-2902
0.005 in. (0.127 mm)	Thermo King P/N 99-2901

7. After correct end-play is obtained, add oil for the bearings.
8. Lock the assembly in a vise with the vent facing up. Pour the oil (P/N 203-278) through the top plug until it runs out of the side hole. The assembly holds 2.2 oz (65 ml). Check the condition of the O-ring used on the plugs and replace if necessary. Install the top and side plugs. Clean up any spillage.
9. Place the assembly on the workbench with the vent up. Rotate the shaft by hand. The shaft should be free enough to rotate without having to hold the housing.

CAUTION: When installing the fan shaft assembly, make sure that the vent is mounted facing up.

Idler Assembly

The unit is equipped with a one-piece idler assembly that contains tapered roller bearings in a sealed oil reservoir. This assembly does not require any maintenance. There is a level plug and a fill plug, but they are not normally used except after removal and repair of the idler assembly. The roadside end oil seal and the curbside end oil seal should be checked during the pre-trip inspection for oil leakage. If there is any sign of leakage, the idler assembly should be removed and repaired.

Idler Assembly Overhaul

Disassembly

1. Remove the idler assembly from the unit. Remove both oil plugs and drain the oil from the housing.
2. After draining the oil from the housing, remove the four retaining bolts from the curbside end of the assembly.
3. To remove the shaft from the assembly, tap the opposite end of the shaft with a soft hammer. After the shaft has been removed, clean all the parts in clean solvent.
4. Using a punch, remove the oil seal from the curbside end of the assembly. With the seal removed, clean the housing in solvent.
5. Check the condition of the vent. If it is loose or damaged, it must be repaired or replaced.
6. After all the parts are cleaned, inspect the bearings and bearing races for wear or damage.
7. To replace the bearings, first drive bearing off shaft with a punch at notch in the base of the shaft.

Reassembly

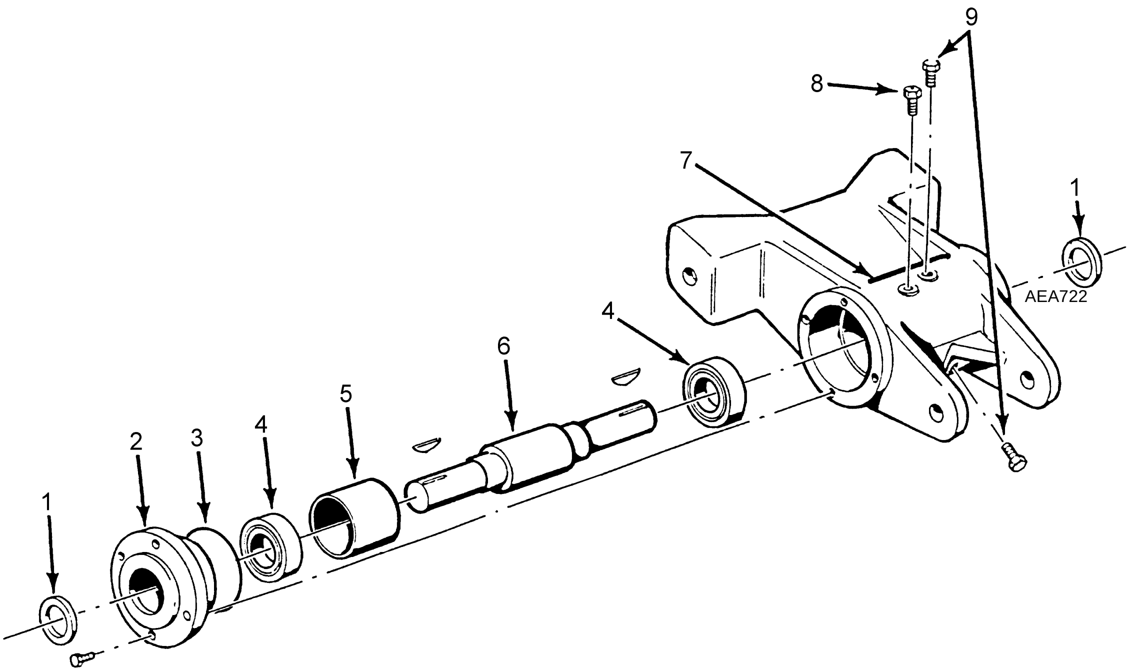
1. Install the new bearings on the shaft with a pipe. Place the pipe over the shaft and drive bearing down. Turn the shaft upside down, and use the pipe to drive the other bearing down.
2. Install a new oil seal on the curbside end of the assembly after replacing the bearing race and splash guard.

