ENGINEERING TOMORROW

Danfoss

Service Manual

Danfoss Turbocor® **Twin-Turbine** Centrifugal Compressors

TT & TG Series Compressors

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TURBOCOR®

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Revision	Date	Page	Description of Change
C	January, 2017	All	Major revision "F" compressor changes throughout the manual.
D	August, 2017	54-57	Added IGBT Control Card Replacement instructions.
E	October, 2017	15 97 123-124	Added R513A refrigerant Updated Figure 95 (SMT Tool Suite Lancher Strip) Removed Appendix B Soft Start Board

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List of Figures

Proprietary Notice

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This section provides a brief introduction to the *Service Manual* including the Purpose, Organization, Document Conventions used, Safety Information, and the DTC Quality Policy.

1.1 Purpose

This *Service Manual* is intended to provide service procedures specific to the Danfoss Turbocor TT and TG Series compressors. It is not intended to teach basic fundamental safety, refrigeration, electrical or fitting skills. It is assumed persons using this manual will be appropriately certified and have detailed knowledge, experience, and skills in respect to working with high-pressure refrigerants and medium voltage electrical components to 1 Kilovolt (KV) high-power alternating current (AC) and direct current (DC).

Some potential safety situations may not be foreseen or covered in the manual. Danfoss Turbocor Compressors, Inc. (DTC) expects personnel using this manual and working on Danfoss Turbocor compressors to be familiar with, and carry out, all safe work practices necessary to ensure safety for personnel and equipment.

The purpose of this manual is to provide:

- A general description of the compressor design.
- A functional description of the various components of the compressor
- Information regarding procedures necessary to detect the source of a problem within the compressor
- The procedures for disassembling and assembling of various components of the compressor
- Fault and calibration interpretations
- System troubleshooting suggestions
- Maintenance tasks that should be followed

This manual gives only general procedures for servicing and does not provide part numbers of single products or single components. If this information is required, please contact a recognized Danfoss Turbocor OEM customer.

1.2 Organization

This manual is organized in the following manner:

- **Section 1: Introduction** - this section describes the purpose of the manual, its organization, conventions used in the manual, and a safety summary which describes the use of Danger, Caution, and Notes symbols
- **Section 2: Compressor Fundamentals** - this section identifies the parts of the compressor and provides fundamental knowledge of the role each component plays in the main fluid path, motor-cooling system, and in the energy and signal flow
- **Section 3: Compressor Components** - this section describes in depth component information, the steps necessary to obtain measurements that verify a component is functional and the steps necessary to replace a compressor component
- **Section 4: Troubleshooting** - this section describes troubleshooting using signals from the compressor to determine the specific source of faults at the system and compressor level
- **Section 5: Maintenance** - this section contains a table containing a list of tasks that should be performed on a regular basis to maintain optimal performance of the system
- **Appendix A: Acronyms/Terms** - this section provides definitions of terms and acronyms used in this manual
- **Appendix B: Compressor Troubleshooting Flowcharts** - this section contains flowcharts to assist you with compressor troubleshooting
- **Appendix C: Compressor Test Sheet** - this section contains a sheet with test points, expected values, and the section in the manual associated with a particular test

•**Index** - this section provides an index to assist in searching for information described in this manual

The following conventions are used in this manual:

•**Procedures** - all user procedures are listed in numerical steps, unless it is a one-step procedure. A one-step procedure is shown as a bullet.

•**User Action Required (software)** - if a user is required to take action in a software procedure, the action will be shown in bold. Example; When the Login window opens, **type in your name and password**.

•**Monitoring Program Window Names** - all window names will be in italic. Example *Compressor Controller window*.

•**External References** - references to items not within this manual are underlined. Example; Refer to the Installation and Operation Manual for installation procedures.

1.3 Commitment to Quality

DTC is committed to quality service and customer satisfaction as outlined by our Quality Policy:

Danfoss Turbocor is dedicated to satisfying our customers by providing "Best in Class" in terms of quality, value, and on-time delivery while striving for continuous improvement.

1.4 Safety Summary

Safety precautions must be observed during installation, start-up, and service of the compressor due to the presence of pressure and voltage hazards. Only qualified and trained personnel should install, start up, and service Danfoss Turbocor compressors. Safety information is located throughout the manual to alert service personnel of potential hazards and is identified by the headings **DANGER** and **CAUTION**.

1.4.1 Danger Notification

A **DANGER** notification signifies an essential operation or maintenance procedure, practice, or condition which, if not strictly observed, could result in injury to or death of *personnel* or long-term health hazards. A Danger notification is displayed in the format shown in Figure 1.

Figure 1 - Danger Notification Example

• • • DANGER • • •

1.4.2 Caution Notification

A **CAUTION** notification signifies an essential operation or maintenance procedure, practice, or condition which, if not strictly observed, could result in damage to or destruction of *equipment* or potential problems in the outcome of the procedure being performed. A Caution notification is displayed in the format shown in Figure 2.

Figure 2 - Caution Notification Example

⚠ • • • CAUTION • • •

1.4.3 Note

A **NOTE** provides additional information such as a tip, comment, or other useful, but not imperative information. A **NOTE** is displayed in the format shown in Figure 3 (Note Example).

Figure 3 - Note Example

NOTE

1.5 Precautions

Consideration for personal safety and equipment safety is very important. The following sections cover safety precautions and methods that must be followed when servicing the compressor.

1.6 Refrigerant Type

1.6.1 R134a/R513A

TT series compressors are totally oil-free and optimized for use with refrigerants R134a and R513A.

1.6.2 R1234ze

TG series compressors are totally oil-free and optimized for use with refrigerant R1234ze only.

ASHRAE standard 34 has classified this refrigerant as "R1234ze(E) with safety classification of A2L." ASHRAE Standard 34, 2010 Addendum 1 contains the change to the standard.

ASHRAE Standard 15 (Safety Standard) has sent out an initial public review document outlining proposed changes to this standard to address 2L refrigerant.

Table 1 - Refrigerant Used with Danfoss Turbocor Compressors

Compressor	Refrigerant
TT Series	R134a/R513A
TG Series	R1234ze

NOTE

Do not use recycled refrigerant as it may contain oil, which can affect system reliability. The refrigerant should be pure and stored in virgin containers.

1.7 Electrical Isolation of the Compressor

Before performing any service on the compressor, electrical power must be isolated.

Before removing top side covers, isolate the compressor power by completing the following steps:

• • • DANGER • • •

This equipment contains hazardous voltages that can cause serious injury or death. Only qualified and trained personnel should work on DTC compressors.

• • • DANGER • • •

Always wear appropriately rated safety equipment when working around equipment and/or components energized with high voltage.

• • • DANGER • • •

Removing the Mains Input Cover will expose you to a high voltage hazard of up to 632VAC. Ensure the Mains Input power is turned off and locked out before removing it.

1. Turn off the Mains Input power to the compressor.

2. Lock Out/Tag Out (LOTO) the mains disconnect to ensure no accidental or unauthorized re-application of the Mains Input power can occur.

NOTE

The Mains Input fast-acting fuses are installed in the power panel for all compressor models except the TT300/TG230.

3. Remove the Mains Cover only.

4. Using an appropriately rated voltage meter, confirm that the AC voltage is isolated.

• • • DANGER • • •

Do not touch any components when removing the Mains Input Cover. This is particularly true for compressors with CE covers because they are coated on the inside for the express purpose of being conductive.

5. Wait at least 20 minutes for the DC bus capacitors to discharge.

6. Remove the top cover, taking particular care not to touch ANY components underneath.

• • • DANGER • • •

Removing the top cover will expose you to a high voltage hazard of up to 860VDC. Wait at least 20 minutes to allow the DC capacitors to discharge and ensure there is no Mains Input voltage present before removing the cover.

7. Using an appropriately rated voltage meter, check the DC bus bars for DC voltage level. If the voltage is above 5VDC, wait five minutes and recheck until voltage is below 5VDC.

1.8 Handling Electronic Static Devices

Active electronic components are susceptible to damage when exposed to static electrical charges. Damage to such components may lead to outright failure or reduction in service life. Since the presence of static charges is not always evident, it is essential that service personnel follow static control procedures at all times when handling sensitive electronic components.

This section outlines static control precautions that must be followed when providing service support in the field. Service support personnel should create a safe, static-free environment.

Service personnel must use a commercially available service kit for handling static-sensitive devices. The kit typically includes:

•Ground cord assembly

•Alligator clip

•Grounding wrist strap

•Wrist strap tester

If a safe, static control environment cannot be created for a specific reason, the operator will ensure that electrostatic discharge (ESD) items and personnel are at the same electrical potential as the equipment.

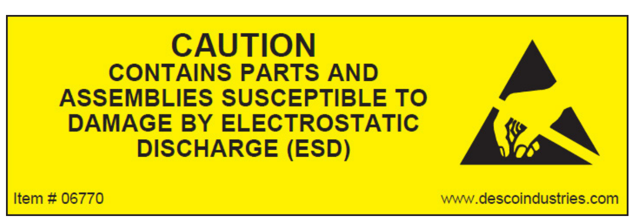
The electronic modules should only be removed from the ESD protective bag at the last moment, just before installation when the operator is ready to do the replacement.

The operator should avoid touching any components or connectors on the module and should hold the module by its edge or enclosure, as applicable.

1.8.1 ESD Protection/Grounding

All parts that are susceptible to damage by ESD will be marked using the following label. See Figure 4. Please follow the instructions below to ensure safety and to protect the parts from ESD damage.

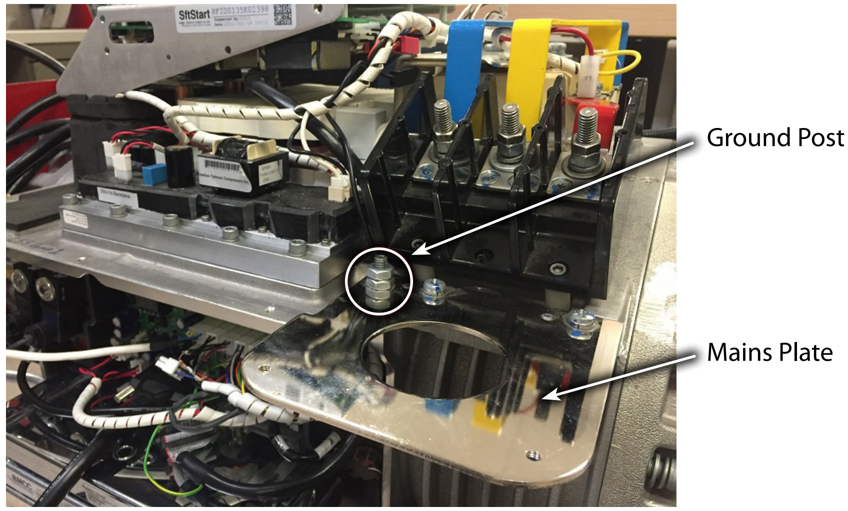
Figure 4 - ESD Label



1. Isolate the compressor power.

2. Clip the ESD strap ground clip to the compressor ground post. See white arrow in Figure 5 (Mains Plate and Ground Post).

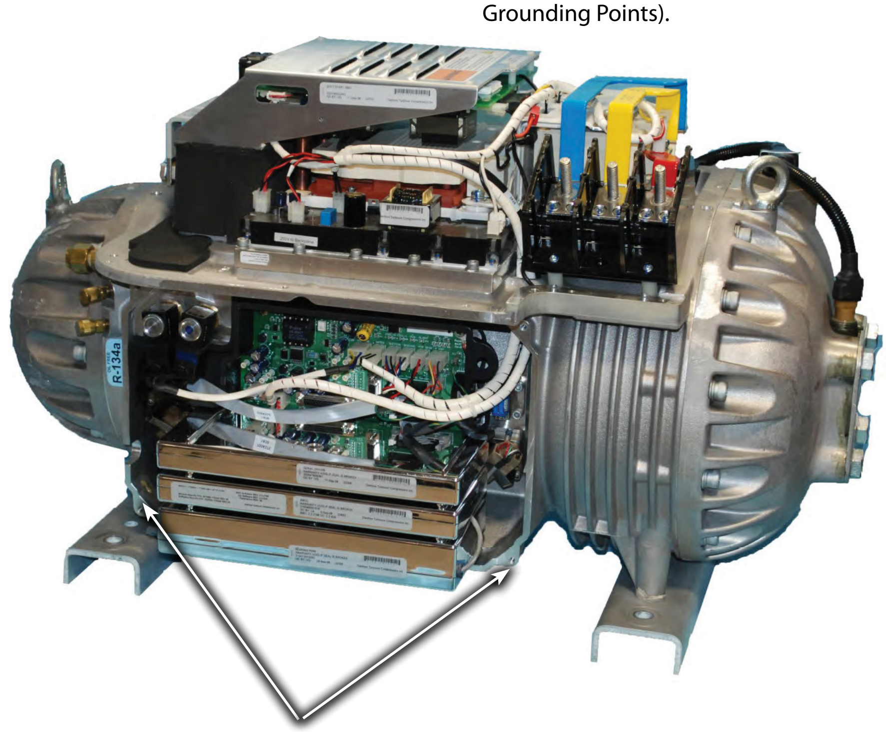
Figure 5 - Mains Plate and Ground Post



3. If you need to remove the Soft Start Board, clip the ESD strap ground clip to the mains plate. Refer to arrow in Figure 5 (Mains Plate and Ground Post).

4. If you only need to remove the Service Side Cover, clip the ESD strap ground to the cover screw hole that is part of the compressor housing. Refer to arrows in Figure 6 (Compressor Grounding Points).

Figure 6 - Compressor Grounding Points



1.9 DC Bus Test Harness Installation and Removal

A DC bus test harness *must* be used when testing the voltages of the compressor's power electronics. The DC bus test harness is not designed to be left in the compressor during normal operation. When checks are complete, disconnect and remove the test harness. Refer to Figure 8 (DC Bus Harness Connection Diagram) for a connection diagram.

Figure 7 - DC Bus Test Harness Diagram

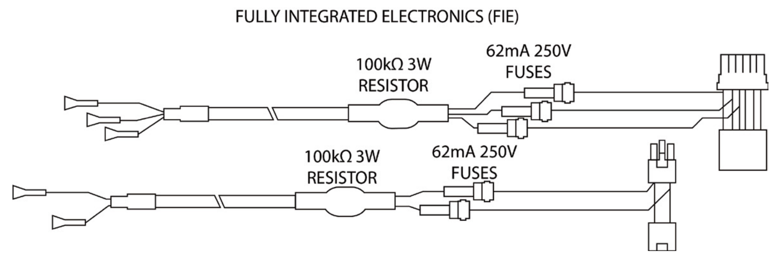
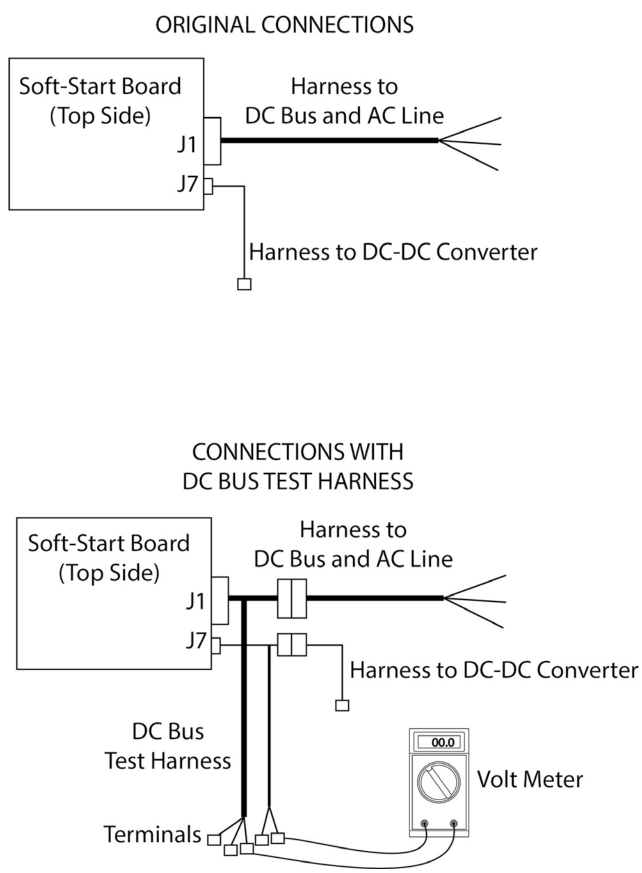


Figure 8 - DC Bus Harness Connection Diagram



• • • DANGER • • •

Before using the DC bus test harness, integrity of the fuses/resistors in the harness and cable must be checked.

1.9.1 Installation of the DC Bus Test Harness

1. Isolate the compressor power and remove the top cover as described in the "Electrical Isolation of the Compressor" section of this manual.

• • • CAUTION • • •

Use your ESD wrist strap before touching the Soft Start Board or any electronic components.

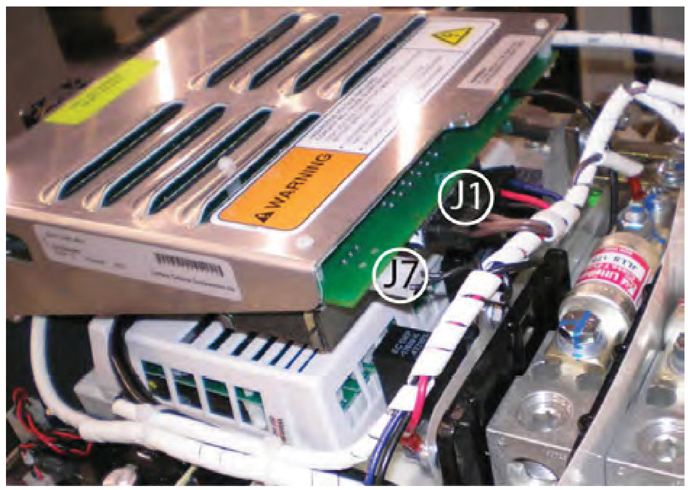
2. Confirm integrity of the fuses and resistors in the DC bus test harness. Check each cable individually. See Figure 9 (Soft Start Board) for harness fuse and resistor locations. The reading for the resistor should be approximately 100kΩ and the reading for the fuse should be 29Ω.

3. Remove the Service Side Cover.

4. Install the ESD clip.

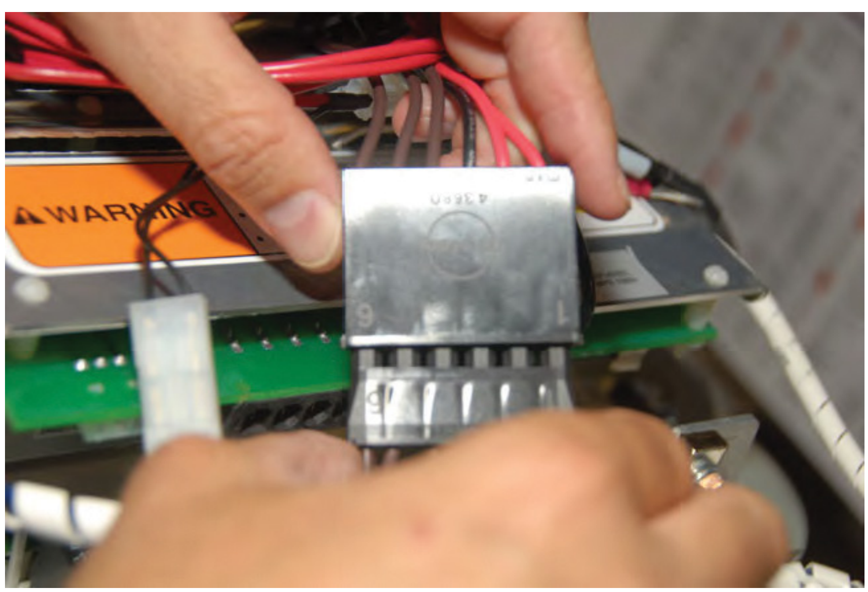
5. Disconnect the J1 and J7 connectors on the Soft Start Board. See Figure 9 (Soft Start Board).

Figure 9 - Soft Start Board



6. Connect the two plugs of the compressor cable harness into the corresponding sockets of the DC bus test harness. See Figure 10 (Connect Test Harness to Soft Start Board).

Figure 10 - Connect Test Harness to Soft Start Board

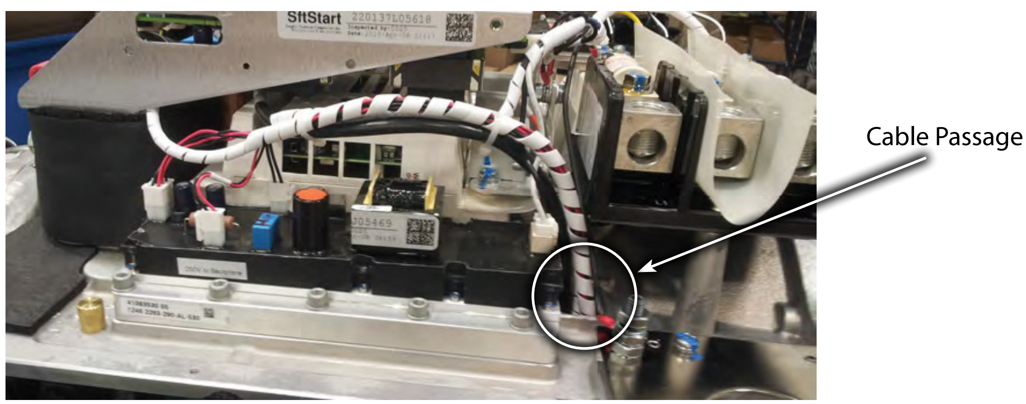


7. Connect the two plugs of the DC bus test harness into the Soft Start Board. See Figure 11 (Connect Test Harness to Compressor).

Figure 11 - Connect Test Harness to Compressor

8. Route the cables through the cable passage on either side of the HV DC-DC Converter, down into the service side. See Figure 12 (Cable Passage).

Figure 12 - Cable Passage



• • • DANGER • • •

The DC bus test harness is not designed to be left in the compressor during normal operation. When checks are complete, disconnect and remove the test harness.

9. Reinstall the Mains Input Cover and Top Cover.

1.9.2 DC Bus Test Harness Use

1. Install the DC bus test harness as described in the "Installation of the DC Bus Test Harness" section of this manual.

2. Reapply AC power to the compressor.

3. Using an appropriately rated voltmeter with the 1000VDC range selected, insert the positive voltmeter lead into the DC(+F) test harness lead, and the negative voltmeter lead into the DC(-) test harness lead. Refer to Table 2 (Expected DC Bus Voltage) for expected DC bus voltage.

The DC(+F) lead connects to the DC output from the F1 Fuse on the Soft Start Board.