3. Replace the shaft in the housing. Install a new seal in the retainer cap. Use the original shims and replace the O-ring if needed.
4. Install the retainer cap assembly over the shaft, then install the bolts.
5. Torque the bolts in a criss-cross pattern in equal steps to 80 in-lb (9.04 N•m).
6. Lock the assembly in a vise and set up a dial indicator to read end-play. To measure the end-play, rotate the shaft while pushing in one direction, and set the dial indicator to ‘0’. Now rotate the shaft and pull in the opposite direction while reading the dial indicator. End-play should be 0.001 to 0.005 in. (0.025 to 0.127 mm). If end-play is incorrect, use different shims to obtain correct end-play.

Shims available from the Service Parts Department	
0.020 in. (0.500 mm)	Thermo King P/N 99-4231
0.007 in. (0.177 mm)	Thermo King P/N 99-2902
0.005 in. (0.127 mm)	Thermo King P/N 99-2901

7. After the correct end-play is obtained, add approximately 1.5 oz (44 ml) of oil for the bearings.
8. Lock the assembly in a vise with the vent facing up. Pour the oil through the top plug until it runs out of the side hole. Check the condition of the O-ring used on the plugs and replace if necessary. Install the top and side plugs. Clean up any spillage.
9. Place the assembly on the workbench with the vent up. Rotate the shaft by hand. The shaft should be free enough to rotate without having to hold the housing.

CAUTION: Reinstall the assembly into the unit, making sure the vent is mounted facing up.



1.	Oil Seal	6.	Shaft
2.	Cap and Shims	7.	Housing
3.	O-ring	8.	Breather Vent
4.	Roller Bearing	9.	Oil Plug Screw (Use Oil P/N 203-278)
5.	Splash Guard Tube		

Figure 73: Idler Assembly

Mechanical Diagnosis

Condition	Possible Cause	Remedy
Engine will not crank	Electrical problem	Check and repair electrical system
	Defective starter solenoid	Replace solenoid
	Defective starter	Repair starter
	Water in cylinders	Check for hydrostatic lock. Remove injectors and turn engine slowly
Starter motor turns but engine does not crank	Starter clutch defective	Replace
Engine cranks but fails to start	Fuel solenoid not energized	Check 8D and 8DP circuits and fuel solenoid pull-in relay. Check that YAN = YES in Super Guarded Access. Refer to appropriate Microprocessor Diagnostic Manual.
	Fuel solenoid defective or stuck	Replace
	Fuel injection pump defective	Replace pump
	Air heater defective	Replace
	No fuel or wrong fuel	Fill with proper fuel
	Fuel pump defective	Replace pump
	Air in fuel system	Bleed air
	Compression low	Overhaul engine
	Injection nozzles defective	Replace nozzles
	Incorrect timing	Adjust timing
	Air cleaner clogged	Replace air filter
	Exhaust plugged	Clean exhaust
	Defective HPCO	Replace HPCO
Engine stops after starting	Air in injection pump	Bleed fuel system
	Fuel filter obstructed	Replace filter element
	High head pressure	Eliminate cause of high head pressure
	Vent of fuel tank obstructed	Unclog vent
	Clogged fuel tank or fuel lines	Clean fuel tank and fuel lines

Condition	Possible Cause	Remedy
Engine does not develop full power	Air intake system clogged	Clean air intake system
	Fuel tank vent clogged	Unclog vent
	Clogged fuel tank or fuel lines	Clean fuel tank and fuel lines
	Speed adjustment wrong	Adjust speed
	Insufficient fuel volume leaving filter	Check for dirty filter or air in system
	Air cleaner clogged	Replace air filter
	Delivery of fuel pump insufficient	Repair pump
	Injection pump timing off	Adjusting timing
	Nozzles defective	Repair or replace nozzles
	Compression low or unbalanced	Overhaul engine
	Worn injection pump plungers, delivery valve defective, injection rate too low, gum formations	Repair or replace pump
Engine speed too high	Misadjusted high speed solenoid	Adjust high speed solenoid
	Defective injection pump	Repair injection pump
Engine fails to stop when unit is OFF	Fuel solenoid defective	Replace
	Injection pump defective	Replace pump
Engine knocks heavily	Air in system	Bleed fuel system
	Injection pump not timed	Retime injection pump
	Wrong fuel	Change fuel
	Compression too low	Overhaul engine
	Injection nozzles fouled or opening pressure too low	Clean, repair or replace injection nozzles
	Delivery valve spring broken	Replace spring or repair injection pump
	Valve out of adjustment	Adjust valves
	Fuel return line plugged	Remove return line restriction
	Rod or main bearing worn	Replace rod or main bearings

Condition	Possible Cause	Remedy
Engine runs hot	Dirty radiator	Wash radiator
	Coolant level is low	Add coolant
	Cooling system heavily scaled	Cleaning cooling system
	Cylinder head gasket leaks	Replace cylinder head gasket. Use correct gasket
	Faulty thermostat	Check or replace thermostat
	Loose or worn water pump belt	Replace belt
Oil pressure low	Insufficient oil in pan	Add oil
	Faulty oil pressure switch	Check oil pressure switch. Replace if necessary
	Oil control valve defective	Check oil pressure control valve
	Worn oil pump, camshaft, main or connecting rod bearings, loose oil gallery plug	Repair engine
High oil consumption	Oil leakage	Check and eliminate possible causes at rocker arm cover, oil lines, oil filter, front timing cover or crankshaft seals
	Damaged valve seals	Replace seals on valve stem
	Worn valve stem	Replace valves
	Broken piston rings or cylinder bore worn or scored	Have engine repaired and rebored. Replace broken piston rings
	Clogged air cleaner system	Unclog air cleaner

Engine Emits Excessive Smoke

WHITE SMOKE

Fuel is not burning

- Air or water in fuel
- Incorrect timing
- Poor compression
- Faulty injectors

BLACK SMOKE

Excessive Fuel to Air Ratio

- Type of fuel used
- Cold engine
- Excessive load
- Clogged air intake system
- Faulty nozzles
- Poor compression
- Restricted exhaust
- Faulty injection pump

BLUE SMOKE

Oil Consumption

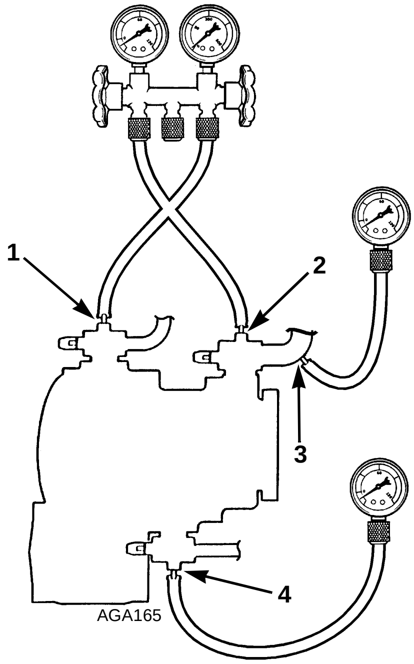
- Poor compression
- Defective valve seals

Refrigeration System Diagnosis

Perform the Diagnosis Procedure and refer to the charts (see “Refrigeration Diagnosis Charts” on page 129) to help diagnose the refrigeration system. Use the THERMOGUARD µP-VI Microprocessor for Screw Compressor Applications Diagnostic Manual TK 51329 to diagnose the Alarm Codes that appear. Record (write down) the following items that appear while performing the procedure:

- All Alarm Codes
- All symptoms and their possible causes as listed in the procedure

After completing the procedure, use the “Refrigeration Diagnosis Charts” on page 129 to find and record the possible causes for the symptoms. Compare these to the possible causes for the Alarm Codes and the possible causes recorded while performing the procedure. Use this information to identify the most likely possible causes, then test and/or repair them.



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 74: Gauge Installation

Diagnosis Procedure

1. Check the unit's history if it is available.
2. Check and record all Alarm Codes that are currently displayed.
3. Install a gauge manifold on the compressor and install two additional low side gauges. Use these gauges to monitor the system pressures.
    a. Attach the low side gauge to the service port on the main suction service valve.
    b. Attach the high side gauge to the service port on the discharge service valve.
    c. Attach one additional low side gauge to the service port on the economizer suction service valve.
    d. Attach the other additional low side gauge to the suction access port, which is located on the suction tube near the main suction service valve.
4. Run a Pretrip Test and record any Alarm Codes that are generated during the Pretrip Test.
5. Download the DAS. Check the log for alarm codes and other irregularities such as extreme temperatures, low temperature differentials, and high compressor temperatures.
6. Check the refrigerant charge. Leak check the unit if the refrigerant charge is low. Adjust the refrigerant level if necessary.
7. Check the compressor oil level. Adjust the oil level if necessary.
8. Use the Service Test Mode [HS.C] to run the unit in high speed cool.
    a. Cover the condenser to maintain discharge pressure of approximately 350 psi (2413 kPa).

b. Let the unit run until the box temperature is at approximately 0 F (-18 C). If the box temperature will not come down to 0 F (-18 C), continue the procedure with the box temperature as low as possible.

c. Observe the system pressures, the CTMP, and the sensor temperatures. Compare the readings to those in the following table.