Table 2 - Expected DC Bus Voltage

Compressor Nameplate AC Voltage	Acceptable AC Voltage Range	Expected DC Bus Voltage Range
575 VAC	518 - 632 VAC	700 - 853 VDC
460 VAC	414 - 506 VAC	559 - 683 VDC
400 VAC	360 - 440 VAC	486 - 594 VDC
380 VAC	342 - 418 VAC	462 - 564 VDC

4. Insert the positive voltmeter lead into the DC (+) test harness lead, and the negative voltmeter lead into the DC(-) test harness lead. Refer to Table 2 (Expected DC Bus Voltage) for expected DC bus voltage.

5. Measure the 15VAC from the Soft Start Board by placing the voltage meter leads into the 15VAC leads. The 15VAC leads connect to the 15VAC output from the Soft Start Board transformer.

The DC(+) lead connects to the DC bus input to the Soft Start Board.

6. When finished, isolate compressor power and remove the DC bus test harness.

1.9.3 Removal of the DC Bus Test Harness

1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual and remove the top side covers.

⚠ • • • CAUTION • • •

Use your ESD wrist strap before touching the Soft Start Board or any electronic components.

2. Remove the DC bus test harness from the cable passage.

3. Disconnect the two plugs of the DC bus test harness from the Soft Start Board.

4. Disconnect the two plugs of the compressor cable harness from the corresponding sockets of the DC bus test harness.

5. Reconnect the J1 and J7 connectors on the Soft Start Board.

6. Reinstall the top covers.

Compressor operation begins with a demand signal applied to the compressor. The startup sequence is configurable in the startup settings. See the OEM Programming Guide for further details.

2.1 Main Fluid Path

The compressor is a two-stage centrifugal type compressor utilizing variable speed as the principle means of capacity control with inlet guide vanes (IGVs) assisting when required. Refrigerant enters the first stage suction side of the compressor as a low-pressure, low-temperature, superheated vapor. It then passes through variable IGVs that assist compressor control at part-load conditions. Both impellers are mounted on a common shaft. Vapor passes through the first stage impeller where velocity energy is added to the refrigerant. This is converted to an intermediate pressure in the first stage volute. Vapor then enters the second stage impeller through a diffuser. In the second stage, impeller velocity energy is again added to the refrigerant and converted to the final discharge pressure in the discharge diffuser and volute. From the second stage impeller, refrigerant passes as a high pressure, superheated vapor to the system discharge line.

Figure 13 - Compressor Fluid Paths

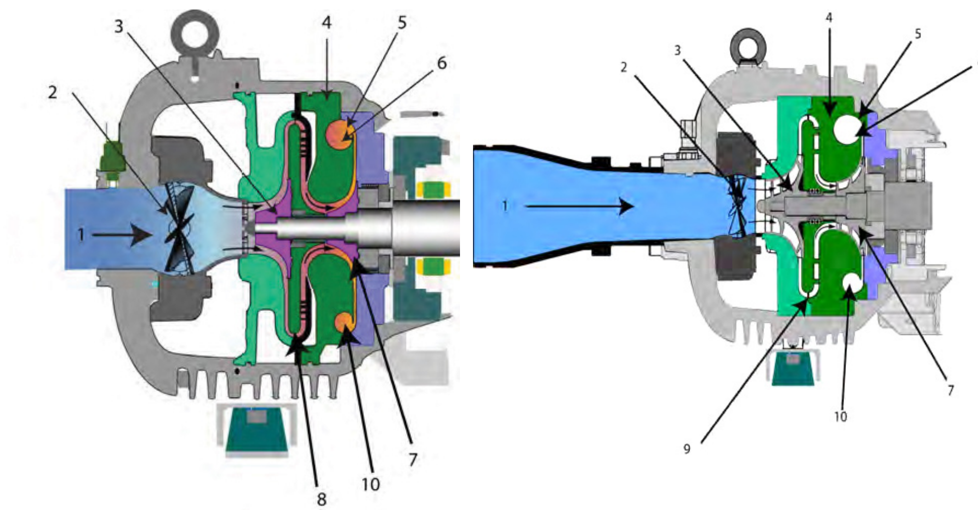


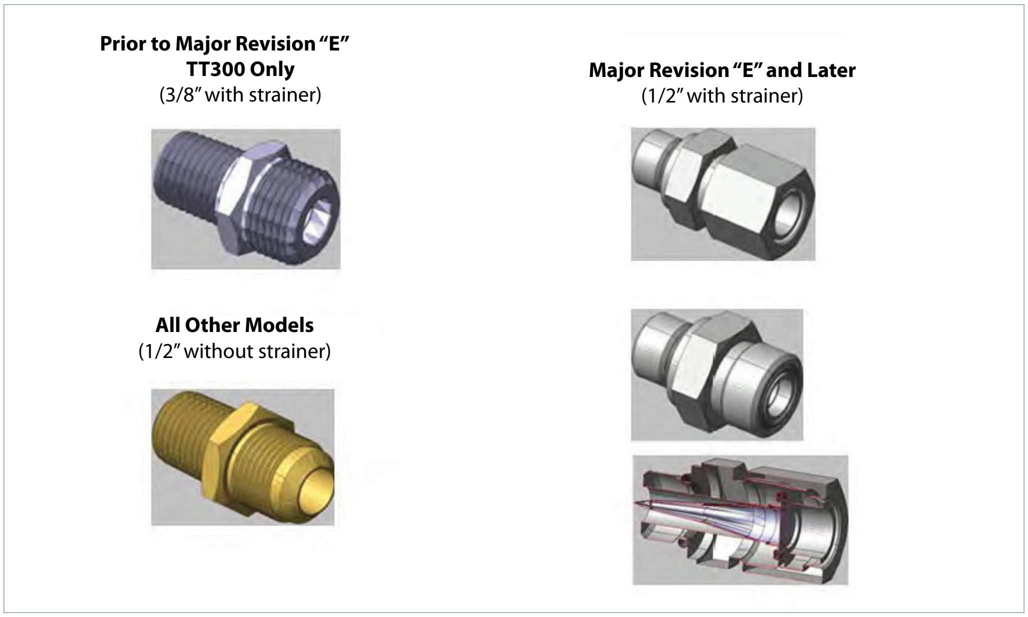
Table 3 - Compressor Fluid Paths

No.	Component	No.	Component
1	Low Pressure/Low Temperature Gas	6	High-Pressure/High-Temperature Gas
2	Inlet Guide Vanes (IGVs)	7	Second-Stage Impeller
3	First-Stage Impeller	8	Vaned Diffuser
4	Volute Assembly	9	Vaneless Diffuser
5	Discharge Port	10	De-Swirl Vanes

2.2 Motor and Power Electronics Cooling

Liquid refrigerant, having at least 2°C (Kelvin)/ 3.6°F (Rankine) sub-cooling at connection point, must be piped to the compressor cooling inlet connection. Depending on compressor model, this connection is a 3/8 or 1/2 inch male flare connection or a 1/2 inch O-ring face seal connection. All connections, except the 1/2 inch flare, have an built-in strainer. Refer to Figure 14 (Cooling Inlet Adapters) for examples of the cooling inlet adapters.

Figure 14 - Cooling Inlet Adaptors



Liquid refrigerant is internally channeled to two solenoid valves. These valves have integral orifices that act as expansion devices to cool the compressor motor, shaft (rotor) and power electronics. TT300 and TG230 compressors have these solenoids arranged so that all components are cooled in series with each other and the solenoids act as two stages of cooling capacity. The TT350, TT400, TT500, TT700, TG310, TG390, and TG520 compressors and some R-22 TT300 compressors have separate cooling paths for motor and power electronics. These cooling methods are identified as serial or split cooling.

Serial cooling has its return suction point to the inlet of the first stage impeller, thus cooling all components with refrigerant evaporating at the main suction evaporation temperature. In serial cooling versions, solenoid 1 is opened if any temperature reaches its "turn on" point and solenoid 2 is opened if any temperature reaches a second "turn on"point value.

The split cooling has the motor/shaft cooling circuit return to the first stage impeller inlet and the power electronics return to the second stage impeller inlet. This ensures a higher evaporating (cooling) temperature to minimize condensation around the power electronic components. In the split cooling version, solenoid 1 is opened if either the cavity temperature or the motor temperature reaches its "turn on" point and solenoid 2 is opened if the Inverter or silicon controlled rectifier (SCR) temperature reaches its "turn on" point.

Medium temperature (MT) version compressors require their motor cooling suction line to be vented externally to the main suction line through an evaporator pressure regulating (EPR) valve. This valve is required to ensure that evaporating temperatures cooling the motor and electronics do not get too cold. The EPR valve should be adjusted to maintain a minimum evaporation temperature of 1.5°C (35°F).

Serial Cooling compressors can be identified by having only one 1/4 inch flare Schrader connection adjacent to the main motor cooling liquid connection, while a split cooling model will have two. These 1/4 inch flare connections access the refrigerant feeds to the components being cooled and bypass the solenoid valves. These ports may be used to inject liquid refrigerant directly to cool components and enable compressors to operate during system charging operations. A minimum pressure ratio of 1.5 and a full liquid seal at the compressor is required to ensure proper and correct compressor cooling.

See cooling circuit diagrams: Figure 15 (Compressor Motor and Power Electronics Cooling (TT300/TG230 Serial Cooling)) and Figure 16 (Compressor Motor and Power Electronics Cooling (All Models Except TT300/TG230 Serial Cooling)).

Figure 15 - Compressor Motor and Power Electronics Cooling (TT300/TG230 Serial Cooling)

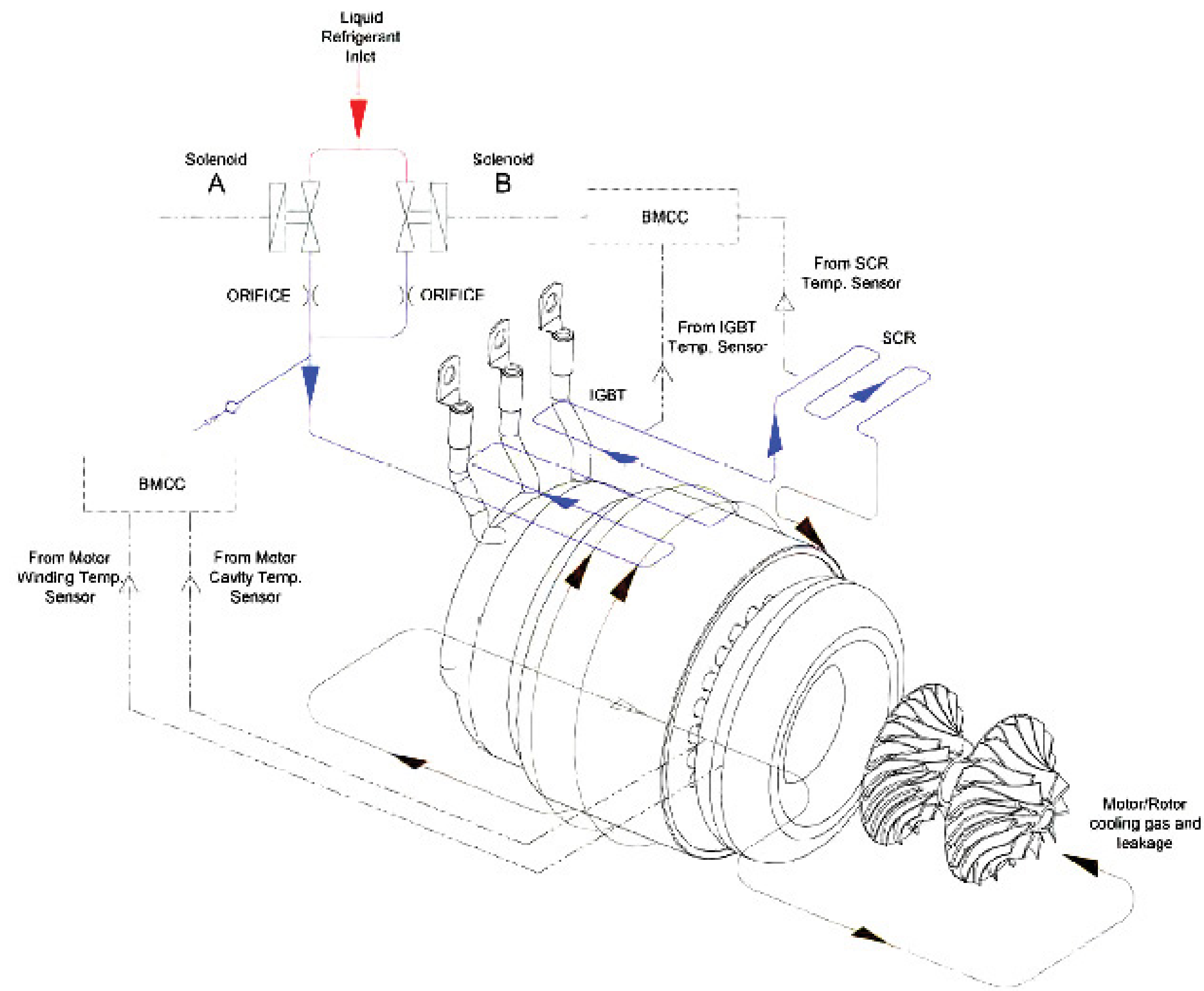
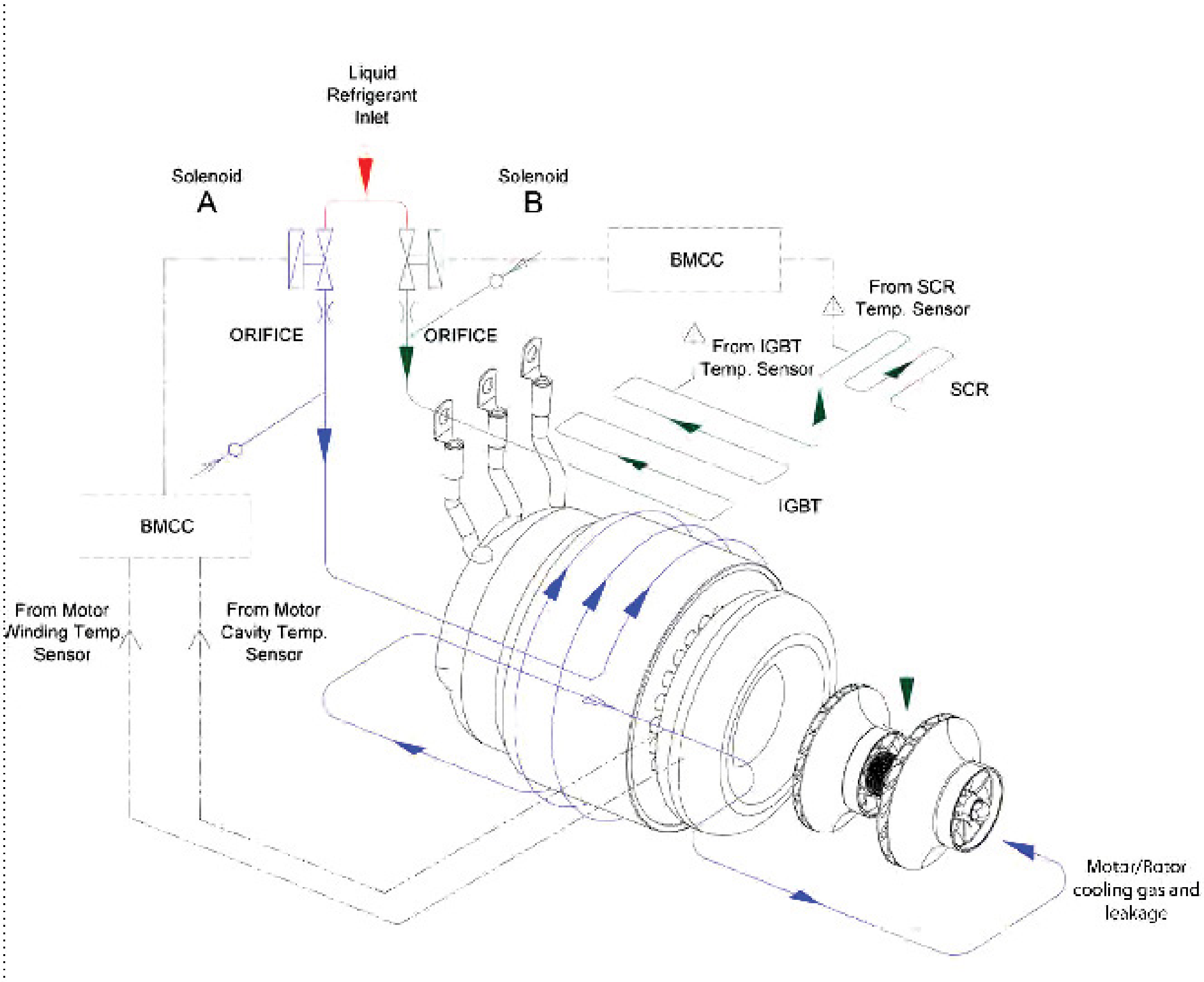


Figure 16 - Compressor Motor and Power Electronics Cooling (All Models Except TT300/TG230 Serial Cooling)



2.3 Capacity Control

Capacity control of the compressor is achieved primarily by speed modulation. When unloading, the compressor's first action is to reduce speed to slightly above the minimum (surge) speed for the pressure ratio present at the time. Further reduction in capacity and an increase in shaft/ impeller stability can be achieved by closing the IGVs. These are variable angle vanes installed in the suction inlet ahead of the first stage impeller. These guide vanes restrict the refrigerant from entering the impeller inlet, as well as imparting a "pre swirl" of the refrigerant in the direction of impeller rotation to increase energy efficiency during part load operation.

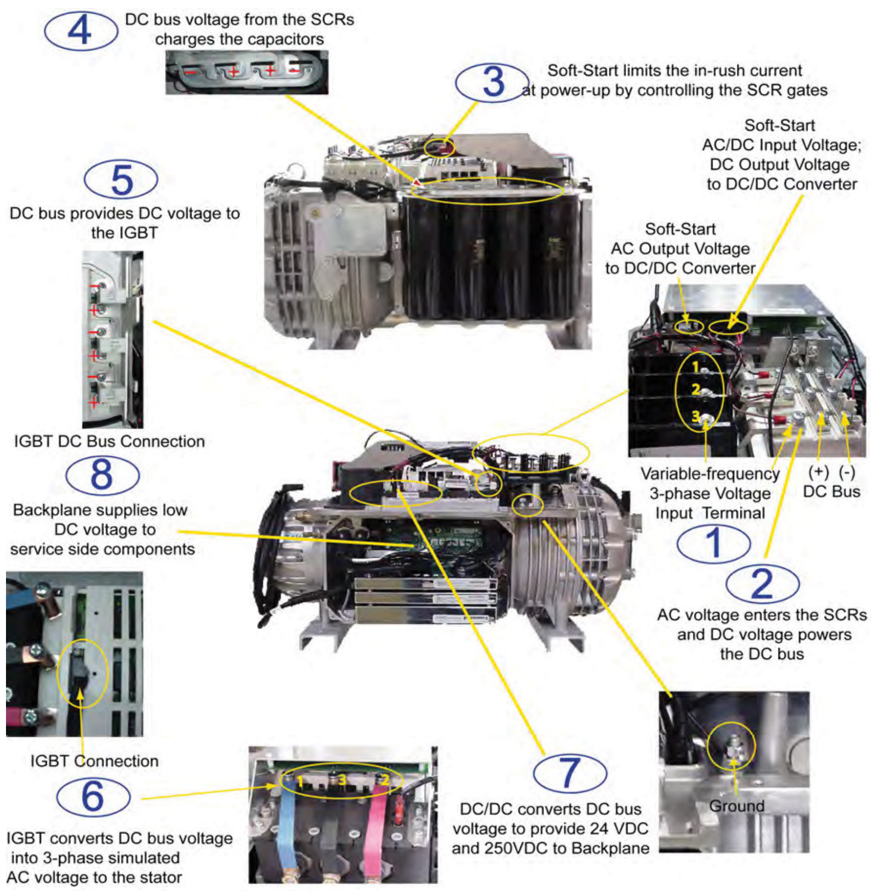
Speed modulation is achieved by the use of "Inverter" control. To accomplish this, the incoming 3-phase AC supply is converted to high voltage DC, incorporating smoothing/storage capacitors, and then switched by the Inverter, utilizing 3-phase rectifiers, to give a simulated 3-phase AC supply of variable voltage and frequency to the compressor motor.

2.4 Compressor Energy and Signal Flow

During normal operation, 3-phase power is required to be connected to the compressor at all times, even if it is not running. Power is distributed through the following components to maintain compressor operation:

- Silicon-Controlled Rectifier (SCR)
- Soft Start Board
- DC Capacitor Assembly
- Inverter
- Stator
- High-Voltage (HV) DC-DC Converter
- Backplane
- Bearing Motor Compressor Controller (BMCC)
- Serial Driver
- Bearing Pulse Width Modulation (PWM) Amplifier
- Compressor I/O Board
- IGV
- Solenoid actuators

Figure 17 - Compressor Energy and Signal Flow Connections (TT300/TG230 Shown)



The order of power and signal flow through the compressor components is as follows (see Figure 17 (Compressor Energy and Signal Flow Connections (TT300/TG230 Shown)):

1. A 3-phase voltage source is provided to the compressor through the voltage input terminal.

2. AC voltage enters the SCRs and DC voltage powers the DC bus.

3. The Soft Start Board limits the in-rush current at power-up by controlling the SCR gates.

4. DC bus voltage from the SCRs charges the capacitors.

5. DC bus provides DC voltage to Inverter.

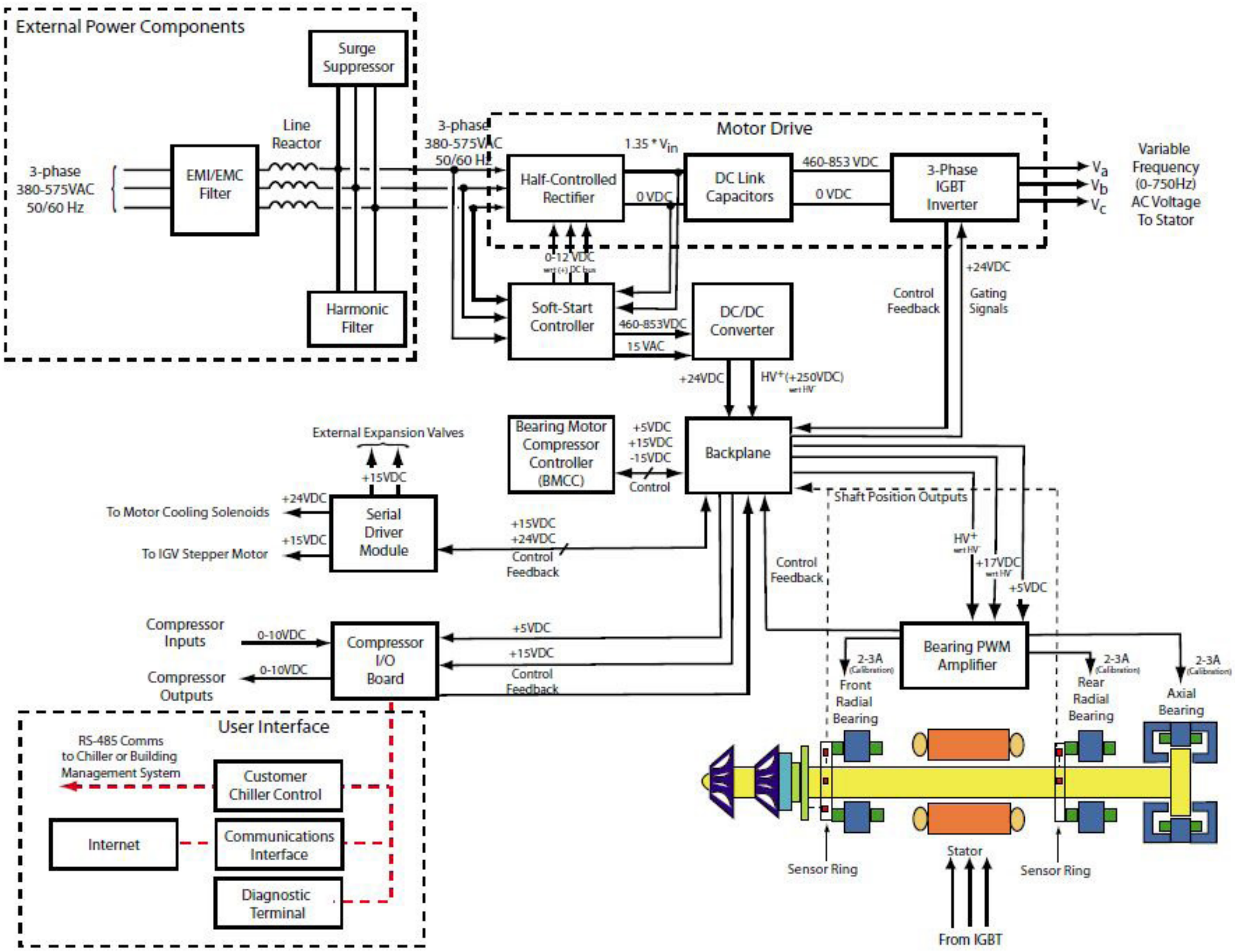
6. The Inverter converts the DC bus voltage into a variable frequency, 3-phase simulated AC voltage to the Stator.

7. The HV DC-DC Converter uses the DC bus voltage to provide 24VDC and 250VDC to the Backplane.

8. The Backplane connects and supplies low DC voltage to the service side components.

Refer to Figure 18 (Compressor Energy and Control Flow Block Diagram) for a block diagram summary of the energy and voltage signal flow through the compressor.

Figure 18 - Compressor Energy and Control Flow Block Diagram



Note:
All voltage levels shown have the following error tolerance:
DC (except the DC bus): ±5%
AC : ±10%

This section provides compressor component locations and functional descriptions, verification and troubleshooting methods, cable connection identification, and steps necessary to replace a component.

3.1 Component Identification

This section identifies the major parts of the compressor.

Figure 19 - Compressor Components Identification (Covers On)

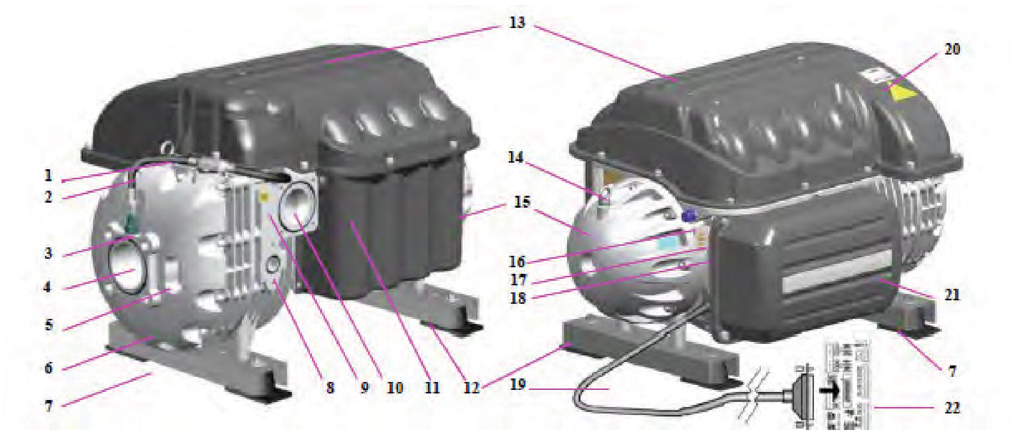


Table 4 - Compressor Component Identification (Covers On)

No.	Component	No.	Component
1	Lift Anchor (Front)	12	Rear Support Base
2	Cable Harness (Sensor)	13	Top Access Cover
3	Suction Pressure/ Temperature Sensor	14	Lift Anchor (Rear)
4	Inlet Guide Vanes (IGV) Suction Port	15	End Bell
5	IGV Position Indicator	16	Motor-Cooling Connection
6	IGV Housing	17	Motor-Cooling (TT300/TG230) and Power Electronics Cooling (TT350/ TT400/TT500/TT700/TG310/TG390/ TG520) Access Port #1 (**NOTE:** TT300/ TG230 have only one access port)
7	Front Support Base	18	Motor-Cooling Access Port #2 (TT350/TT400/TT500/TT700/TG310/ TG390/TG520 Only)
8	Economizer Port	19	Compressor I/O Board Cable
9	Optional Pressure Regulating Port	20	Mains Input Access Cover
10	Discharge Port	21	Service Side Access Cover
11	Capacitor Side Access Cover	22	Compressor I/O Board

Figure 20 - Compressor Component Identification (Covers Off) (TT300/TG230)

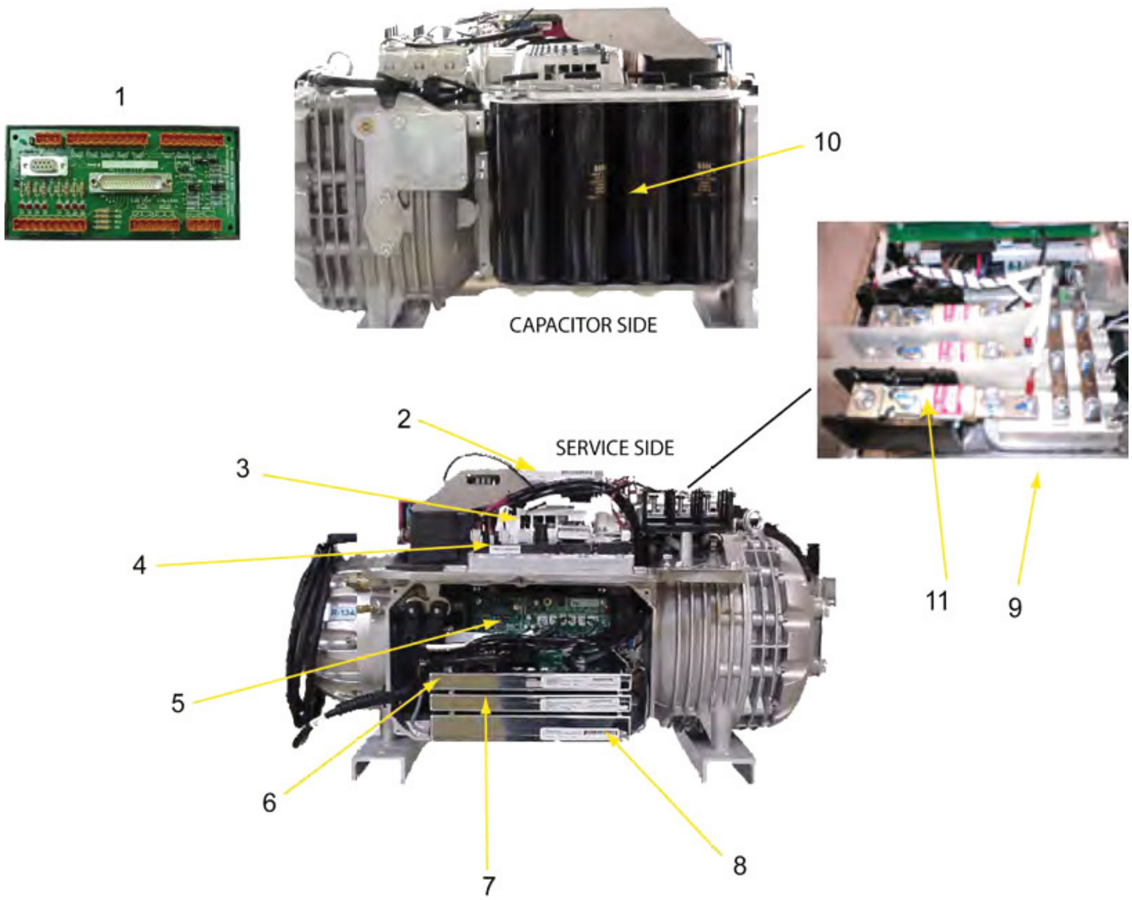


Table 5 - Compressor Component Identification (Covers Off) (TT300/TG230)

No.	Component	No.	Component
1	Compressor I/O Board	7	Bearing Motor Compressor Controller (BMCC)
2	Soft Start Board	8	Bearing Pulse Width Modulation (PWM) Amplifier
3	Insulated Gate Bipolar Transistor (IGBT) Inverter	9	Silicon-Controlled Rectifier (SCR)
4	High-Voltage (HV) DC-DC Converter	10	DC Capacitor Assembly
5	Backplane	11	Fast-Acting Fuses (TT300/TG230 only)
6	Serial Driver		

Figure 21 - Compressor Sensors, Cables and Indicators (TT300/ TG230)

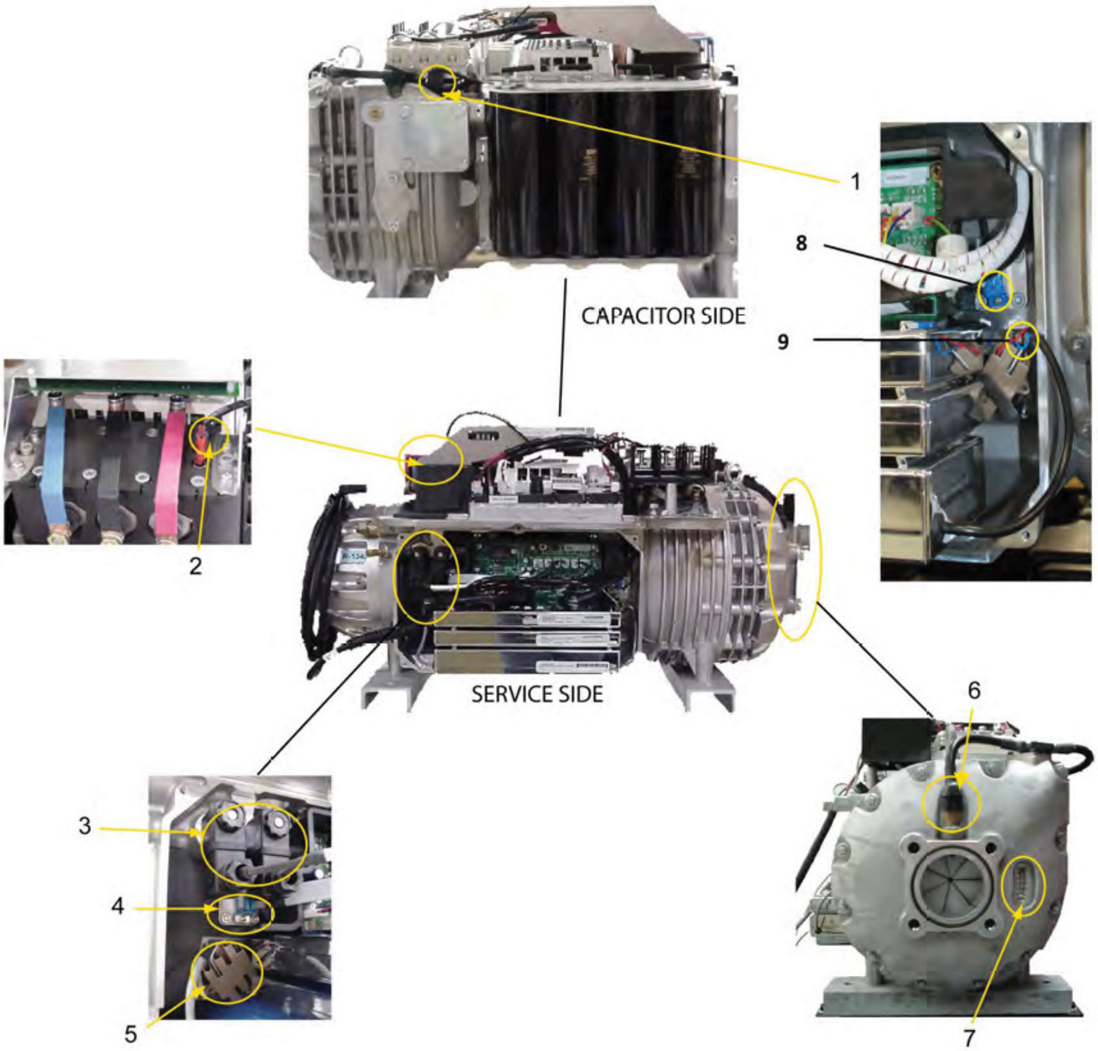


Table 6 - Compressor Sensors, Cables, and Indicators (TT300/TG230)

No.	Component	No.	Component
1	Discharge Temperature / Pressure Sensor	6	Suction Temperature/Pressure Sensor
2	Motor-Winding Sensors	7	Inlet Guide Vanes (IGV) Position Indicator
3	Motor-Cooling Solenoids	8	Bearing Sensor Ring Cable (Front)
4	Bearing Sensor Ring Cable (Rear)	9	PWM Current Output (Front Bearing)
5	Bearing Pulse Width Modulation (PWM) Current Output (Rear Bearing)		

Figure 22 - Compressor Component Identification (Covers Off) (TT350/TT400/ TT500/TT700/TG310/TG390/TG520)

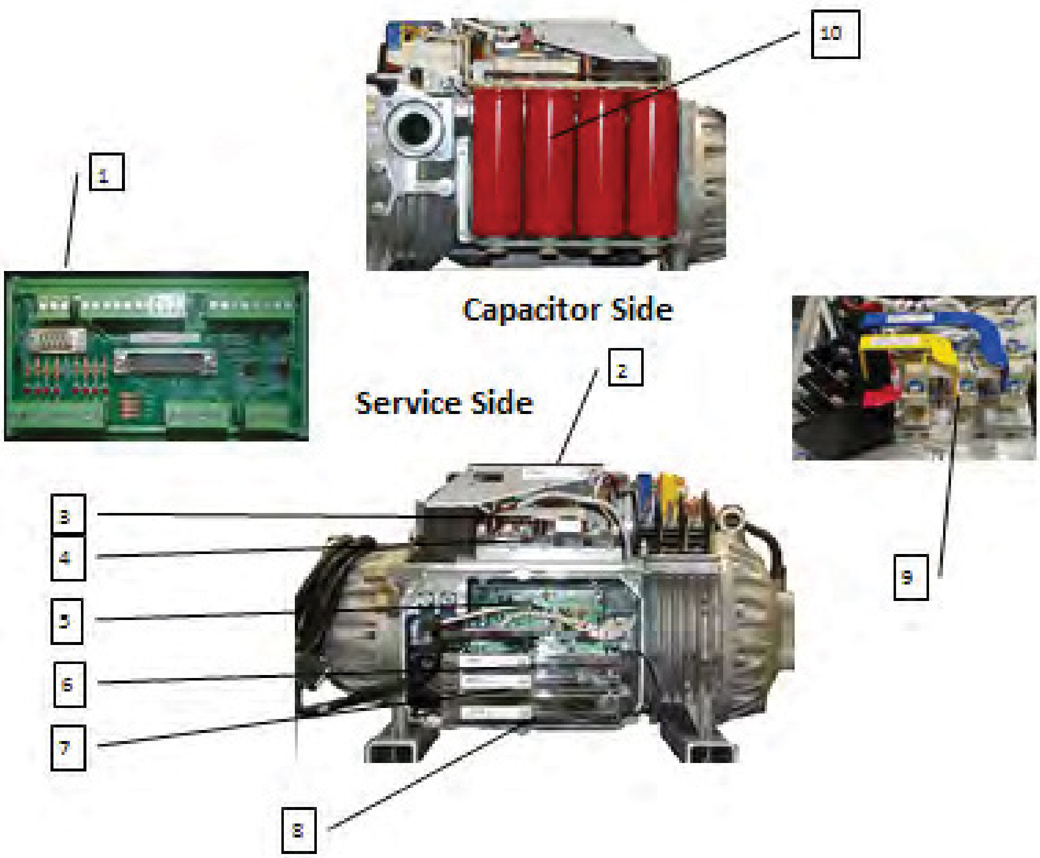


Table 7 - Compressor Component Identification (Covers Off) (TT350/TT400/ TT500/TT700/TG310/TT390/ TT520)

No.	Component	No.	Component
1	Compressor I/O Board	6	Serial Driver
2	Soft Start Board	7	Bearing Motor Compressor Controller (BMCC)
3	Insulated Gate Bipolar Transistor (IGBT) Inverter	8	Bearing Pulse Width Modulation (PWM) Amplifier
4	High-Voltage (HV) DC-DC Converter	9	Silicon-Controlled Rectifier (SCR)
5	Backplane	10	DC Capacitor Assembly

Figure 23 - Compressor Sensors, Cables, and Indicators (TT350/TT400/TT500/TT700/TG310/TG390/TG520)

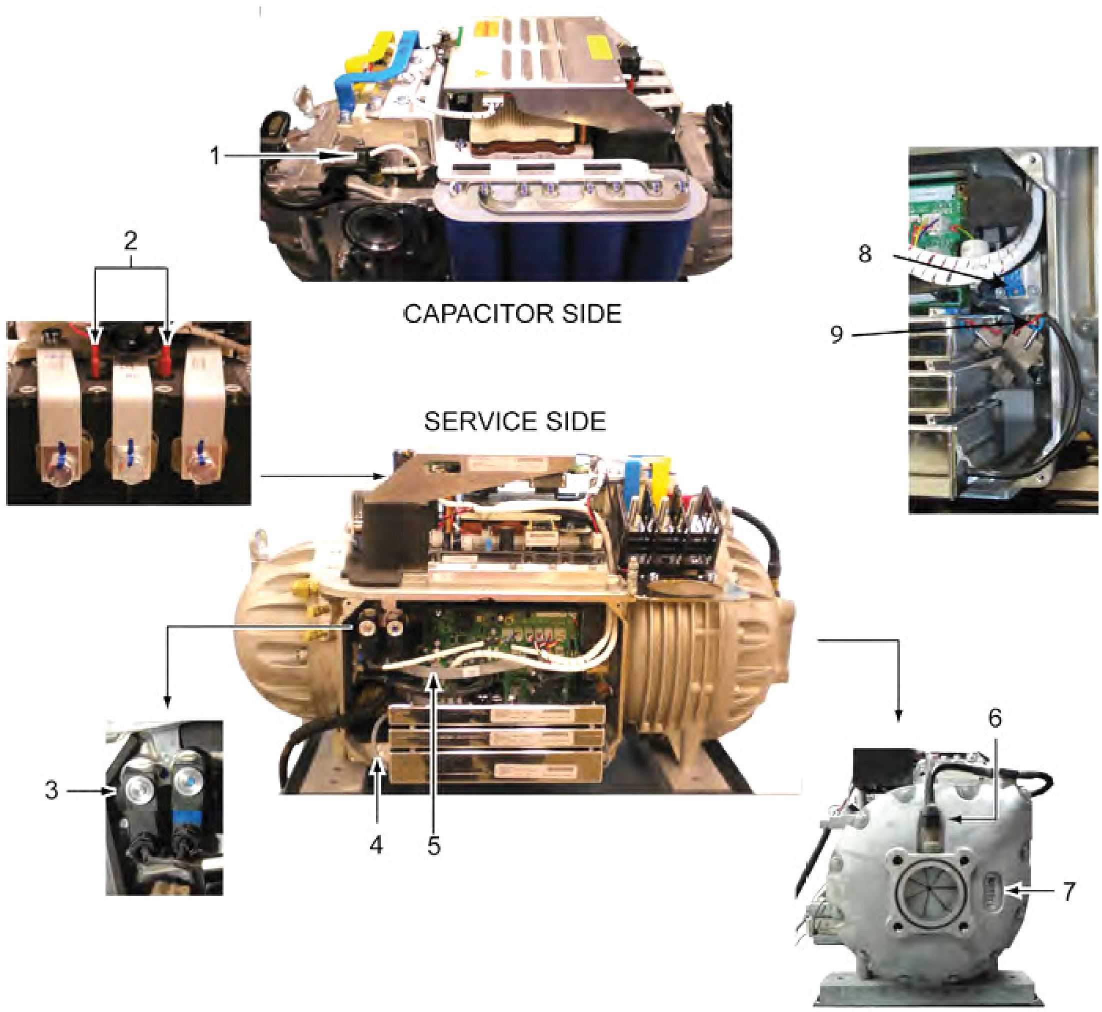


Table 8 - Compressor Sensors, Cables, and Indicators (TT350/TT400/TT500/TT700/TG310/TG390/TG520)

No.	Component	No.	Component
1	Discharge Temperature / Pressure Sensor	5	Bearing Sensor Ring Cable
2	Motor-Winding Sensors	6	Suction Temperature/Pressure Sensor
3	Motor-Cooling Solenoids	7	Inlet Guide Vanes (IGV) Position Indicator
4	Bearing Pulse Width Modulation (PWM) Amplifier Current Output	8	Bearing Sensor Ring Cable (Front)
		9	PWM Current Output (Front Bearing)

3.2 Compressor - Removal and Installation

3.2 .1 Refrigerant Containment

⚠ • • • CAUTION • • •

Isolation and recovery of the refrigerant must be performed by a qualified service technician adhering to industry/ASHRAE standards.

1. Close the suction, discharge, and economizer isolating valves as appropriate.

2. Close the motor-cooling liquid line shut-off valve.

3. Use a magnet to manually open at least one of the motor cooling solenoids.

4. Connect a refrigerant recovery system to the compressor as per industry-standard procedures and transfer the refrigerant to an appropriate containment vessel.