Main suction pressure	10-20 psi (69-138 kPa)
Economizer suction pressure	30-50 psi (207-345 kPa)
Discharge pressure	330-390 psi (2275-2689 kPa)
CTMP	240 F (116 C) maximum

d. Check the condition of the suction line. It is normally cool and moist when the unit is in high speed cool.

9. The following are some of the more common symptoms that may appear while the unit is in Service Test Mode [HS.C] high speed cool.

a. Low main suction pressure and a frosted suction line suggest poor air flow through evaporator coil. This may be caused by the following: iced evaporator coil, restricted evaporator air flow (dirt, damper closed, plugged air inlet), fan or belt failure.

b. Low main suction pressure and a dry suction line suggest insufficient refrigerant flow through evaporator coil. This may be caused by the following: low refrigerant charge, faulty or restricted main expansion valve, main expansion valve adjustment too far closed, restricted drier, restricted line on high side, restricted line on low side, closed liquid line solenoid, stuck ETV.

c. High main suction pressure and a frosted suction line suggest liquid is flooding the low side. This may be caused by the following: faulty main expansion valve, main expansion valve adjustment too far open, poor contact between main expansion valve feeler bulb and suction line, leaking heat check valve.

d. High main suction pressure and a dry suction line suggest internal vapor leaks or low compressor capacity: This may be caused by the following: leaking three-way valve, leaking or open LV1, low compressor oil, faulty compressor.

e. Low discharge pressure may be caused by the following: low refrigerant charge, restriction on the low side, closed liquid line solenoid, low ambient temperature, faulty three-way valve, low compressor oil, faulty compressor.

f. High discharge pressure may be caused by the following: restricted condenser air flow (dirty coil), fan or belt failure, overcharge of refrigerant, air in refrigeration system, restriction on the high side, high ambient temperature, faulty three-way valve.

g. High CTMP may be caused by the following: high discharge pressure and/or its causes, low refrigerant charge, low compressor oil, faulty compressor, water valve stuck open, faulty or restricted LV1 or LV2.

h. Low economizer suction pressure may be caused by the following: low refrigerant charge, faulty or restricted economizer expansion valve, economizer expansion valve adjustment too far closed, restricted drier, restricted line on high side, leaking or open LV1.

i. High economizer suction pressure may be caused by the following: faulty economizer expansion valve, economizer expansion valve adjustment too far open, poor contact between economizer expansion valve feeler bulb and suction line, low compressor oil, faulty compressor.

10. Use the Service Test Mode [DE.F] to shift the unit to defrost.

a. Check to see if the three-way valve shifts to the heat position. If not, the three-way valve, the pilot solenoid, or the pilot solenoid circuits may be faulty.

b. Check to see if the liquid line solenoid closes. If not, liquid line solenoid or its circuits may be faulty.

c. Check to see if the water valve opens. If not, the water valve or its circuits may be faulty.

d. Check to see if the damper closes. If not, the damper solenoid or its circuits may be faulty.

11. Use the Service Test Mode [HS.C] to shift the unit back to high speed cool.

    a. Check to see if the three-way valve shifts to the cool position. If not, the three-way valve, the pilot solenoid, or the pilot solenoid circuits may be faulty.

    b. Check to see if the liquid line solenoid opens. If not, liquid line solenoid or its circuits may be faulty.

    c. Check to see if the water valve closes. If not, the water valve or its circuits may be faulty.

    d. Check to see if the damper opens. If not, the damper solenoid or its circuits may be faulty.

    e. Check the suction pressure.

12. With the unit running in high speed cool, close the receiver tank outlet valve to pump down the low side. The low side should pump down to a 25 in. Hg vacuum (-85 kPa).

13. With the unit still running in high speed cool, close the economizer suction service valve and the main suction service valve to pump down the compressor. The compressor should pump down to a 25 in. Hg vacuum (-85 kPa) within 30 seconds.