3.2.2 Compressor - Removal

1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

2. Remove the Mains Input Cover.

3. Remove the AC mains cables from the compressor terminals. Protect/isolate cable ends.

4. Remove the Mains Input ground wire from the ground post.

5. Remove the cable gland that secures the Mains Input cable conduit to the Mains Input bracket.

6. Remove the Service Side Cover.

⚠ • • • CAUTION • • •

Ensure that there is no secondary power source connected to the compressor before disconnecting the I/O cable.

7. Disconnect the I/O cable from the Backplane I/O connector (J7) and remove the cable from the compressor.

8. Reinstall the Service Side Cover.

9. Once the transfer of refrigerant is complete, bring the compressor back to atmospheric pressure according to industry standards using dry nitrogen.

10. Disconnect the compressor from the refrigerant system connections (suction, discharge, economizer and motor cooling line), taking care when removing connections that there is no residual pressure.

11. Reinstall the Mains Input Cover.

12. Remove the four compressor mounting bolts and associated hardware.

13. Connect an appropriate lifting device to the eyebolts provided on each side of the compressor, and remove compressor.

14. Using the blanking plates and bolts provided with the new compressor, seal the compressor and charge to 25 psi with inert gas for shipment (this will prevent moisture and foreign material from entering the compressor).

3.2.3 Compressor - Installation

NOTE

Blanking plates should not be removed from the new compressor until you are ready to place the new compressor in position. New compressors are pressurized with inert gas to 50 psi. Pressure should be relieved through the Schrader valve, located next to the motor cooling connection, prior to removing the blanking plates.

1.Inspect the compressor to ensure all connections and fasteners are correctly installed.

2. Relieve the inert gas pressure through the motor cooling Schrader valve.

3. Remove the suction, discharge and economizer (if applicable) blanking plates from the new compressor.

4. Remove the motor cooling inlet adapter cap. See Section 3.2.3.1 (Compressor Replacement Considerations for Motor Cooling Adapter).

5. Mount the compressor in position and install the rubber mounts and hardware.

6. Attach all refrigerant line connections to the compressor using the new O-rings supplied with the compressor.

NOTE

Install new O-rings when attaching flanges to the compressor.

7. Tighten the economizer flange bolts (if applicable).

8. Tighten the discharge flange bolts.

9. Tighten the motor cooling line connection.

10. Tighten the suction flange bolts.

11. Remove the Service Side Cover.

12. Connect the compressor I/O cable to the Backplane.

13. Remove the Mains Input Cover.

• • • DANGER • • •

Ensure that electrical power is isolated from the AC mains cables before handling them.

14. Connect the cable gland that secures the Mains Input cable conduit to the Mains Input bracket.

15. Install the Mains Input ground wire to the ground post.

16. Attach the AC mains cables to the terminals.

17. Re-install the Mains Input Cover.

18. Leak test the compressor to appropriate pressure and industry accepted standards.

19. Evacuate compressor to appropriate pressure and industry accepted standards.

20. Charge the compressor with refrigerant.

21. Apply power to the compressor.

3.2.3.1 Compressor Replacement Considerations for Motor Cooling Adapter

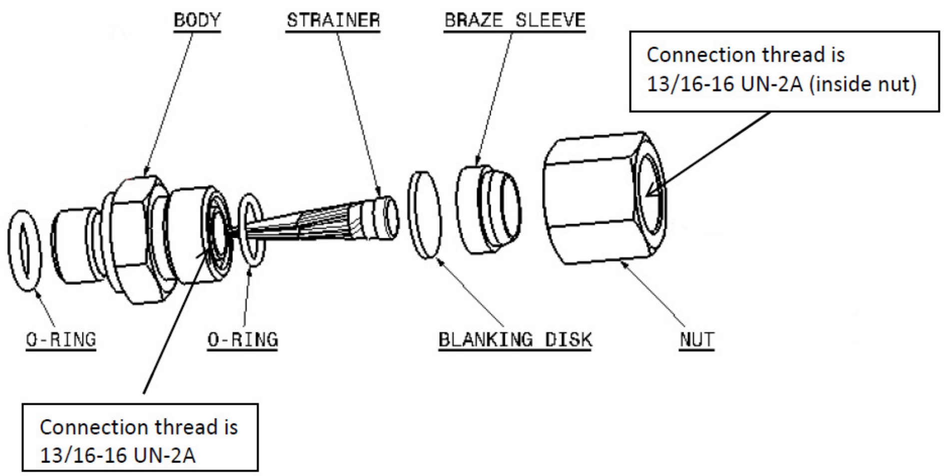
To minimize refrigerant leak potential, the Motor Cooling Adapter NPT-to-flare connection has been replaced by a fitting incorporating all O-ring seals for all Major Revision "E" and later compressors. See Section 2.2 (Motor and Power Cooling).

The housing connection seal is now an ISO standard O-ring seal and the external pipework connection is an O-ring face seal (ORFS). In addition, the line size has been standardized at 1/2 inch for all models and the fitting includes an in built (removable) strainer. This will require a modification of the previous standard connection size of TT300 compressors (from 3/8 inch).

The new fitting consists of 1) body (including both O-rings), 2) strainer, 3) blanking disc, 4) 1/2" braze sleeve, steel (all for connecting 1/2 inch copper tube) and 5) nut. Body to housing thread is M16 x 1.5.

Tube connection thread is 13/16-16 UN-2A. Strainer recess is Ø 9.5. See Figure 24 (Major Revision "E" Compressor Fittings).

Figure 24 - Major Revision "E" Compressor Fittings



The following link will provide general information on ORFS fittings: http://www.hoseandfittingsetc.com/product/fittings/tube-fittings/o-ring-face-seal-fittings/orfs-nuts-sleeves/

Field installation from old style fitting

Flexible Line

1. If connection is flexible hose to 3/8 or 1/2 inch flare, entire hose will require replacement with new style.

2. Remove pressure from compressor as per OEM standard procedure.

3. Source appropriate OEM specified and procured flexible line.

4. Remove nut from connection fitting body. Discard blanking disc, nut, and braze sleeve.

5. Before installation of OEM supplied flexible line, inspect O-ring face is clean and free from scratches or other damage. Lightly smear O-ring lube on O-ring face of line and install line using two wrenches, one to hold body of fitting.

NOTE

Flexible lines are not supplied by DTC. Selection of appropriate hose and fitting is the responsibility of OEM/installer. This information is readily available from various sources. The following link is one source that may be used to obtain this data. The line selected should be tested for adequate flow capacity. http://www.hoseandfittingsetc.com/product/fittings/hose-fittings/26-series/26-series-orfs-fittings/

Rigid 1/2 inch copper connection

1. If connection is 1/2 inch rigid copper, a length of 1/2 inch copper must be brazed into the braze sleeve.

2. Remove pressure from compressor as per OEM standard procedure.

3. Remove nut from connection-fitting body. Discard blanking disc. Locate braze sleeve and clean. Ensure removal of all oil and surface debris. Braze as for standard OEM process for copper/steel joint.

4. Place appropriate length of 1/2 inch copper tube into braze sleeve. Pretreat/flux joint area as per OEM standard procedure. Braze pipe to sleeve ensuring nut can be fitted after brazing or otherwise position as required. Clean flux and any excess filler from joint.

5. Clean O-ring face of sleeve ensuring no scratches or debris is present. Apply light smear of O-ring lube to face of sleeve and assemble to fitting. Tighten nut using two line wrenches with one holding body of fitting.

Rigid 3/8 inch copper connection TT300/ TG230

• If connection is 3/8 inch rigid copper, a length of 1/2 inch copper must be brazed into the braze sleeve as above. A transition fitting should be brazed to connect the 3/8 to 1/2 inch tubes. Follow procedure as noted above in Rigid 1/2 Copper Connection section.

Important

• It should be noted that the inclusion of a strainer within the connection body is intended as a last resort backup only to prevent ingress of debris that may block solenoid orifices or restrict motor and power electronics cooling. It is not a substitute for a correctly sized full-flow filter drier. A filter drier must be installed in all instances. If it is found that a filter drier is not installed and the fitting is changed due to a field replacement of the compressor, a filter drier must be included in the line modification.

• If it is required to remove the fitting from the housing for any reason, clean the O-ring, fitting and housing threads, and apply a small amount of O-ring lube before reassembly.

3.3 3-Phase Main Voltage Input Terminal Block

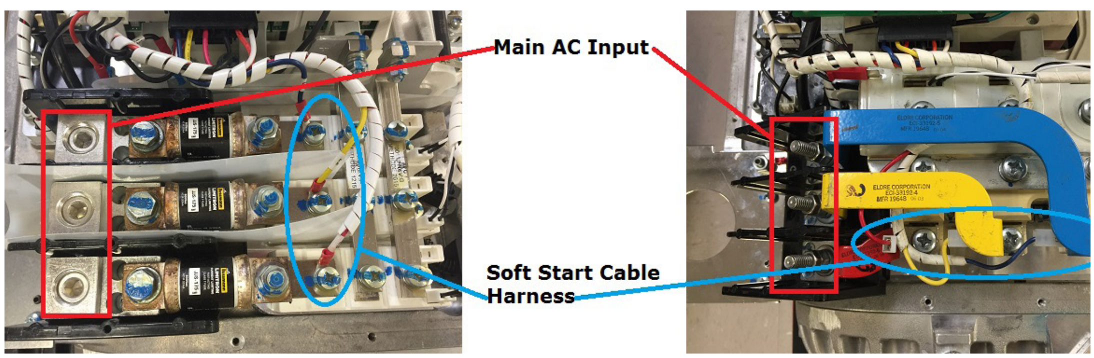
3.3.1 Function

The terminal block is the location where the compressor receives 3-Phase AC voltage, even when not running. All compressors must be fitted with class T fast-acting fuses to protect the solid state Inverter. Danfoss Turbocor control does NOT directly measure 3-phase power values. All 3-phase voltage information displayed in the SMT is calculated from DC bus voltage and motor power as measured by the Inverter. The input voltage varies between 380-575VAC at a frequency of 50/60Hz.

Refer to Figure 25 (Main AC Input Terminal) to locate the AC voltage input terminal block and bus bars.

3.3.2 Connections

Figure 25 - Main AC Input Terminal TT300/TG230 (left) TT350/TT400/TT500/ TT700/TG310/TG390/ TG520 (right)



The TT300/TG230 are the only compressors where the Mains Input terminal connections include in-line fuses.

The AC line power is routed to the SCRs by the three main AC input bus bars and to the Soft Start Board by the Soft Start Cable Harness to allow control timing of the SCR circuits.

3.3.3 Verification

3.3.3.1 3-Phase AC Input Verification

The compressor requires a 3-phase power source with UL-approved or CE-approved components in circuit with code-compliant protection.

• • • DANGER • • •

This equipment contains hazardous voltages that can cause injury or death. Exercise extreme caution when working on energized circuits.

• • • DANGER • • •

Always wear safety glasses when working around components energized by high voltage. Faulty components can explode and cause serious eye injuries.

3.3.3.2 Connecting the AC Input Cable

1. Isolate compressor power.

2. Ensure the AC cables are securely fastened to the input terminal block.

3. If the cables cannot be securely fastened to the input terminal, the terminal block is damaged and needs to be replaced.

3.3.3.3 Verifying the 3-Phase AC Input

1. Turn ON the AC input power.

2. Set the multimeter for AC voltage measurements.

3. Place the meter probe on one phase of the AC input terminals and the other meter probe on another phase of the AC input terminals as shown in Figure 26 (Measuring the AC Input Voltage on the AC Input Terminals) and Figure 27 (Measuring 3-Phase AC Input). Repeat for all AC input terminals. Repeat on load side of the fuses (TT300/TG230 only).

Figure 26 - Measuring the AC Input Voltage on the AC Input Terminals

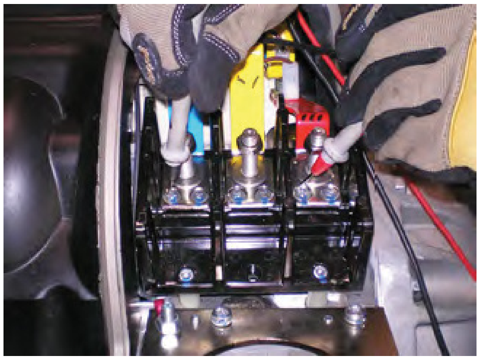


Figure 27 - Measuring 3-Phase AC Input (TT300/ TG230 Only)

4. Verify that the meter shows the expected AC measurement within the range as indicated in Table 9 (Expected AC Voltage Range). The acceptable AC input voltage range is +/-10% of the nameplate AC input voltage.

Table 9 - Expected AC Voltage Range

AC Input	
Nameplate Voltage	Acceptable Voltage Range
575VAC	518 to 632VAC
460VAC	414 to 506VAC
400VAC	360 to 440VAC
380VAC	342 to 418VAC

5. If the meter does not show any reading, it is possible that there is no power from the AC source. Ensure the AC power source is turned ON and try again. If there is no power on the load side of the fuses (TT300/TG230 only), isolate the power and check the fuses.

6. If the measured values correspond to the specified values for all phases, the AC input voltage is OK.

3.3.4 Removal and Installation

3.3.4.1 Terminal Block Removal (TT350/TT400/TT500/TT700/TG310/TG390/TG520)

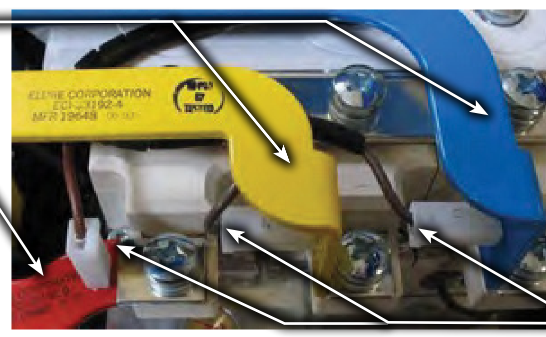
1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

2. Disconnect the main input cables from terminal blocks.

3. Disconnect the three connectors of the Soft Start Cable Harness from the bus bars.

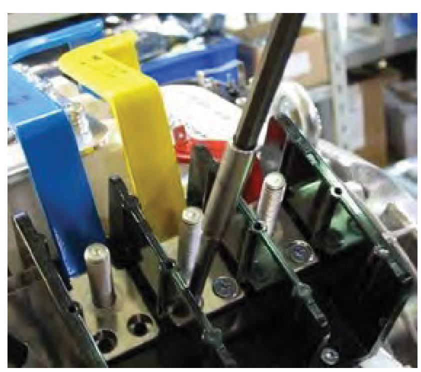
4. Remove the screws that secure the three terminal block bus bars to the SCR diodes. See Figure 28 (Terminal Block Bus Bars).

Figure 28 - Terminal Block Bus Bars (TT350/TT400/TT500/TT700/TG310/TG390/TG520)



5. Remove the screws that secure the three terminal block bus bars to the terminal block. See Figure 29 (Terminal Block Bus Bars).

Figure 29 - Terminal Block Bus Bars (TT350/TT400/TT500/TT700/TG310/TG390/TG520)



6. Lift and remove the terminal block bus bars.

7. Remove the screws that secure the terminal block to the casting.

8. Remove the terminal block.

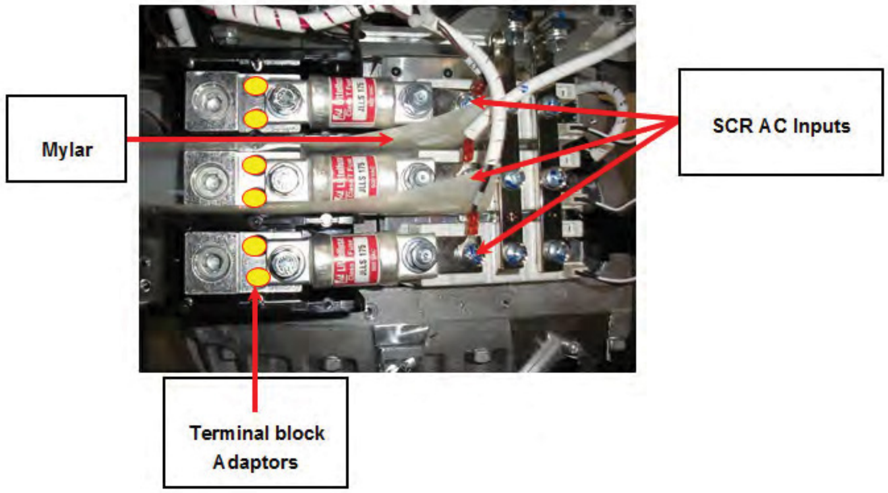
3.3.4.2 Terminal Block Removal (TT300/TG230)

1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

2. Disconnect the main input cables from terminal blocks.

3. Remove the screws that secure the fuse assembly to the SCR at the AC input. Make note of the Soft Start Cable Harness locations. See Figure 30 (AC Input to SCRs (TT300/TG230)).

Figure 30 - AC Input to SCRs (TT300/TG230)



4. Remove the screws from the terminal block adaptors and lift away the fuse assemblies and insulating Mylar. See Figure 30 (AC Input to SCRs (TT300/TG230)).

5. Remove the screws that secure the terminal block to the casting and remove the terminal block.

3.3.4.3 Terminal Block Installation (TT350/TT400/TT500/TT700/TG310/TG390/TG520)

1. Place the terminal block on the two spacers. See Figure 32 (Screws Securing Terminal Block to Casting).

Figure 31 - Terminal Block Spacers

2. Install the screws that secure the terminal block to the casting. See Figure 32 (Screws Securing Terminal Block to Casting).

Figure 32 - Screws Securing Terminal Block to Casting

3. Install the three bus bars to the terminal block and secure them. See Figure 29 (Terminal Block Bus Bars).

4. Install the screws that secure the three terminal block bus bars to the SCR Diodes. See Figure 28 (Terminal Block Bus Bars).

5. Connect the three connectors of the Soft Start Cable Harness to the bus bars. See Figure 28 (Terminal Block Bus Bars).

6. Replace the mains and the top covers.

3.3.4.4 Terminal Block Installation TT300/TG230

1. Place the terminal block on the casting and secure it with the screws.

2. Place the Mylar in the middle of the terminal block before installing the fuse assembly. See Figure 30 (AC Input to SCRs).

3. Install the fuse assemblies and secure the terminal block adaptors to the terminal block. See Figure 30 (AC Input to SCRs).

4. Install the screws that secure the fuse assembly to the SCR at the AC input. Make note of the Soft Start Cable Harness locations. See Figure 25 (Main AC Input Terminal).

3.4 Soft Start Board

3.4.1 Function

The Soft Start Board limits in-rush current when power is applied to the compressor by progressively increasing the conduction angle of the voltage through the SCRs to charge the DC capacitors. It uses a 3-phase voltage input at 50/60Hz, between 380-575VAC, and a DC voltage signal from the SCR output to generate output pulses of 0-12VDC to the SCR gates for the in-rush current control signal.

In addition to monitoring the HV DC bus, the Soft Start carries the fuse that both protects the high power side electronics from the service side and passes HV DC to the DC/DC Converter.

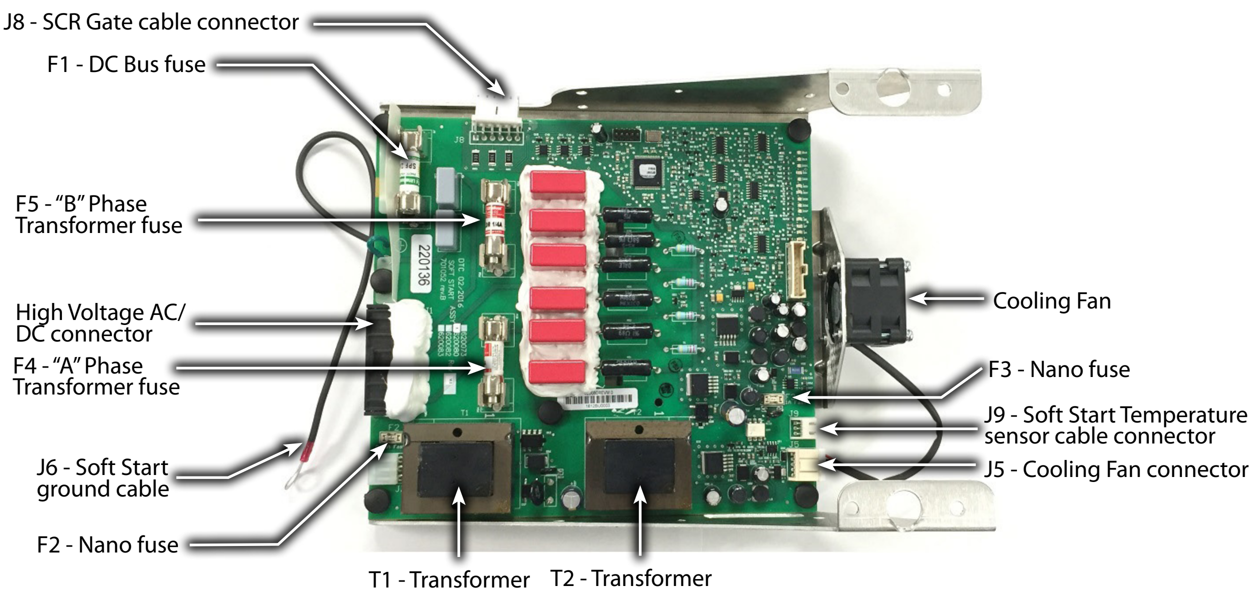
Main AC voltage is passed through a fast-acting fuse to two onboard transformers that reduce the primary voltage to a secondary 15VAC. One transformer powers the Soft Start itself. The second powers the HV DC/DC converter after DC bus voltage levels reach the minimum level. Both transformers pass the secondary voltage through separate Nano fuses.

All DC voltages from the Soft Start Board are with respect to the positive DC bus, not the compressor ground.

3.4.2 Connections

See Figure 33 (Soft Start Board) for cable connection locations:

Figure 33 - Soft Start Board



3.4.3 Verification

3.4.3.1 Verifying Soft Start Voltages

1. Before verifying Soft Start voltages, ensure that the correct 3-phase main AC voltage is present at the Mains Input terminals.

2. Using the DC bus test harness (see Section 1.9) with power applied to the compressor, verify that the expected DC bus voltage is present for the application. Refer to Table 2 (Expected DC Bus Voltage).

• No DC voltage may indicate that the Soft Start is not controlling the SCRs

3. Using the DC bus test harness with power applied to the compressor, verify that the 15VAC to the DC/DC converter is present. Output can range from 12 – 25VAC, depending on primary input voltage.

• No 15VAC may indicate an open F2 or F4 fuse

• If the 15VAC supply is not present at start-up, the DC/DC converter will not function

3.4.3.2 Verifying Soft Start Fuses

NOTE

Fast-acting fuses may show a resistance value other than 0Ω.

1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

2. Remove the screws that secure the Soft Start mounting bracket to the compressor.

3. Lift the Soft Start and turn it over, placing it board-side up on the AC bus bars.

4. Using a multimeter set for resistance measurements, place the leads on the ends of the F1 fuse. The reading should be around 0.25Ω.

• An open F1 fuse may indicate a problem with the DC/DC

5. Using a multimeter set for resistance measurements, place the leads on the ends of the F2 Nano fuse. The reading should be around 1Ω.

• An open F2 fuse may indicate a problem with the DC/DC

6. Using a multimeter set for resistance measurements, place the leads on the ends of the F3 Nano fuse. The reading should be 0.5Ω.

• An open F3 fuse may indicate a problem with the Soft Start Circuit Board.

7. Using a multimeter set for resistance measurements, place the leads on the ends of the F4 and F5 fast-acting fuses. The reading should be around 30-38Ω for either fuse.

• An open F4 or F5 fuse may indicate a problem with the Soft Start transformers, circuit board, or DC/DC Converter.

3.4.4 Removal and Installation

3.4.4.1 Removing the Soft Start

1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

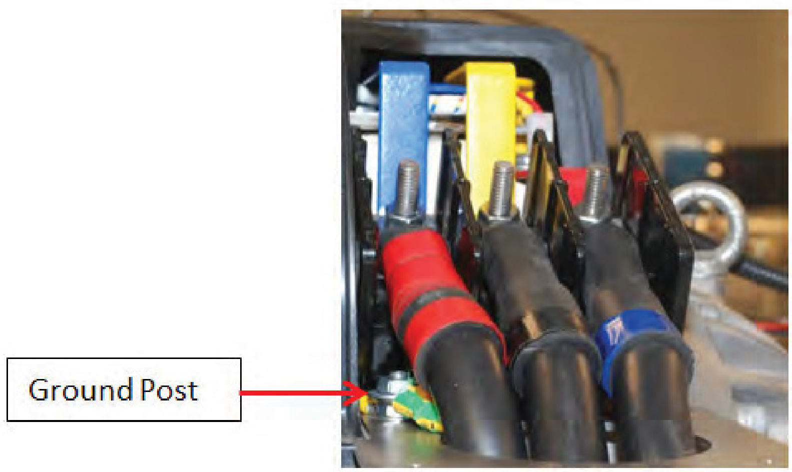
2. Disconnect the Soft Start ground wire by removing the nuts and Mains Input ground wire from the ground post on the compressor housing. See Figure 34 (Mains Input).

3. Remove the screws that secure the mounting bracket to the compressor.

4. Lift the Soft Start and turn it over, placing it board side up on the AC bus bars.

5. Unplug the cable connectors from the Soft Start Board.

Figure 34 - Mains Input



3.4.4.2 Installing the Soft Start

1. Place the Soft Start in position.

2. Secure the screws that hold the mounting bracket to the compressor. Tighten to 5Nm (3.6 ft.lb.).

3. Connect the cable connectors to the Soft Start Board.

4. Connect the Soft Start ground wire to the ground post on the compressor housing. Tighten to 7Nm (5 ft.lb.). See Figure 34 (Mains Input).

5. Connect the Mains Input ground to the ground post. Tighten to 15Nm (11 ft.lb.).

6. Replace topside covers.

3.5 Silicon-Controlled Rectifier

3.5.1 Function

The AC input voltage is connected to the SCRs by the Mains Input bus bars. The SCRs are used to convert the AC voltage into DC voltage. SCRs maintain the high voltage DC bus necessary to provide power to the Inverter to run the compressor motor.

Using both the AC input voltage and the DC voltage output from the SCRs, the Soft Start Board generates the gate signal and outputs pulses of 0-12VDC to the SCRs to control the in-rush current when power is initially applied to the compressor. This is used at compressor start-up while the DC capacitors are charging up.

The DC bus voltage output from the SCRs is about 1.35 times that of the AC input voltage (460-900VDC).

3.5.2 Connections

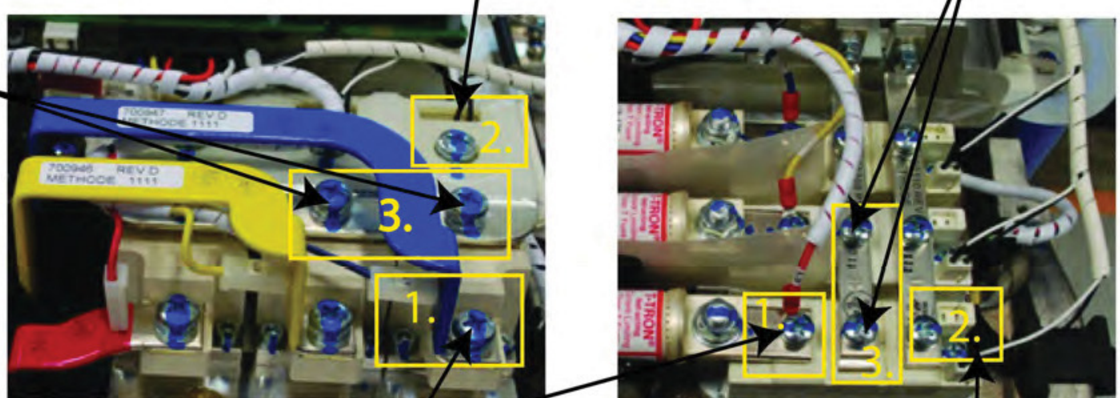
See Figure 35 (SCR Connections) to locate the connections to the SCRs:

1. AC input voltage to SCR

2. SCR Gate cables to Soft Start

3. SCR to DC bus

Figure 35 - SCR Connections (TT300 - left/TG230 - right)



3.5.3 Verification

3.5.3.1 Diodes Verification

NOTE

A faulty SCR module can cause the DC bus and Mains Input current to be imbalanced. This can stress the Inverter and Stator. If an SCR module is found to be faulty, then the Inverter and Stator must also be verified.

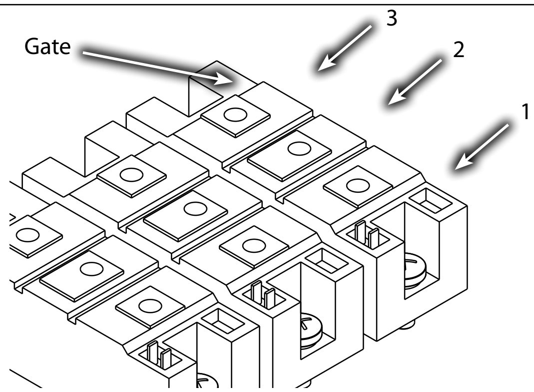
1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

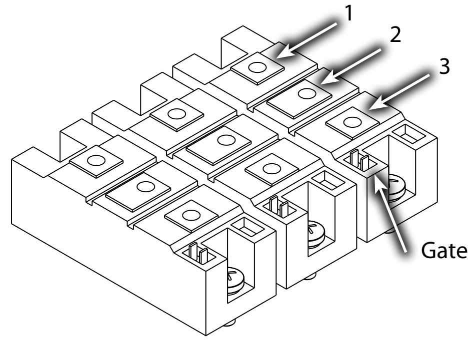
2. Remove the Soft Start.

3. Remove the AC Mains Input bus bars, snubber capacitors and DC bus to isolate the SCRs from the system.

4. Using a multimeter set for diode measurements, place the black (-) lead on terminal 1 of the SCR and place the red (+) lead on terminal 3. The measured value should be between 0.3V and 0.45V. See Figure 36 for terminal locations.

Figure 36 - Silicon-Controlled Rectifier Terminals





5. All other terminals should read infinity or open in both directions (polarity). See Table 10 (SCR Diode Values).

Table 10 - SCR Diode Values

Positive (+) Lead	Negative (-) Lead	Expected Result
1	2	Infinity or Open
1	3	Infinity or Open
2	1	Infinity or Open
3	1	0.3V and 0.45V

3.5.3.2 Gates Verification

1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

2. Using needle-nose pliers, carefully remove the SCR gate cable harness from the SCRs.

3. Using a multimeter set for resistance measurements, place the leads on the two gate terminals. The value should be between 1 to 25Ω.

4. Reverse the leads. The measured value should be the same.

NOTE

These values can vary depending on the meter being used. It is important that the values be consistent between SCRs.

Table 11 - SCR Gate Resistance Ranges

SCR Model	Range
All models	1 - 25Ω

3.5.3.3 SCR Temperature Sensor Verification

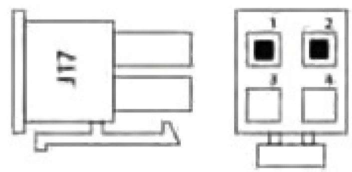
NOTE

The temperature sensor in the SCR manifold is a negative temperature coefficient (NTC) type 10KΩ @ 70°F (21°C).

1. Isolate compressor power and remove the Service Side Cover.

2. Disconnect the SCR temperature sensor cable plug (INTER - J17) from the Backplane Board.

Figure 37 - J17 Connector



3. Using a multimeter set for resistance measurements, place the leads in terminal 1 and 2 of the cable plug. See Figure 36. The value should correspond with an NTC thermistor 10KΩ @ 70°F (21° C).

4. Place the multimeter leads in terminal 1 and 2 of the cable plug. The value should correspond with an NTC 10KΩ @ 70°F (21°C).

3.5.4 Removal and Installation

3.5.4.1 SCR Removal

⚠ • • • CAUTION • • •

It is recommended that all three SCRs be replaced when one is found faulty.

1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

2. Using needle-nose pliers, carefully remove the SCR gate cable harness from the SCRs.

3. Remove the Soft Start and Soft Start Cable Harness.

4. Remove the AC Mains Input bus bars, snubber capacitors, and DC bus. See Figure 35 (SCR Connections) and Figure 38 (DC Bus Components Identification).

5. Remove the screws that secure the SCRs to the cooling manifold.

6. Lift off the SCRs from the cooling manifold and wipe clean the heat sink paste.

3.5.4.2 SCR Temperature Sensor Removal

⚠ • • • CAUTION • • •

TT300/TG230 only: Compressor must be isolated and refrigerant must be recovered before removing the SCR temperature sensor.

1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

2. Using needle-nose pliers, carefully remove the SCR gate cable harness from the SCRs.

3. Remove the Soft Start and Soft Start Cable Harness.

4. Remove the AC Mains Input bus bars and terminal block. See Figure 35 (SCR Connections).

5. Remove the DC bus and snubber capacitors. See Figure 35 (SCR Connections).

6. Disconnect the SCR temperature sensor connector from the cable harness.

7. (TT300/TG230 Only) Loosen the Inverter manifold screws and lift the SCR manifold, allowing the SCR temperature sensor cable to pass under the SCR manifold.

8. Remove the SCR temperature sensor from the SCR manifold.

3.5.4.3 SCR Installation

1. Apply a thin layer of heat sink paste to the bottom of the SCRs.

2. Install the SCRs to the cooling manifold.

3. Install the DC bus and snubber capacitors. See Figure 38.

4. Install the AC Mains Input bus bars. See Figure 35 (SCR Connections).

5. Install the Soft Start cable harness and Soft Start.

6. Using needle-nose pliers, carefully install the SCR gate cable harness to the SCRs.

7. Install the topside covers.

3.5.4.4 SCR Temperature Sensor Installation

1. Install the SCR temperature sensor into the SCR manifold.

2. (TT300/TG230 Only) Lift the SCR manifold and route the SCR temperature sensor cable under the SCR manifold.

3. (TT300/TG230 Only) Tighten the Inverter manifold screws.

4. Connect the SCR temperature sensor connector to the cable harness.

5. Install the DC bus and snubber capacitors. See Figure 38 (DC Bus Components Identification).

6. Install the terminal block and AC Mains Input bus bars. See Figure 35 (SCR Connections).

7. Install the Soft Start Cable Harness and Soft Start.

8. Using needle-nose pliers, carefully install the SCR gate cable harness to the SCRs.

9. Install the topside covers.

3.6 DC Bus

3.6.1 Function

The DC bus includes the bus bars, DC capacitors, snubber capacitors, and bleed resistors. See Figure 38 (DC Bus Components Identification).

The SCRs output DC voltage to the bus bars.

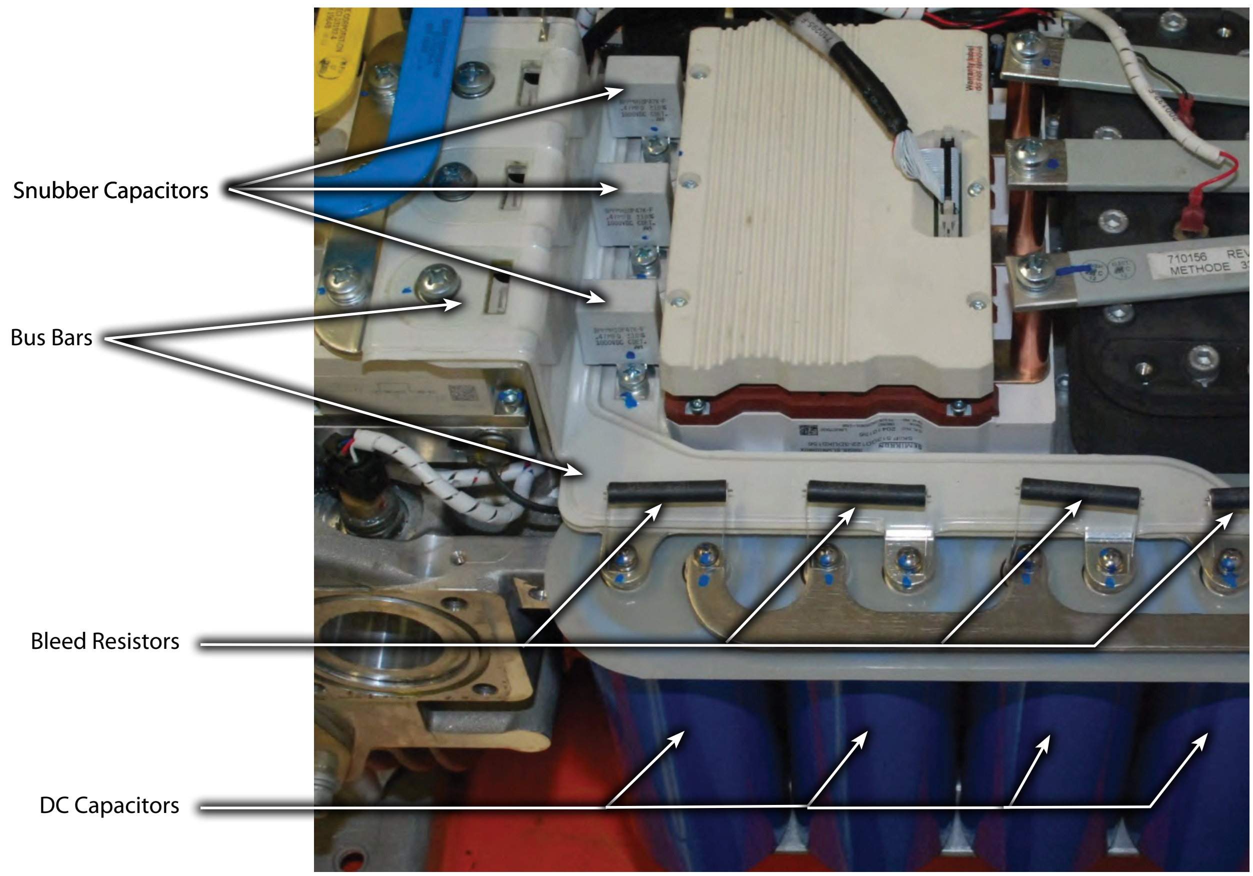
DC capacitors serve as energy storage and filter out the voltage ripple associated with the operation of the rectifier circuit and any voltage unbalance in the 3-phase supply.

Snubber capacitors reduce noise associated with the Inverter switching frequency.

Bleed resistors are used to discharge the capacitors after power is removed to allow the compressor to be serviced safely.

See Figure 38 (DC Bus Components Identification) for location of the DC bus components.

Figure 38 - DC Bus Components Identification



⚠ • • • CAUTION • • •

The DC Bus Capacitor Assembly should not be disassembled. Bleed resistors, bus bars, and capacitors are factory assembled and should only be removed and installed as a single component. Incorrect dissassembly/assembly will result in damage to the compressor.

3.6.2 Connections

See Figure 39 for location of the DC bus connections.

1. +DC to Soft Start

2. -DC to Soft Start and DC/DC

3. DC bus to Inverter

3.6.3 Verification

3.6.3.1 DC Bus Voltage Verification

Use the DC bus test harness to determine if DC bus voltage is within the correct range for the application. See Section 1.9 (DC Bus Test Harness Installation and Removal).

3.6.3.2 Bleed Resistor Verification

1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

2. Disconnect the bleed resistor from one side of the capacitor.

3. Bend the bleed resistor back slightly until it no longer contacts the DC bus.

⚠ • • • CAUTION • • •

A faulty bleed resistor can be the result of a faulty DC capacitor.

4. Using a multimeter set for resistance measurement, place the leads on each of the bleed resistor terminals. The measured value should be between 24.3kΩ and 29.7kΩ for TT300/TG230 compressors or between 16.2kΩ and 19.8kΩ for TT350, TT400, TT500, TT700, TG310, TG390, and TG520 compressors.

3.6.3.3 Snubber Capacitor Verification

1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

2. Remove the Soft Start Module.

3. Remove the snubber capacitors.

4. Using a multimeter set for capacitance measurement, place the leads on the capacitor terminals. The measured value should be 0.42µF to 0.52µF.

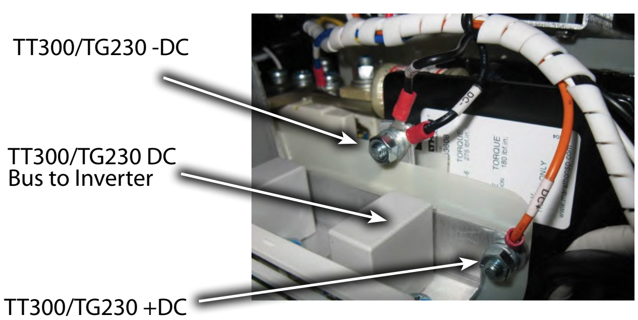
3.6.4 Removal and Installation

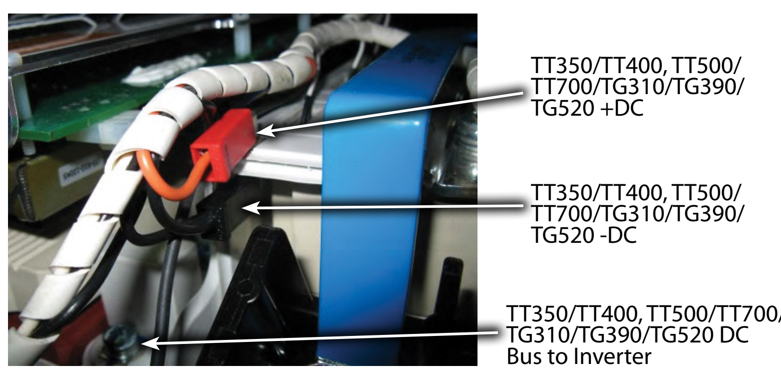
3.6.4.1 DC Bus Removal

1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

2. Remove the Soft Start and the Soft Start Cable Harness. See Figure 39 (Soft Start Cable Harness to DC Bus).

Figure 39 - Soft Start Cable Harness to DC Bus





3. Disconnect the SCR DC bus bars from the capacitor DC bus bars (TT300/TG230 only). See Figure 40 (Removing Attaching Hardware from DC Bus Bars).

Figure 40 - Removing Attaching Hardware from DC Bus Bars (TT300/TG230 Pictured)

4. Using needle-nose pliers, carefully remove the SCR gate cable harness (TT350, TT400, TT500, and TT700 only).

5. Remove main AC bus bars (TG310, TG390, TG520, TT350, TT400, TT500, and TT700 only).

6. Remove the screws that secure the DC bus bars to the SCRs (TG310, TG390, TG520, TT350, TT400, TT500, and TT700 only).

7. Remove the snubber capacitors.

8. Remove the nylon nuts at the base of the DC Capacitor Assembly, located under the main compressor housing.

9. Lift out the DC capacitors and DC bus as an assembly. See Figure 41 (Removing DC Capacitor Assembly).

Figure 41 - Removing DC Capacitor Assembly (TT300/ TG230)

3.6.4.2 DC Bus Installation

1. (TT300/TG230 only) Place the insulating Mylar on the Inverter. See Figure 42 (Insulating Mylar on Inverter).

Figure 42 - Insulating Mylar on Inverter (TT300/TG230 Only)

2. Place the DC capacitors and DC bus on the compressor as an assembly. See Figure 41 (Removing DC Capacitor Assembly).

3. Install the nylon nuts at the base of the DC Capacitor Assembly, located under the main compressor housing.

4. Install the snubber capacitors.

5. Install the screws that secure the DC bus bars to the SCRs (TT350, TT400, TT500, TT700, TG310, TG390, and TG520 only).

6. Install Soft Start Cable Harness (TT350, TT400, TT500, TT700, TG310, TG390, and TG520 only). See right side of Figure 39 (Soft Start Cable Harness to DC Bus).

7. Install the main AC bus bars (TT350, TT400, TT500, TT700, TG310, TG390, and TG520 only).

8. Using needle-nose pliers, carefully install the SCR gate cable harness (TT350, TT400, TT500, TT700, TG310, TG390, and TG520 only).

9. Connect the SCR DC bus bars to the capacitor DC bus bars (TT300/TG230 only). See Figure 40 (Removing Attaching Hardware from DC Bus Bars).

10. Install the Soft Start Sable Harness (TT300/TG230 only). See left side of Figure 39 (Soft Start Cable Harness to DC Bus).

11. Install the Soft Start Board.

3.7 Inverter

3.7.1 Function

The function of the Inverter (also known as the IGBT) is to take the DC bus voltage as an input and generate the AC output voltage to the compressor motor at the required fundamental frequency to generate the requested shaft speed. Voltage to the motor is also controlled to provide the appropriate motor torque.