14. Shut the unit off and check the pressures. The pressures in the compressor should equalize. The pressure at the suction access port should remain near the vacuum level obtained in step 12.

    a. If the low side does not pump down but the compressor does pump down, at least one of the following components may be leaking or defective: three-way valve, pilot solenoid, heat check valve, receiver tank outlet valve, or an external leak to the atmosphere.

    b. If the compressor does not pump down within approximately 30 seconds, the compressor may be low on oil or defective.

    c. If the low side and the compressor both pump down but the pressure at the suction access port rises after the suction service valves are closed, at least one of the following components may have a small leak: three-way valve, pilot solenoid, heat check valve, receiver tank outlet valve, a suction service valve, or an external leak to the atmosphere.

Refrigeration Diagnosis Charts

The charts on the following pages show possible causes for various symptoms. The charts should be used along with the Diagnosis Procedure and the Alarm Codes to diagnose problems in the refrigeration system. Note the following items concerning the charts:

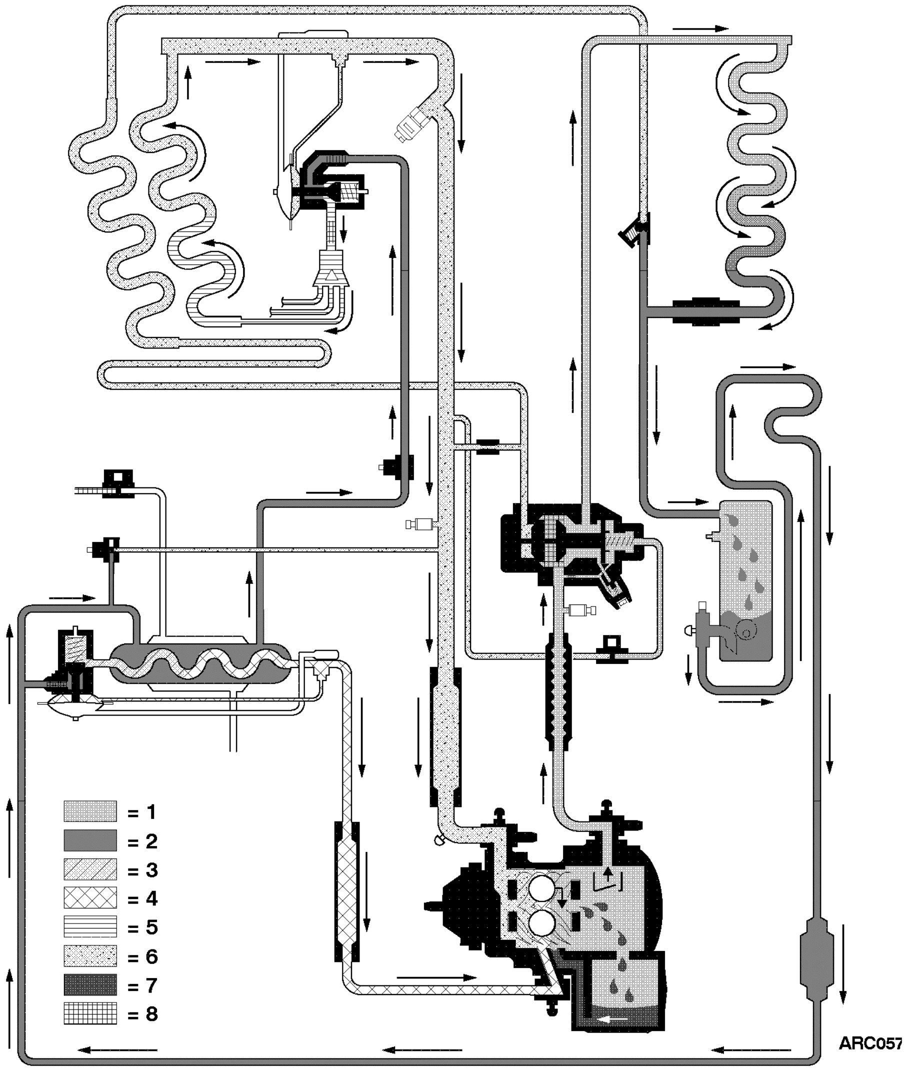
- The TPDF can be used as a quick check of the cooling capacity. The minimum TPDF is -10 F (-6 C) while the unit is running in Service Test Mode [HS.C] high speed cool with a box temperature of 35 F (2 C) and an ambient temperature of 90 F (32 C).

  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).

- The TPDF can be used as a quick check of the heating capacity. A TPDF of 10-12 F (6-7 C) is normal in Service Test Mode [HS.H] high speed heat, except with low ambient temperatures or high box temperatures. The minimum acceptable TPDF is 4 F (2 C).