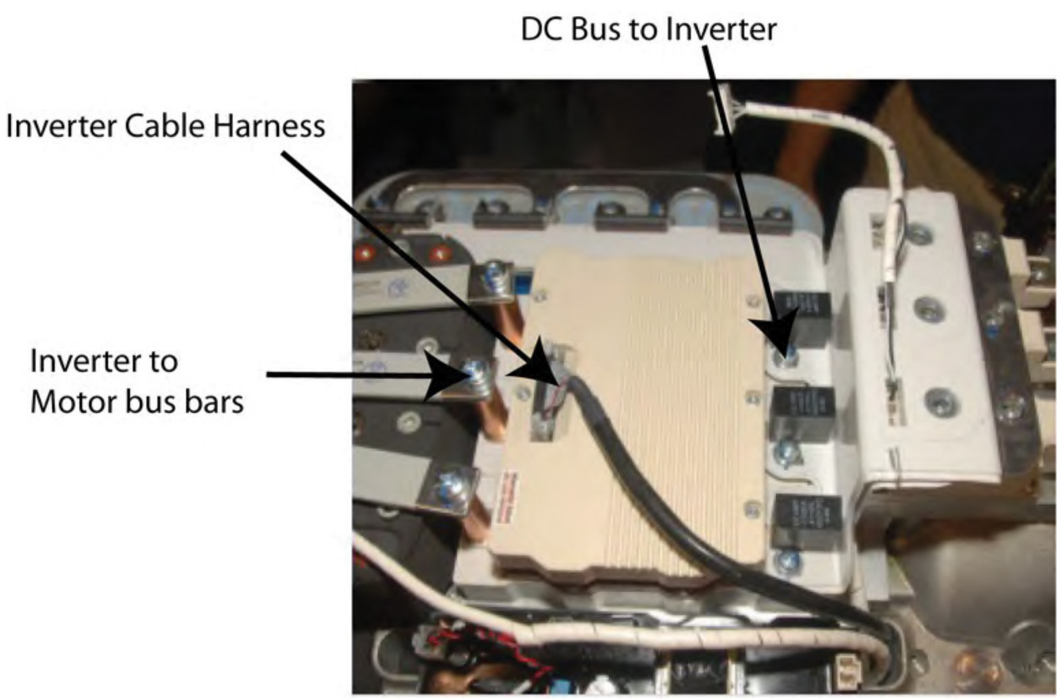
The Backplane sends +24VDC and gating signals to the Inverter from the BMCC. In return, the Inverter sends current, temperature, error, and DC bus voltage information to the BMCC via the Backplane. Motor currents and voltages displayed in the SMT cannot be directly compared or correlated to incoming 3-phase AC values.

In the event of a 3-phase voltage power loss while the compressor is running, the Inverter switches to Generator Mode, acting as a rectifier to maintain the DC bus voltage until the shaft comes to a complete stop and de-levitates.

3.7.2 Connections

See Figure 43 (Inverter Connections) for connection locations of the Inverter.

Figure 43 - Inverter Connections



3.7.3 Verification

3.7.3.1 Inverter Verification

This procedure only verifies the Inverter diodes. The Inverter Control Board cannot be verified in the field. A faulty Inverter may also appear as an "Inverter Error Signal Active" fault.

1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

2. Remove the Soft Start Module.

3. Remove the DC Capacitor Assembly.

4. Remove the copper standoffs and fasteners connecting the motor bus bars to the Inverter Module.

5. Disconnect the Inverter ribbon cable from the Inverter Module.

⚠ • • • CAUTION • • •

A faulty Inverter module could be the result of a faulty Stator. If an Inverter module is found to be faulty, the Stator must be verified as well.

6. Using a multimeter set for diode measurements, place the red (+) multimeter lead on the phase 1 AC terminal and the black (-) multimeter lead on the DC+ terminal. The measured value should be 0.275V – 0.4V. See Figure 44 (Inverter Connections).

7. Keeping the red (+) multimeter lead on the phase 1 AC terminal, place the black (-) multimeter lead on the DC- terminal. The measured value should be open. See Figure 44 (Inverter Connections).

8. Place the black (-) multimeter lead on the phase 1 AC terminal and the red (+) multimeter lead on the DC+ terminal and record the results. The measured value should be open. See Figure 44 (Inverter Connections).

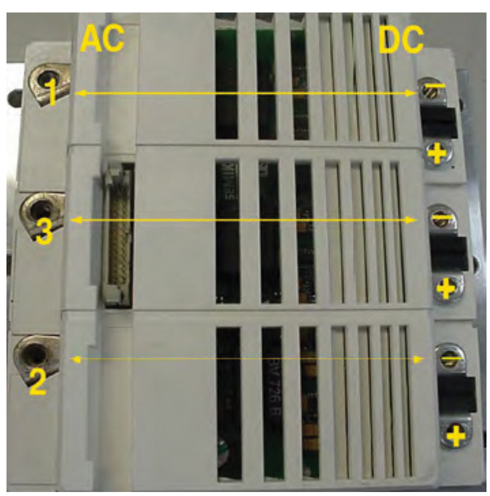
9. Keeping the black (-) multimeter lead on the phase 1 AC terminal, place the red (+) multimeter lead on the DC- terminal. The measured value should be 0.275V – 0.4V. See Figure 44 (Inverter Connections).

10. Repeat Steps 6 through 9 for the remaining Inverter phases. See Figure 44 (Inverter Connections).

NOTE

These values can vary depending on the meter being used. The main idea is that the values be consistent between phases.

Figure 44 - Inverter Connections (TT300/TG230)



3.7.4 Removal and Installation

⚠ • • • CAUTION • • •

Removal of the Inverter mounting screws will release refrigerant. Isolation and recovery of the refrigerant must be performed by a qualified service technician adhering to industry/ASHRAE standards.

This section details the steps to remove and install the IGBT Control Card (all models except for the TT300/TG230) and also the entire Inverter assembly. If the Inverter proves to be working properly and the IGBT Control Card has been confirmed to have failed, follow the removal and installation steps for the IGBT Control Card.

3.7.4.1 IGBT Control Card Removal

NOTE

The TT300/TG230 Compressor IGBT Control Cards are not serviceable.

1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

2. Remove the Soft Start Board.

3. Remove the Mains Input terminal and bus bars.

4. Remove the DC capacitor and bus assembly.

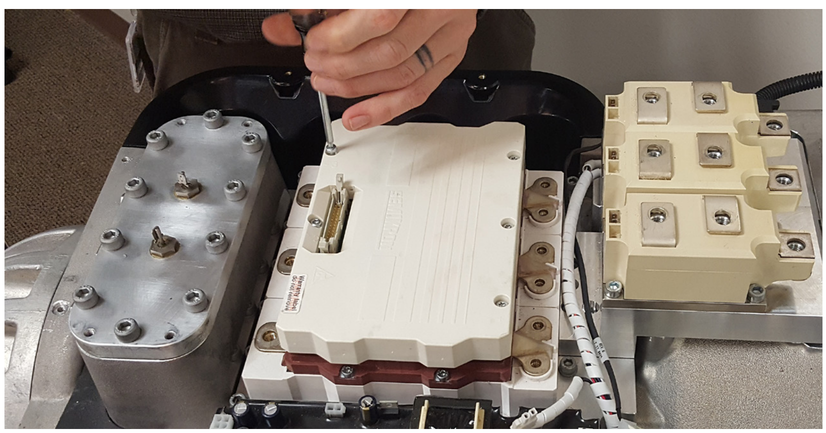
5. Disconnect the ribbon cable from the Inverter.

6. Remove the copper tubes that connect the motor bus bars to the Inverter.

Important: Do not remove the screws that secure the Inverter to the compressor main housing.

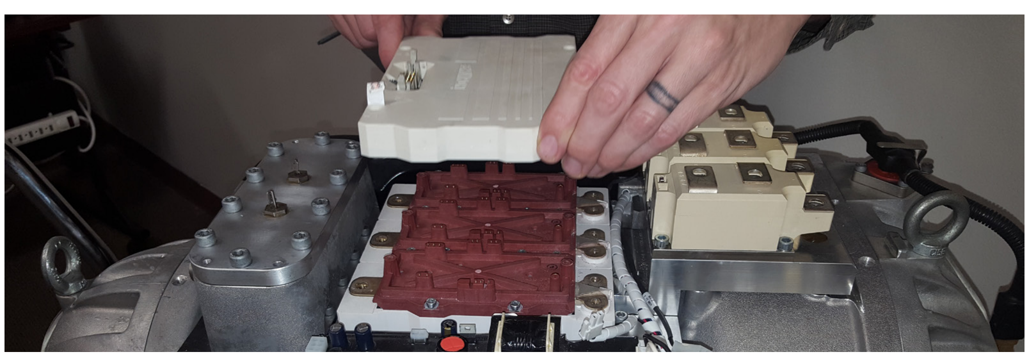
7. Unscrew the six (6) screws using a T15 Torx bit. Begin on the outside and work towards the center.

Figure 45 - Driver Board Screw Removal



8. Carefully lift the driver board vertically.

Figure 46 - Driver Board Removal



9. Set aside the driver screws for re-use.

10. Properly discard the old driver board.

⚠ • • • CAUTION • • •

Do not move or touch any spring pins unless they are not in proper alignment. Damage or misalignment of spring pins can cause failure of the entire Inverter module.

3.7.4.2 IGBT Control Card Installation

1. Verify that all spring pins are present and that they are in proper alignment (refer to Figure 50 (Seated Spring Pins)). There should be a total of 39 pins. There are two (2) different length spring pins, if any are replaced, be sure to replace with the same length spring pin. Figure 47 (Long Spring Pin Locations) identifies the location of the "long" spring pins; all other spring pins are "short." Figure 48 (Spring Pin Identification) identifies the difference between the two different spring pin lengths.

NOTE

Use *extreme* care when removing the new driver board and cover from the packaging. The cover snaps into place over the driver board but could separate. Be sure to hold both to avoid dropping the driver board if separation occurs. If they do become separated, carefully snap the cover back into place prior to assembly. ESD protection must be worn when handling the driver board.

Figure 47 - Long Spring Pin Locations

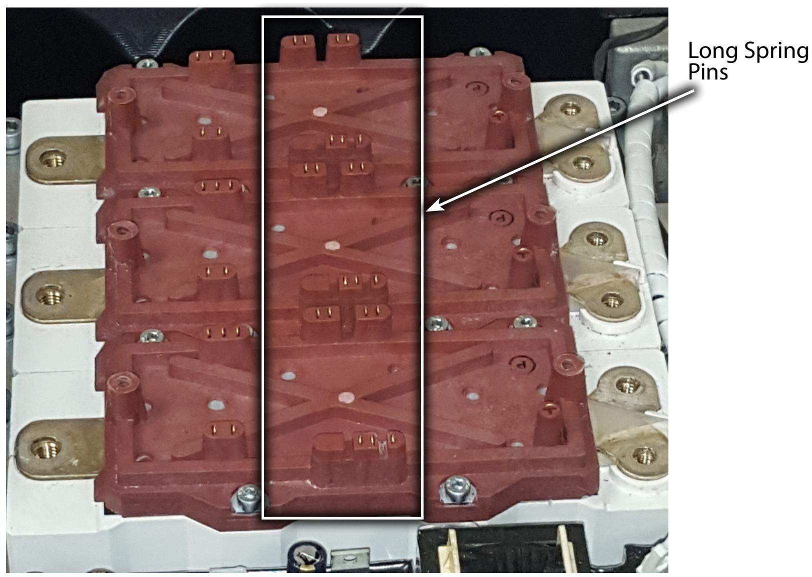
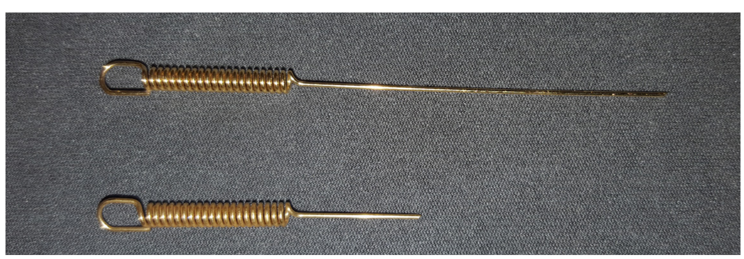


Figure 48 - Spring Pin Identification



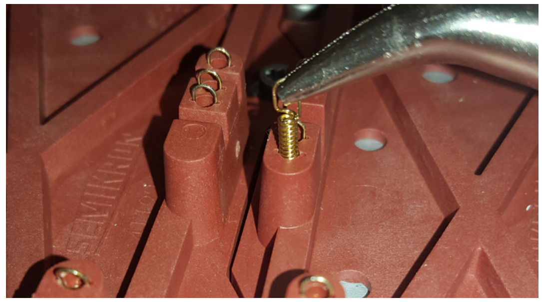
2. Replace any defective spring pins (bent pin head or inconsistent height on top with others) with new ones. Only do this when absolutely necessary. When removing the spring pins, use small needle-nose pliers and gently pull straight up with no lateral movement.

NOTE

Do not attempt to straighten or repair any damaged pins.

3. Discard the defective spring pins and inspect the IGBT for any foreign objects.

Figure 49 - Spring Pin Removal



4. Insert the new pins carefully and verify they line up in the notches. Refer to Figure 50 (Seated Spring Pins).

Figure 50 - Seated Spring Pins

5. For proper alignment, insert two (2) of the screws in opposite corners of the Driver Board.

6. Align the new Driver Board over the IGBT module with the connector towards motor stator output bus bar (the shape of Driver Board must be aligned with IGBT Press Plate shape).

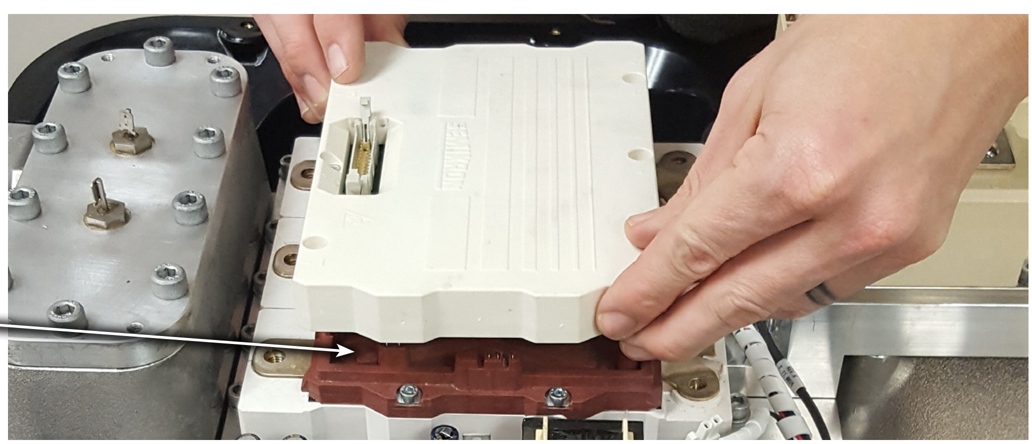
7. Insert the screws into the corresponding Press Plate holes.

8. Moving in a vertical direction only, lower the Driver Board down on the IGBT module, do not allow for any lateral movement.

• • • CAUTION • • •

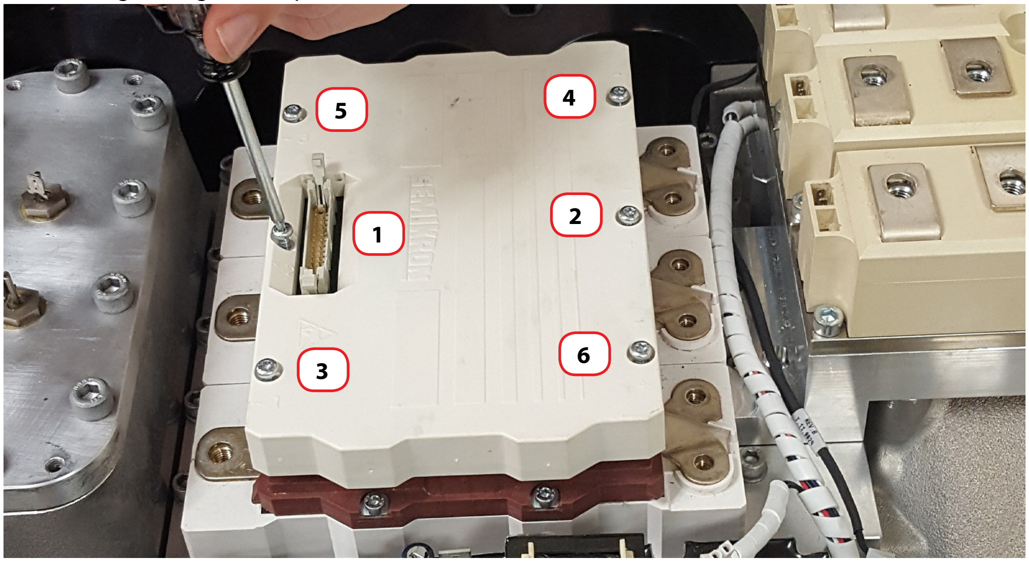
Any lateral movement may damage the spring pins.

Figure 51 - Driver Board Placement



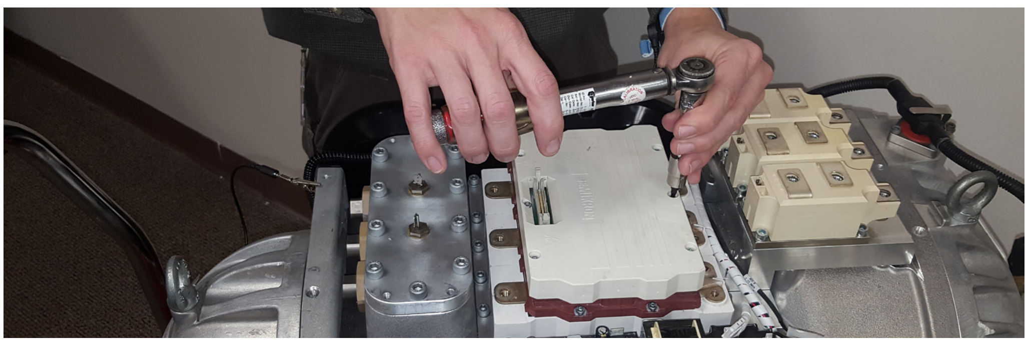
9. Insert the remaining screws and tighten the screws from center outward according to Figure 52 (Initial Tightening Pass Sequence). This will be the first pass and the screws should only be snug and not torqued at this step.

Figure 52 - Initial Tightening Pass Sequence



10. Using an appropriately rated torque wrench, tighten the screws from center outward (same sequence as previous step) to 1.5 Nm (13.2 in. lbs.).

Figure 53 - Final Torque



NOTE

It is recommended to verify Inverter functionality using an inverter tester prior to reassembly of the top-side electronics.

11. Install the copper tubes that connect the motor bus bars to the Inverter.

12. Connect the ribbon cable from the Inverter.

13. Install the DC capacitor and bus assembly.

14. Install the Mains Input terminal and bus bars.

15. Install the Soft Start Board.

16. Connect all remaining cable harnesses.

17. Replace compressor covers.

18. Apply mains power to the compressor.

⚠ • • • CAUTION • • •

Removal of the Inverter mounting screws will release refrigerant. Isolation and recovery of the refrigerant must be performed by a qualified service technician adhering to industry/ASHRAE standards.

3.7.4.3 Inverter Removal

1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

2. Recover the refrigerant from the compressor.

3. Remove the Soft Start Board.

4. Remove the Mains Input terminal and bus bars.

5. Remove the DC capacitor and bus assembly.

6. Remove the HV DC/DC Converter.

7. Disconnect the ribbon cable from the Inverter.

8. Remove the copper tubes that connect the motor bus bars to the Inverter.

9. Remove the DC bus bars from SCRs (TT300/TG230 only).

10. Disconnect the SCR gate connectors from the SCRs (TT300/TG230 only).

11. Remove the screws that secure the Inverter to the compressor main housing. See Figure 54 (Removing the Inverter).

12. Disconnect the SCR temperature sensor connector.

13. Remove the SCR cooling manifold (TT350, TT400, TT500, TT700, TG310, TG390, and TG520 only).

14. Carefully remove the Inverter and discard the O-ring.

Figure 54 - Removing the Inverter (TT300/TG230 Shown)

3.7.4.2 Inverter Installation

1. Clean the O-ring groove in housing.

2. Install the O-ring into the groove of the main compressor housing.

3. Carefully install the Inverter.

4. Install the SCR cooling manifold (TT350, TT400, TT500, TT700, TG310, TG390, and TG520 only).

5. Route the SCR temperature sensor cable under the SCR cooling manifold.

6. Connect the SCR temperature sensor connector to the cable harness.

7. Install Inverter screws in a diagonal sequence. Torque to 6Nm (4.5 ft./lb.).

8. Leak test the compressor in accordance with industry standard.

9. Evacuate compressor to appropriate pressure and industry accepted standards.

10. Connect the SCR gate connectors to the SCRs (TT300/TG230 only).

11. Install the DC bus bars to the SCRs (TT300/TG230 only).

12. Install the copper tubes that connect to the motor bus bars to the Inverter.

13. Connect the ribbon cable to the Inverter.

14. Install the HV DC/DC Converter.

15. Install the DC capacitor and bus assembly.

16. Install the Mains Input terminal and bus bars.

17. Install the Soft Start Module.

3.8 Motor

3.8.1 Function

The motor type employed is a permanent magnet, synchronous speed motor. The winding section of the motor is similar in design to a standard 3-phase star-connected Stator.

3.8.1.1 Stator

The Stator operates as the force that drives the shaft, utilizing the HV DC pulses provided to the motor windings by the Inverter.

3.8.1.2 Rotor

The rotor is an integral part of the motor shaft and is a permanent magnet design that allows the synchronous characteristic required for broad range speed control.