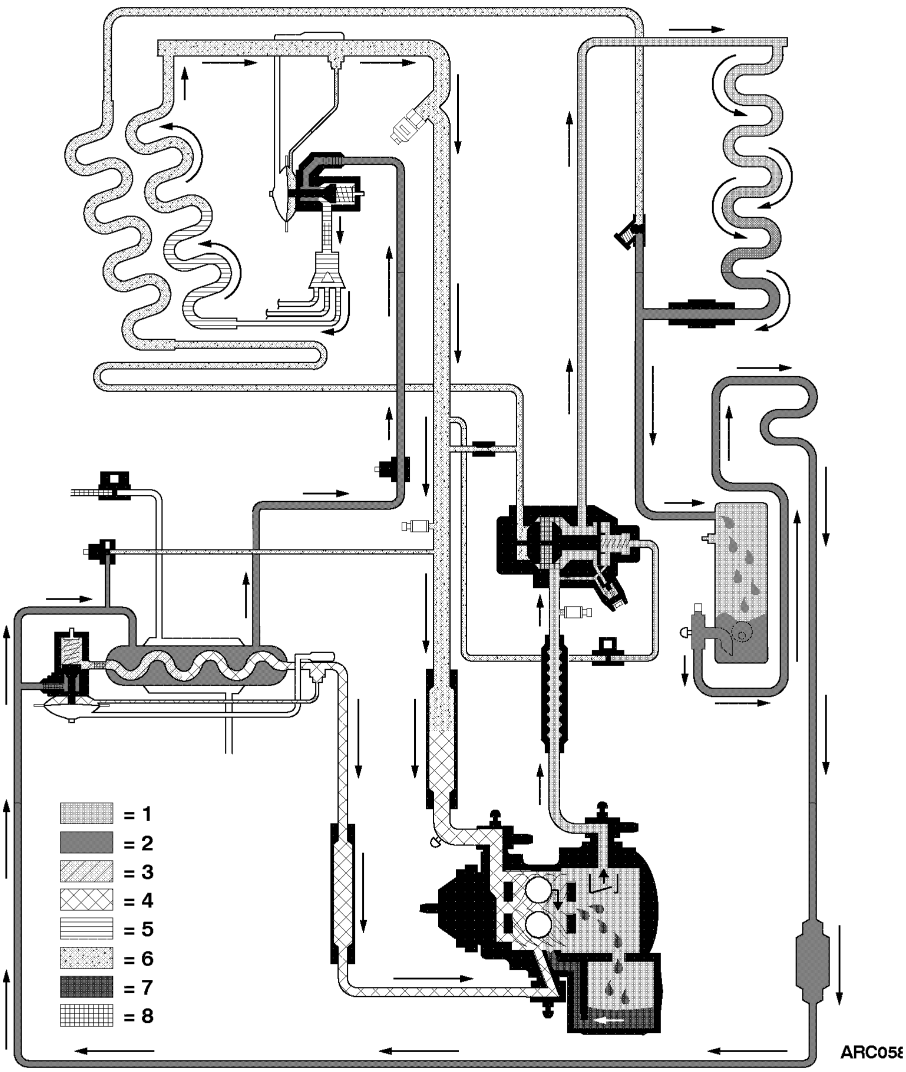
Rapid cycling between cool and heat	Unit cools in heat and defrost cycle	Unit heats in refrigeration cycle	High head pressure	Low head pressure	High main suction pressure	Low main suction pressure	High economizer suction pressure	Low economizer suction pressure	Unit operating in a vacuum	Receiver sight glass empty	Unable to pump down system	Unable to pull vacuum in low side	Noisy compressor	Low cooling capacity	Low Heating/Defrost Capacity	High CTMP	**Symptom** / **Possible Causes**
			•		•								•	•		•	Overcharge of refrigerant
				•		•		•	•	•			•	•	•	•	Shortage of refrigerant
			•											•		•	Air through condenser too hot (ambient)
			•											•		•	Air flow through condenser restricted
				•		•		•	•	•				•			Air through condenser too cold (ambient)
			•										•	•		•	Air in refrigerant system
			•													•	Condenser fan blades bent or broken
•														•			Air short cycling around evaporator coil
						•			•					•			Air through evaporator restricted
						•			•				•	•			Evaporator needs defrosting
														•			Too much compressor oil in system
				•	•		•				•	•	•	•	•	•	Too little compressor oil in system
				•	•		•				•	•	•	•	•	•	Faulty compressor
													•				Faulty compressor drive coupling
				•		•			•					•			Expansion valve power element lost its charge
			•		•		•							•			Expansion valve feeler bulb improperly mounted
			•		•		•							•			Expansion valve feeler bulb making poor contact
			•		•		•							•			Expansion valve open too much
			•			•								•			Expansion valve closed too much
			•		•		•										Expansion valve needle eroded or leaking
						•	•		•					•			Expansion valve partially closed by ice, dirt or wax
•																	Loading valve #1 stuck closed
•																	Loading valve #2 stuck closed
					•	•			•					•		•	Faulty main expansion valve
						•			•					•			Restricted line on the low side
						•		•	•					•		•	Restricted line on the high side
						•		•	•					•			Restricted drier
•															•		Defrost damper stays open
						•			•					•			Defrost damper stuck closed
	•	•	•	•	•						•			•	•	•	Faulty three-way valve
	•	•									•			•	•		Faulty pilot solenoid
	•													•	•	•	Loose or broken electrical connections
•					•	•			•					•		•	Sensor out of calibration

Rapid cycling between cool and heat	Unit cools in heat and defrost cycle	Unit heats in refrigeration cycle	High head pressure	Low head pressure	High main suction pressure	Low main suction pressure	High economizer suction pressure	Low economizer suction pressure	Unit operating in a vacuum	Receiver sight glass empty	Unable to pump down system	Unable to pull vacuum in low side	Noisy compressor	Low cooling capacity	Low Heating/Defrost Capacity	High CTMP	**Symptom** / **Possible Causes**
												•					Leaky receiver tank outlet valve
															•		Leaky condenser check valve
					•						•			•			Leaky heat check valve
					•			•						•			Leaky loading valve #1
															•		Leaky liquid line solenoid
	•														•		Liquid line solenoid not closing
					•			•						•			Open loading valve #1
												•					Leaky suction service valve
												•					Leaky economizer suction service valve
			•				•	•						•	•	•	Faulty economizer expansion valve
				•		•							•	•			Closed liquid line solenoid
			•											•		•	Open water solenoid
				•		•		•							•		Closed water solenoid
						•		•						•			Restricted vent line (orifice) between heat circuit and suction line (appears to be shortage of refrigerant)
					•		•							•			Leaky loading valve #2
					•		•							•			Open loading valve #2



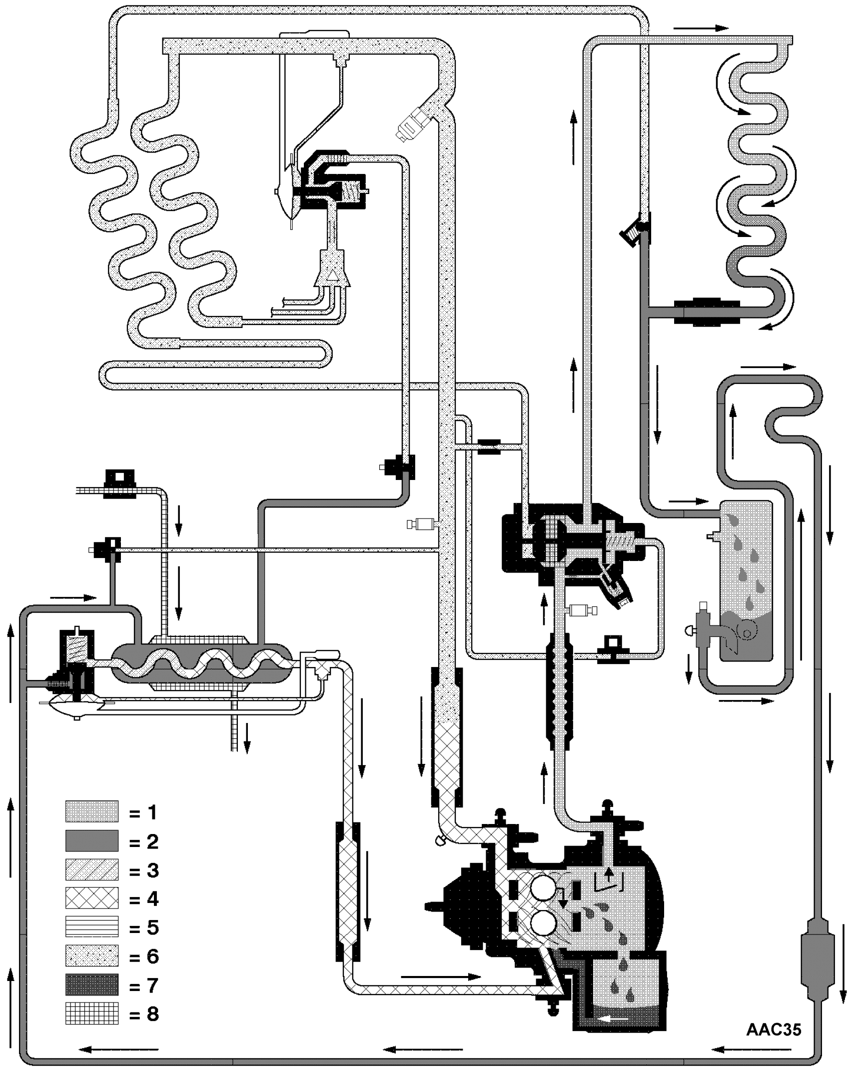
1.	High Pressure Gas	5.	Low Pressure Liquid
2.	High Pressure Liquid	6.	Low Pressure Gas
3.	Medium Pressure Liquid	7.	High Pressure Compressor Oil
4.	Medium Pressure Gas	8.	Engine Coolant