3.8.2 Motor Protection

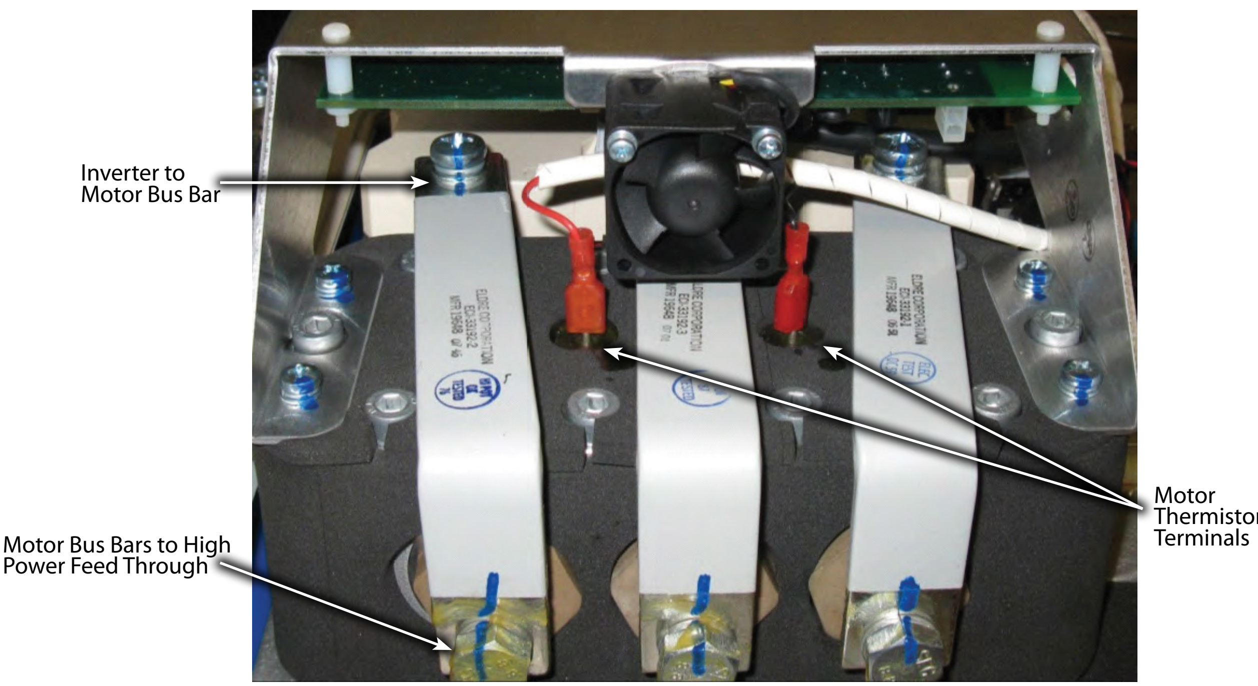
Conventional motor protection based on incoming 3-phase currents and voltage conditions are inadequate to protect the motor and electronics in the event of mishap due to the total separation of the motor windings from the incoming 3-phase current by the DC conversion. Therefore, the bulk of protection is based on measurements taken by the Inverter and calculations derived from those measurements. Motor currents and voltages displayed in the SMT cannot be directly compared or correlated to incoming 3-phase AC values.

All Stators employ overheat cutout protection utilizing thermistors in each winding. In all models except the TT300/TG230, Stator temperature initiation and control of the motor winding/shaft cavity cooling solenoid is provided.

3.8.3 Connections

See Figure 55 (Connection to Stator) to identify connections to the motor.

Figure 55 - Connection to Stator



3.8.4 Verification

3.8.4.1 Stator Insulation Verification

⚠ • • • CAUTION • • •

Do not attempt to perform an insulation test on a component under vacuum. This can cause insulation breakdown or failure during the testing process.

1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

2. Remove the Soft Start Module.

3. Remove the copper standoffs and fasteners connecting the motor bus bars to the Inverter Module.

⚠ • • • CAUTION • • •

A faulty Stator can cause the Inverter to fail.

4. Using a mega-ohm meter set for 1000VDC measurements, connect the red (+) mega-ohm meter lead to one of the three motor bus bars and the black (-) mega-ohm meter lead to the compressor housing. The measured value should be greater than 100 mega-ohms. If the measured value does not correspond to the expected resistance, then the Stator insulation is faulty and the compressor needs to be replaced.

5. Repeat Step 4 for the remaining two motor bus bars to ensure all windings are intact.

3.8.4.2 Stator Resistance Verification

To verify the Stator resistance, complete the following steps:

1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

2. Remove the Soft Start Module.

3. Remove the copper standoffs and fasteners connecting the motor bus bars to the Inverter Module.

4. Using a multimeter set for resistance measurements, place the red (+) multimeter lead on one of the three motor bus bars and the black (-) multimeter lead on another motor bus bar and record the results. The measured value should be less than 1Ω but not zero. If the measured value is 0.0Ω or greater than 1Ω, then the Stator winding is faulty and the compressor must be replaced.

5. Repeat Step 4 for the remaining combinations of motor bus bars to ensure all windings are intact.

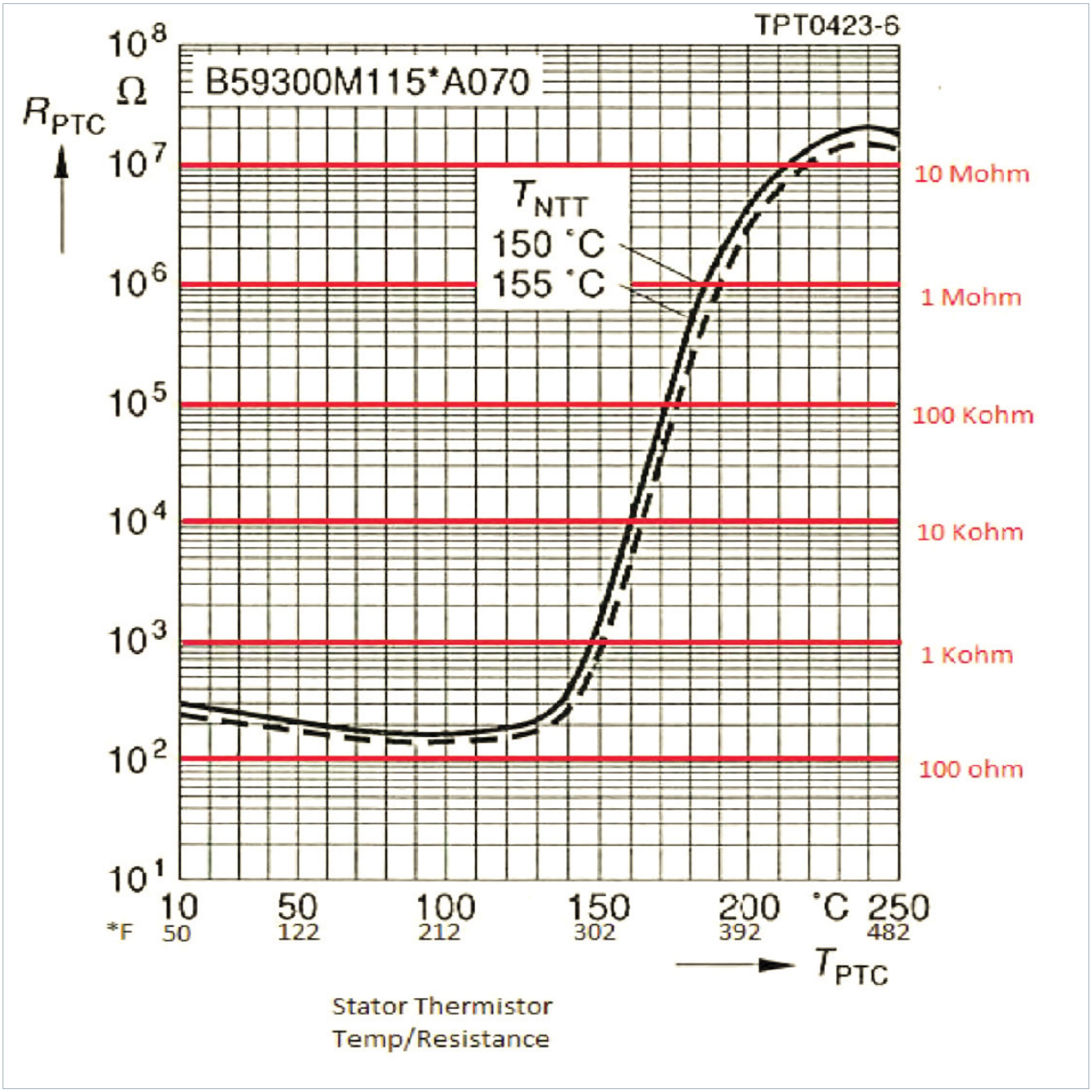
3.8.4.3 Stator Thermistor Resistance Verification

1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

2. Disconnect the DC supply cable harness from the motor thermistor terminals. See Figure 55 (Connection to Stator).

3. Using a multimeter set for resistance measurements, place the red (+) multimeter lead on one motor thermistor terminal and the black (-) multimeter lead on the other motor thermistor terminal. The measured value should correspond to the expected resistance outlined in Figure 56 (Stator Thermistor R/T Curve 1) (150-300Ω at 70°F (21°C)). If the measured value does not correspond to the expected resistance, then the Stator thermistor is faulty and the Stator assembly must be replaced. Due to the fact that this is not a field-serviceable component, the compressor must be replaced.

Figure 56 - Stator Thermistor R/T Curve 1



3.9 High-Voltage DC/DC Converter

3.9.1 Function

The HV DC/DC Converter provides the Backplane with +24VDC (with respect to 0V) and HV+ (+250VDC with respect to HV-) for the Bearing PWM Amplifier.

DC bus voltage (460-900VDC) is supplied to the HV DC/DC converter through the Soft Start Board F1 fuse. The Soft Start Board also powers the HV DC/DC Converter with 15VAC when the DC bus has reached minimum level.

3.9.2 Connections

See Figure 57 (DC/DC Converter Connections) for the HV DC/DC Converter input-output (I/O) connections:

Inputs:
1.J1 HV DC Bus
2. J4 15VAC

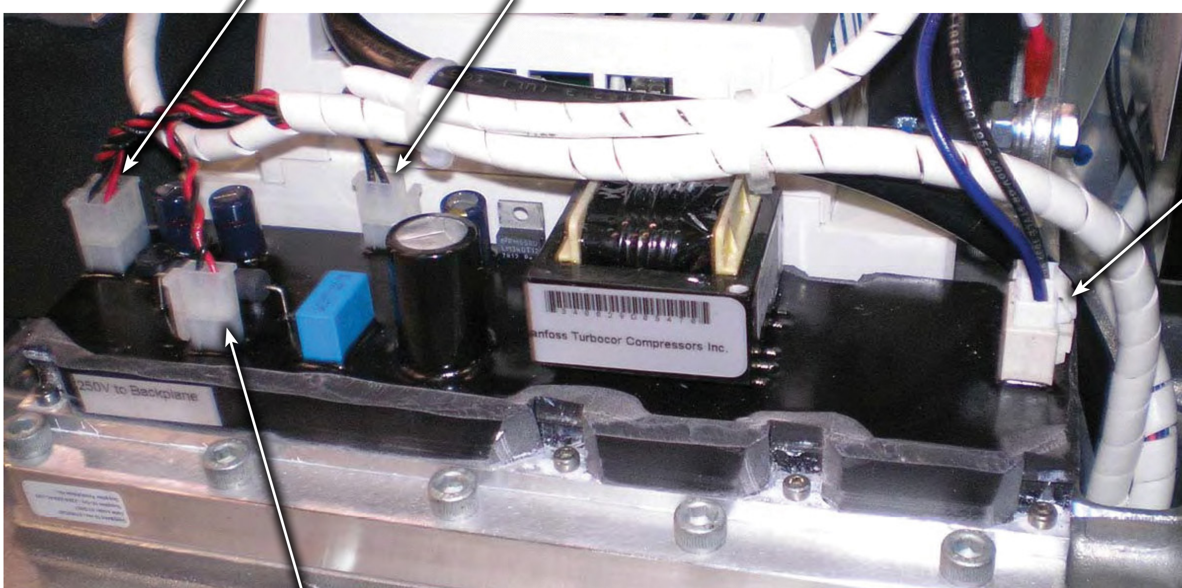
Outputs:
3. J2 250VDC
4. J3 24VDC

Figure 57 - DC/DC Converter Connections

J3

J4

J1



J2

3.9.3 Verification

3.9.3.1 Input Voltage Verification

1. Isolate the compressor power as described in the “Electrical Isolation of the Compressor” section of this manual.

2. Install the DC bus test harness.

3. Turn on the mains power to the compressor.

4. Using the DC bus test harness, verify the expected voltages are present.

3.9.3.2 Output Voltage Verification

1.Remove the Service Side Cover.

2. With main power on, using a multimeter set for DC voltage measurements, place the multimeter leads in the HV+ and HV- test points on the Backplane. See Figure 60 (Backplane Connections and Test Points), terminal A and B. The result should be 220 – 280 VDC.

3. Place the multimeter leads in the +24 and 0V test points on the Backplane. See Figure 60 (Backplane Connections and Test Points). The result should be 22 – 26 VDC.

3.9.3.3 Input Resistance Verification

1. Isolate the compressor power as described in the “Electrical Isolation of the Compressor” section of this manual.

2. Unplug all connectors to the HV DC/DC Converter.

3. Using a multimeter set for resistance measurements, place the multimeter leads in the J1, HV DC input plug terminals. See Figure 57 (DC/DC Converter Connections). The result should not be 0.0Ω. The result can be open or >150kΩ.

4. Reverse the multimeter leads on the J1 plug terminals. See Figure 57 (DC/DC Converter Connections). The result should not be 0.0Ω. The result can be open or >150kΩ.

5. Place the multimeter leads in the J4, 15VAC input terminals. See Figure 57 (DC/DC Converter Connections). The result should be >1MΩ.

6. Reverse the multimeter leads on the J4 terminals. See Figure 57 (DC/DC Converter Connections). The result should be >1MΩ.

3.9.3.4 Output Resistance Measurement

1. Isolate the compressor power as described in the “Electrical Isolation of the Compressor” section of this manual.

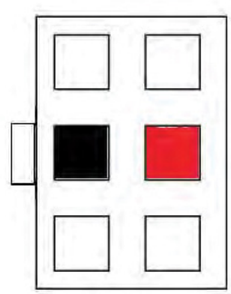
2. Unplug all connectors to the HV DC/DC Converter.

3. Using a multimeter set for resistance measurements, place the multimeter leads on the J2, 250VDC output terminals. See Figure 57 (DC/DC Converter Connections). The result should be a rising or falling value, not zero or infinity.

4. Reverse the multimeter leads on the J2 terminals. The result should be a rising or falling value, not zero or infinity.

5. Place the multimeter leads in the middle row of the J3, 24VDC output terminals. See Figure 57 (DC/DC Converter Connections) and Figure 58 (J3 24 VDC Output Connector). The result should be a rising or falling value, not zero or infinity.

Figure 58 - J3 24VDC Output Connector



6. Reverse the multimeter leads on the J3 terminals and measure the resistance. The result should be a rising or falling value, not zero or infinity.

3.9.4 Removal and Installation

3.9.4.1 HV DC/DC Converter Removal

1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

2. Remove the Soft Start.

3. Unplug all connectors to the HV DC/DC Converter.

4. Loosen the screws next to the Inverter.

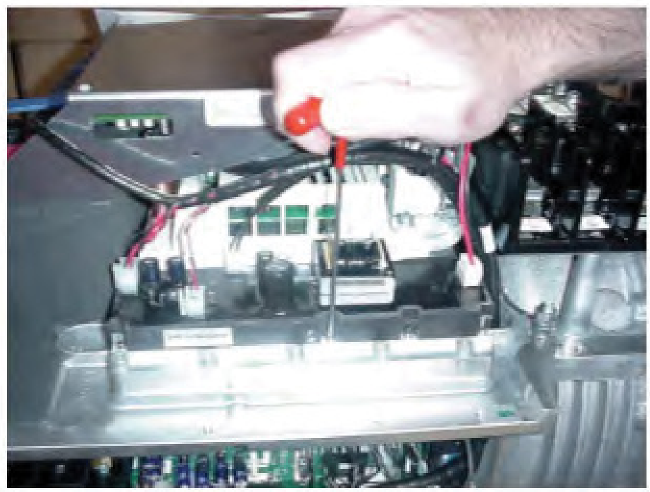
5. Remove the screws located on front side of the converter. See Figure 59 (HV DC/DC Converter Removal).

6. Lift the HV DC/DC Converter by the front side and slide it clear of the rear screws.

⚠ • • • CAUTION • • •

Do not lift the DC/DC by the transformer.

Figure 59 - HV DC/DC Converter Removal



3.9.4.2 HV DC/DC Converter Installation

1. Apply heat conductive paste to the underside of the HV DC/DC Converter heat sink plate.

2. Slide the HV DC/DC Converter under the screws pre-set in the Inverter plate.

3. Insert the front screws and tighten the eight screws that secure the HV DC/DC Converter to the Inverter plate. See Figure 59 (HV DC/DC Converter Removal).

4. Plug in all connectors to the HV DC/DC Converter.

5. Install the Soft Start.

3.10 Backplane

3.10.1 Function

The Backplane is powered by +24VDC (with respect to 0V) from the HV DC-DC Converter. The HV DC/DC Converter also provides the Backplane with HV+ (+250VDC with respect to HV-) for the Bearing PWM Amplifier. The Backplane connects the onboard plug-in modules with the power electronics, expansion valves, IGV stepper motor, motor-cooling solenoids, bearing sensors, and pressure/temperature sensors. It is a means to transfer control, sensor, and error information between the BMCC and other compressor components.

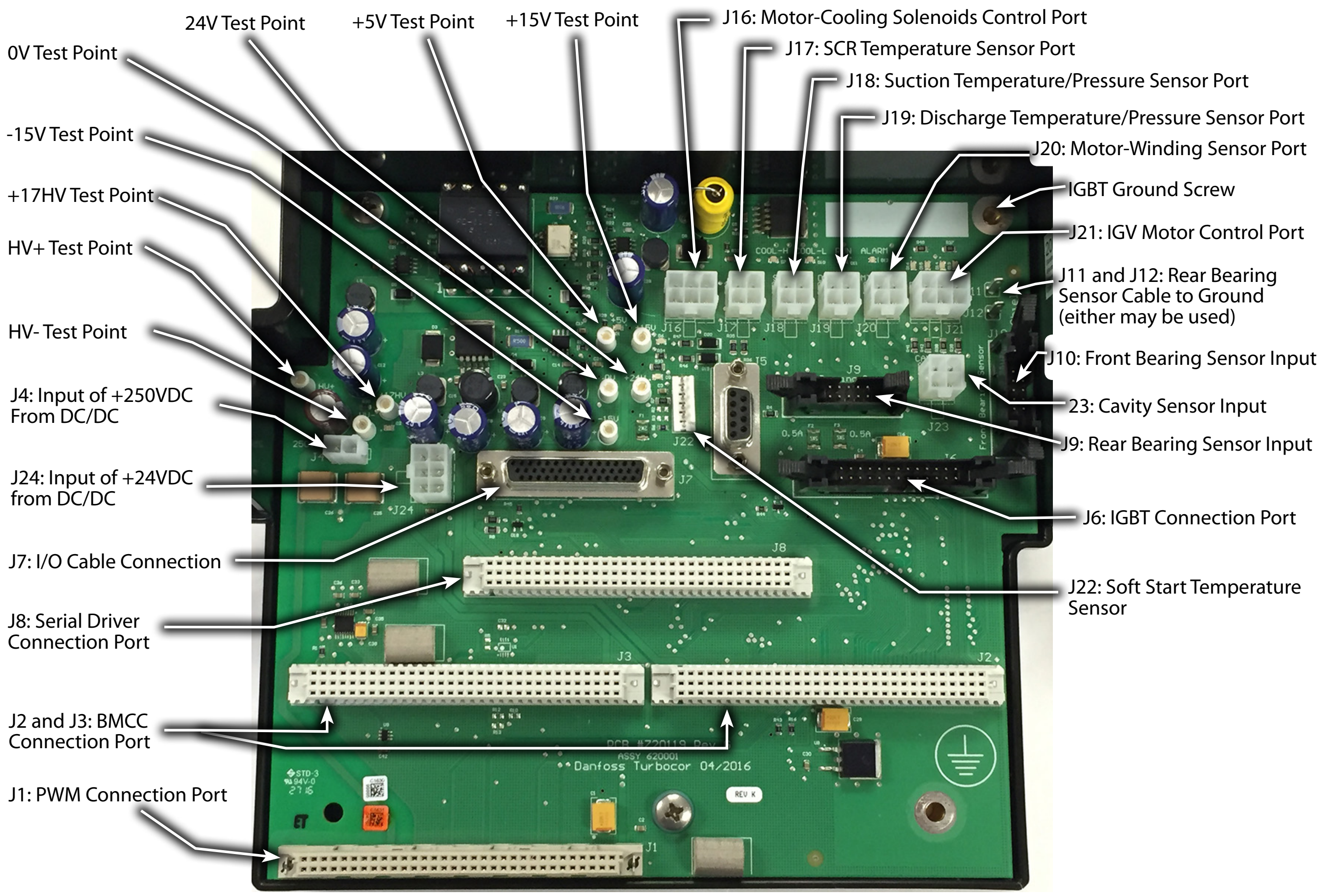
The Backplane also serves as the source of power to the parts connected to it. It features onboard, low-voltage DC/DC converters for converting +5V, +15V, -15V, and +17V from its input of +24VDC. Note that the +5V, +15V, and 15V are with respect to 0VDC, but the +17V is with respect to HV-.

The Backplane is also equipped with status-indicating light-emitting diodes (LEDs). All LEDs are amber in color except for the alarm LED (D12) which is green or red, depending on alarm status.

3.10.2 Backplane Connections and Test Points

The Backplane connections and test points are indicated in Figure 60 (Backplane Connections and Test Points).

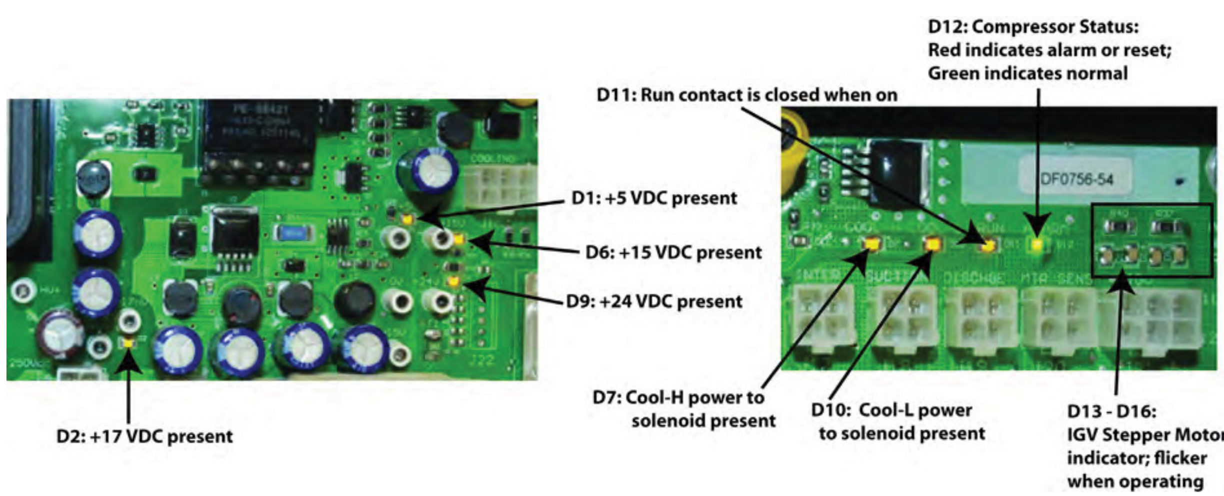
Figure 60 - Backplane Connections and Test Points



3.10.2.1 LED Locations

The LED locations are indicated in Figure 52 (LED Locations).