Figure 75: High and Low Speed Cool



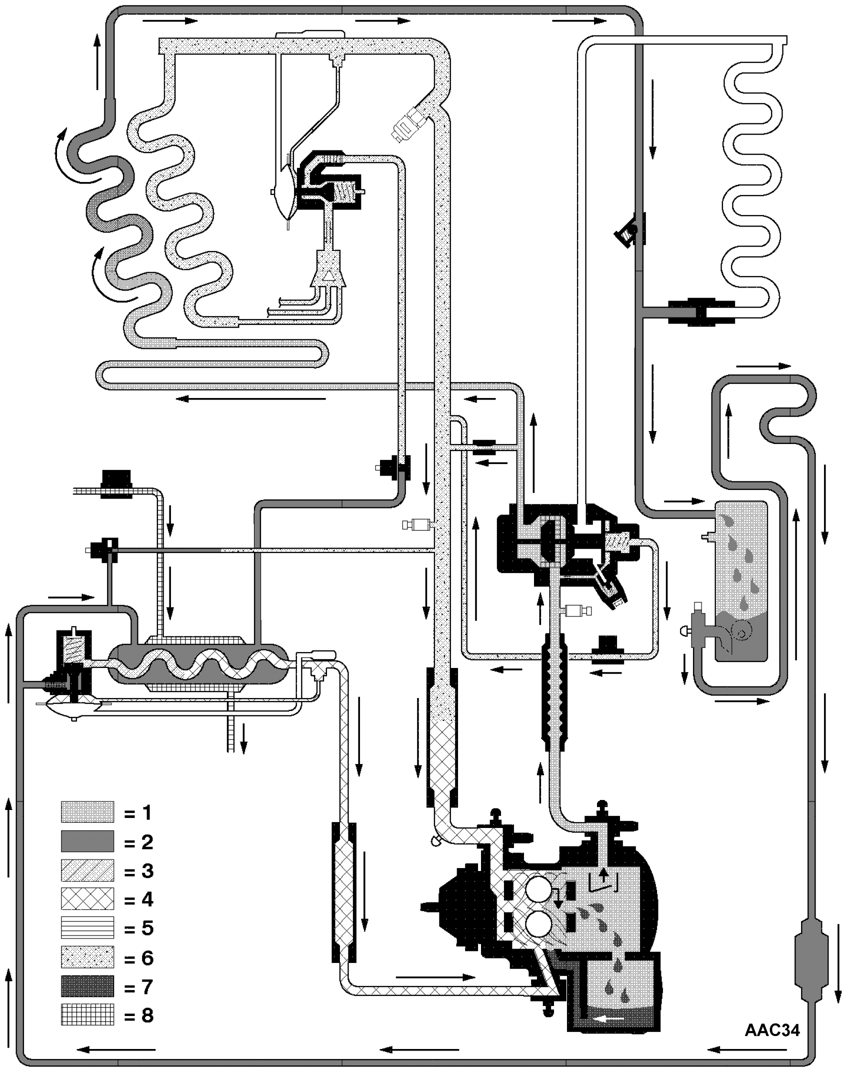
1.	High Pressure Gas	5.	Low Pressure Liquid
2.	High Pressure Liquid	6.	Low Pressure Gas
3.	Medium Pressure Liquid	7.	High Pressure Compressor Oil
4.	Medium Pressure Gas	8.	Engine Coolant

Figure 76: Modulated Cool with LV1 Open



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 77: Running Null



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 78: Defrost and Heat

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Wiring Diagram Index