Figure 61 - LED Locations



3.10.2.2 Backplane Verification

NOTE

The test-point LEDs are ON if any voltage is present. The test points must be measured to determine the actual voltage.

1. Remove the Service Side Cover.

2. With main power on, using a multimeter set for DC voltage measurements, place the multimeter leads in the Backplane test points as defined in Table 12 (Backplane Test Point Values). See Figure 60 (Backplane Connections and Test Points). The results should be within the voltage range specified in the table.

3. Isolate compressor power.

4. Unplug connectors J4 and J24 from the Backplane.

5. Using a multimeter set for resistance measurements, place the multimeter leads in the Backplane test points as defined in Table 12 (Backplane Test Point Values). See Figure 60 (Backplane Connections and Test Points). The results should be greater than the resistance specified in the table.

6. If one of the test points does not output the expected voltage and the HV+ and +24V test points output the correct voltage, remove the Serial Driver, BMCC, and PWM.

7. Plug connectors J4 and J24 to the Backplane.

⚠ • • • CAUTION • • •

The Inverter cable must be connected to the Backplane, J6, if the BMCC is removed and power is applied to the compressor.

8. Repeat Step 2. If the voltages are as expected, the Backplane is functioning correctly.

Table 12 - Backplane Test Point Values

Test Point	Test Point Reference	DC Voltage Range	Minimum Resistance
HV+	HV-	220 to 280	250Ω
+17HV	HV-	16.5 to 17.85	28Ω
+24V	0V	22 to 26	9Ω
+15V	0V	14.75 to 15.25	20Ω
+15V	0V	-14.75 to -15.25	150Ω
+5V	0V	4.75 to 5.25	8Ω

3.10.3 Removal and Installation

3.10.3.1 Backplane Removal

1. Isolate compressor power and wait for the Backplane LEDs to go out.

2. Remove the J4 and J24 connectors from the Backplane.

3. Remove the Bearing PWM Amplifier, Serial Driver, and BMCC.

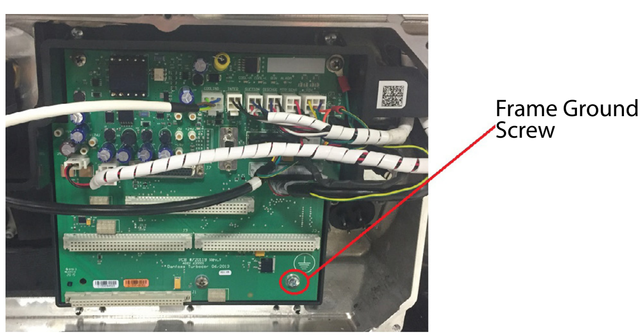
4. Disconnect all remaining connectors from the Backplane. See Figure 60 (Backplane Connections and Test Points).

5. Remove the Inverter ground screw from top right of the Backplane to release the Inverter cable ground ring.

6. Replace the Inverter ground screw.

7. Remove the fasteners at the top of the Backplane frame and the frame ground screw at the bottom right that secures the Backplane to the housing. See Figure 62 (Removing the Backplane).

Figure 62 - Removing the Backplane



8. Remove the Backplane from the housing.

3.10.3.2 Backplane Installation

1. Align the Backplane with the mounting holes, ensuring the cavity temperature sensor connector is available.

2. Insert and tighten fasteners at the top of the Backplane Frame.

3. Insert and tighten frame ground screw at the bottom right of the Backplane. See Figure 62 (Removing the Backplane).

4. Install all connectors to their appropriate locations. See Figure 60 (Backplane Connections and Test Points).

5. Remove the Inverter ground screw from top right of the Backplane.

6. Connect Inverter ground ring to Inverter ground screw and install at top right of Backplane.

7. Reinstall the Bearing PWM Amplifier, the BMCC, and the Serial Driver. See Figure 70 (BMCC Insertion Guides).

8. Reinstall cover.

3.11 Serial Driver

3.11.1 Function

The Serial Driver is powered with +15VDC and +24VDC from the Backplane.

The Serial Driver provides +24VDC to the Motor-Cooling Solenoids, +15VDC to the IGV stepper motor, and +15VDC to the external expansion valves on the I/O board.

The Serial Driver also controls the RUN and Alarm LEDs on the Backplane and the STATUS indicator on the I/O board.

All actions of the Serial Driver occur when signaled from the BMCC.

3.11.2 Connections

The Serial Driver is connected to J8 of the Backplane. All components that communicate with the Serial Driver are connected to the Backplane. See Figure 60 (Backplane Connections and Test Points).

3.11.3 Verification

3.11.3.1 Input Voltage Verification

1. Remove the Service Side Cover.

2. With main power on, using a multimeter set for DC voltage measurements, verify the voltage on the Backplane +15V and +24V test points as defined in Table 12 "Backplane Test Point Values." See Figure 60 (Backplane Connections and Test Points). The results should be within the voltage range specified in Table 12 (Backplane Test Point Values).

3. Isolate compressor power and wait for the Backplane LEDs to go out.

4. Unplug connectors J4 and J24 from the Backplane.

5. Using a multimeter set for resistance measurements, place the multimeter leads in the Backplane +15V and +24V test points as defined in Section 3.10.2.1 "LED Locations." The results should be greater than the resistance specified in Table 12 (Backplane Test Point Values).

3.11.3.2 Output Voltage Verification

1. Remove the Service Side Cover.

2. Isolate compressor power and wait for the Backplane LEDs to go out.

3. Wait a minimum of one minute.

4. Reapply compressor power.

• The Alarm LED will illuminate green and the Cool-H, Cool-L and Run LEDs will illuminate amber, all for about five seconds. The Alarm LED will then switch to red and the others will turn off. See Figure 61 (LED Locations).

• After the compressor completes start-up check, The Alarm LED will change to green (provided no alarm is present)

and the IGV LEDs will flicker until the IGV is reset. Additionally, if an external expansion valve is connected to the I/O board, the LEDs on the I/O board will flicker as the external expansion valve is reset.

3.11.4 Removal and Installation

3.11.4.1 Serial Driver Removal

1. Isolate compressor power.

2. Remove the Service Side Cover verifying the LEDs on the Backplane have turned off.

3. Carefully disconnect the Serial Driver from the Backplane. See Figure 70 (BMCC Insertion Guides).

3.11.4.2 Serial Driver Installation

1. Carefully align the Serial Driver on top of the BMCC. See Figure 70 (BMCC Insertion Guides).

2. Slide the Serial Driver onto the J8 connector on the Backplane.

3. Install the Service Side Cover.

3.12 Solenoids and Actuators

3.12.1 Function

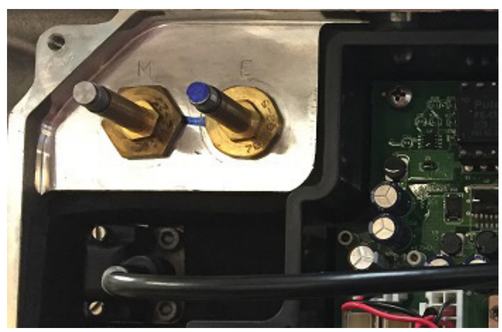
The solenoids pass the high pressure liquid refrigerant to the low pressure motor and/or electronics cooling path.

The solenoid actuator coils control the opening and closing of the solenoids.

3.12.2 Connections

Solenoids are secured to the service side of the compressor housing in the upper left. See Figure 63 (Cooling Valve Bodies).

Figure 63 - Cooling Valve Bodies

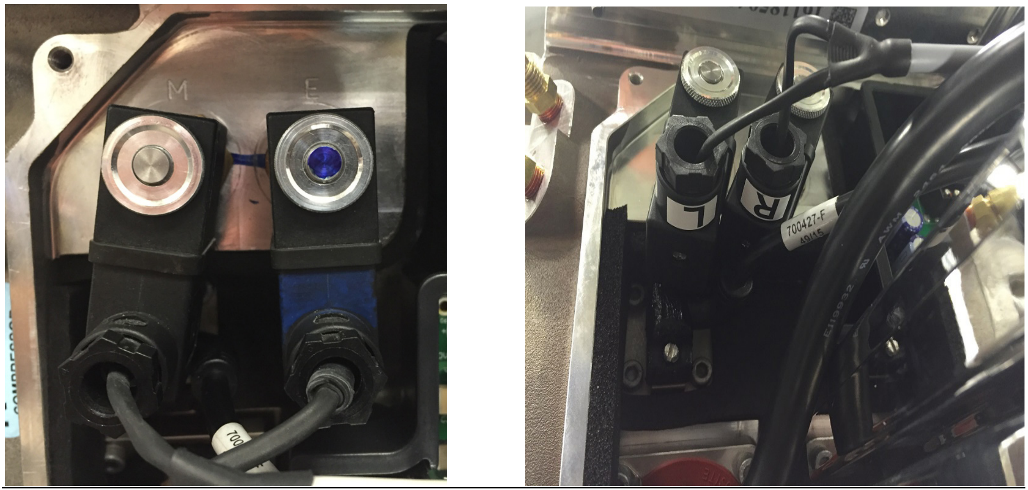


Solenoid orifice size will vary between compressor models. The size can be identified by reading the number stamped into the solenoid orifice body. For solenoid identification by model, reference the Danfoss Turbocor Spare Parts Guide.

Solenoid actuator coils are secured to the solenoids by nuts hand tightened at the back of each actuator. See Figure 64 (Motor Cooling Solenoid Actuators).

Power is supplied to the actuators through the Backplane from the Serial Driver and controlled by signals from the BMCC to the Serial Driver. The actuator cable is clipped to J16 on the Backplane. See Figure 60 (Backplane Connections and Test Points).

Figure 64 - Motor Cooling Solenoid Actuators



3.12.3 Verification

3.12.3.1 Resistance Measurement of Cooling Solenoid Actuator Coils

⚠ • • • CAUTION • • •

When actuator coils are removed from the solenoids, they must be replaced in the same location. Incorrect installation can result in damage to compressor components.

1. Isolate compressor power.

2. Remove the Service Side Cover.

3. Disconnect the Motor-Cooling Solenoid Connector (J16) from the Backplane.

4. Set the multimeter for resistance measurement.

5. Observe the voltage and power specification indicated on the side of the Motor-Cooling Solenoids. From Table 13 (Solenoid Actuator Coil Resistance Ranges), find the expected resistance for the left and right Motor-Cooling Solenoids.

6. To measure the resistance across the left Motor-Cooling Solenoid, place the meter probes at Pins 1 and 3 of the cable connector. See Figure 65 (Motor Cooling Solenoid Cable Connector).

7. To measure the resistance across the right Motor-Cooling Solenoid, place the meter probes at Pins 5 and 6 of the cable connector. See Figure 65 (Motor Cooling Solenoid Cable Connector).

Table 13 - Solenoid Actuator Coil Resistance Ranges

Model	Voltage	Power	Resistance
TT300 starting at 142035030, TT350, TT500, TT700, TG230, TG310, TG390, & TG520	24V	9.3W	56.25Ω – 68.75Ω
TT300 prior to 142035030	24V	4.8W	108Ω – 132Ω

Figure 65 - Motor Cooling Solenoid Cable Connector

3.12.3.2 Output Voltage to Solenoids

1. Remove the Service Side Cover.

2. To ensure the Serial Driver is providing power to the solenoids, look for the Cool-L and Cool-H LEDs on the Backplane. See Figure 60 (Backplane Connections and Test Points).

3. When the solenoids are energized, measure the +24V test point on the Backplane to verify the Serial Driver is providing power to the motor cooling solenoids.

3.12.3.3 Cooling Path Blockage Inspection

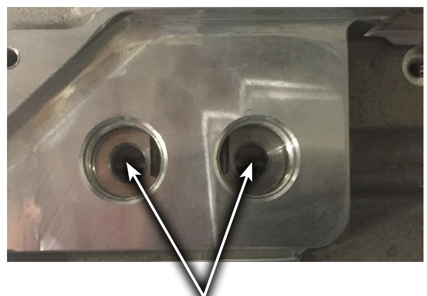
1. Isolate compressor power.

2. Isolate the compressor; recover the refrigerant according to industry standards.

3. Remove the actuators, solenoids and orifice.

4. Ensure that the cooling paths are clean, as shown in Figure 66 (Solenoid Cooling Path).

Figure 66 - Solenoid Cooling Path (TT300/TG230 Shown)



3.12.4 Removal and Installation

NOTE

On current TT350, TT400, TT500, TT700, TG310, TG390, and TG520 models and certain TT300 models, the solenoid valve bodies may have different orifice sizes due to the split-cooling configuration. It is important to not get the left and right confused when removing and installing these solenoid bodies. See Figure 64 (Motor Cooling Solenoid Actuators).

⚠ • • • CAUTION • • •

Removal of the compressor solendoids will release refrigerant. Isolation and recovery of the refrigerant must be performed by a qualified service technician adhering to industry/ASHRAE standards.

3.12.4.1 Solenoid Removal

1. Isolate compressor power.

2. Recover the refrigerant from the compressor.

3. Remove the Service Side Cover

4. Disconnect the solenoid actuator coils connector from the Backplane.

5. Remove the solenoid actuator coils.

6. Remove the solenoid body and cooling valve orifice.

3.12.4.2 Solenoid Installation

1. Lubricate a new O-ring with O-ring lubricant and install it on the valve.

2. Insert the valve orifice and solenoid body in the opening and engage the first few threads by hand.

3. Tighten the valve using a socket and driver.

4. Leak test compressor to appropriate pressure and industry accepted standards.

5. Evacuate compressor to appropriate pressure and industry accepted standards.

6. Reinstall solenoid actuator coils.

7. Reconnect the solenoid coils to the Backplane.

8. Reinstall Service Side Cover.

9. Reapply power to compressor.

Compressor Components

For split cooling models ONLY

•The actuator coil positions are dedicated.

•The coils can be disassembled to verify the wire colors for proper reinstallation.

•The right-side coil can be identified by a blue mark on the outside of the component or by the presence of an "R" affixed to the coil. See Figure 64 (Motor Cooling Solenoid Actuators).

•The left-side coil can be identified by no mark present or the presence of an "L" affixed to the coil. See Figure 64 (Motor Cooling Solenoid Actuators).

3.13 IGV

3.13.1 Function

The IGV assembly consists of movable vanes and a motor. The IGV assembly is a variable-angle guiding device that is used to control the capacity at low-load conditions. The IGV position can vary between approximately 0% (closed/perpendicular to flow) and 100% (open/parallel to flow). The vane angle is determined by the BMCC and controlled by the Serial Driver. The Serial Driver, in turn, uses +15VDC to control the IGV stepper motor.

3.13.2 Connections

NOTE

Refer to Figure 58 (IGV Connections) for the location of the IGV connections.

1. The IGV assembly is bolted to the compressor housing.

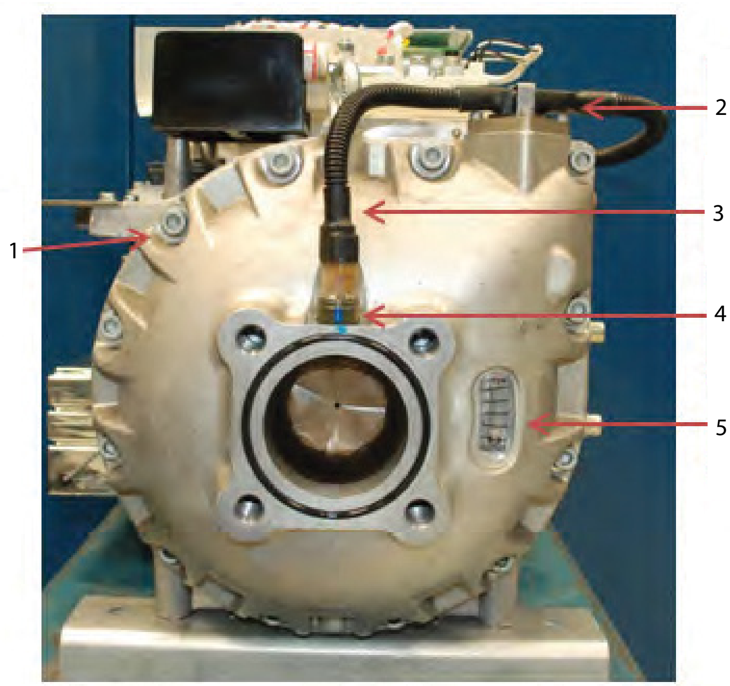
2. The compressor controller cable is held to the IGV Motor feed through by the cable clip.

3. The compressor controller cable continues on to the suction pressure/temperature sensor.

4. The suction pressure/temperature sensor is connected to the IGV Housing.

5. IGV Position Indicator

Figure 67 - IGV Connections



3.13.3 Verification

3.13.3.1 IGV Stepper Motor Verification

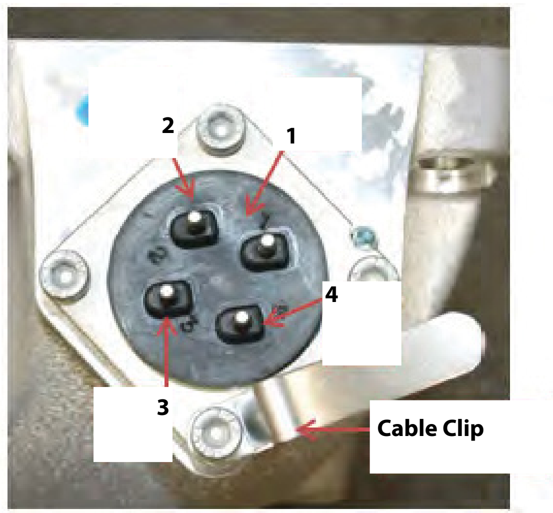
1. Isolate compressor power.

2. Disconnect the compressor controller cable from the suction pressure/temperature sensor and the IGV Motor power feed through. See Figure 67 (IGV Connections).

3. Measure the resistance between terminals 1 and 2, and 3 and 4 of the IGV Motor feed through. The measured value should be between 46Ω and 59Ω. See Figure 68 (IGV Motor Feed Through).

4. Measure the resistance between the IGV Motor feed through terminals and the IGV Housing. The measured value should be open or infinity.

Figure 68 - IGV Motor Feed Through



3.13.3.2 IGV Operation Verification

1. Remove the Service Side Cover.

2. Open the Service Monitor Tool (SMT) installed on your computer and connect to the compressor.

3. Open the **Compressor Configuration** tool. Set the *Compressor Control Mode* to **Manual Control** by selecting **Manual Control** from the *Compressor Control Mode* drop-down list.

4. Open the **Compressor Monitor** tool.

5. In the *IGV Open Percentage* parameter box, **input 110%**.

6. On the Backplane, there are four LEDs that should light up when the IGV Motor is being driven. See Figure 61 (LED Locations).

• Check that all four LEDs are blinking and that the IGV position indicator moves toward open. See Figure 67 (IGV Connections).

7. In the *IGV Open Percentage* parameter box, **input 0%**.

8. Check that all four LEDs are blinking and that the IGV position indicator moves toward closed. See Figure 67 (IGV Connections).

9. Measure the +15V test point on the Backplane to verify voltage is supplied to the Serial Driver for the IGV.

3.13.4 Removal and Installation

⚠ • • • CAUTION • • •

Removal of the IGV mounting screws will release refrigerant. Isolation and recovery of the refrigerant must be performed by a qualified service technician adhering to industry/ASHRAE standards.

3.13.4.1 IGV Removal

1. Isolate compressor power.

2. To disconnect power to the IGV Motor, remove the clamp securing the connector. See Figure 68 (IGV Motor Feed Through).

3. Detach the connector on the IGV Housing. See Figure 69 (Disconnecting the Power to the IGV Motor).

Figure 69 - Disconnecting Power to the IGV Motor

4. Recover the refrigerant from the compressor.

5. Disconnect the cable at the suction sensor. See Figure 67 (IGV Connections).

6. Remove the bolts that secure the IGV assembly to the compressor housing. See Figure 67 (IGV Connections).

7. Pull the IGV assembly away from the compressor housing.

3.13.4.2 IGV Installation

1. Install the O-ring into the groove of the main compressor housing.

2. Position the IGV Housing in place.

3. Install the bolts and washers, tighten in a diagonal pattern to 25Nm (18.4 ft./lb).

4. Leak test compressor to appropriate pressure and industry accepted standards.

5. Evacuate compressor to appropriate level and industry accepted standards.

6. Reconnect the cable at the feed through connector on the IGV Housing.

7. Secure the connector clamp.

8. Reconnect the suction sensor connector.

3.14 BMCC

3.14.1 Function

The BMCC is the central processor board of the compressor. Based on sensor inputs, it controls the bearing and motor system and maintains compressor control within the operating limits.

• The BMCC uses +5VDC, +15VDC, and -15VDC power supplied from the Backplane.

• The BMCC relays compressor information over RS-485/RS-232 via Modbus communication.

3.14.2 Connections

The BMCC is connected to J2 and J3 on the Backplane. See Figure 60 (Backplane Connections and Test Points).

3.14.3 Verification

⚠ • • • CAUTION • • •

When the BMCC is disconnected from the Backplane, it is important that the Inverter remain connected. Either the BMCC or Inverter is required to be connected to the Backplane before applying power to the compressor.

3.14.3.1 BMCC Power Supply Verification

1. Remove the Service Side Cover.

2. Measure the voltages at the +15V, -15V, and +5V test points.

3. Isolate compressor power and wait for the Backplane LEDs to go out.

4. Remove the BMCC from the Backplane.

5. Verify if the Inverter cable is connected to the Backplane.

6. Turn ON the AC input power and measure the voltages at the +15V, -15V, and +5V test points. The measured voltages should be similar to those measured when the BMCC is installed.

3.14.3.2 BMCC Communication Verification

1. Using the SMT installed on your computer, connect to the compressor using the Compressor Connection Manager tool.

2. If the system is able to connect, the BMCC is able to communicate with the user interface.

3. If the system is not able to connect, verify:

a. The BMCC is properly connected to the Backplane.

b. The I/O cable connection between the Backplane and the Compressor I/O Board is properly attached.

c. The cable connection between the Compressor I/O Board (RS485 or RS232) and the user interface (user PC or chiller controller) is properly attached.

d. Inspect Backplane for indication of damage.

4. Cycle power and reattempt communication with the compressor.

3.14.4 Removal and Installation

3.14.4.1 BMCC Removal

1. Isolate compressor power.

2. Remove the Service Side Cover verifying the LEDs on the Backplane have turned off.

3. Carefully, remove the Serial Driver.

4. Carefully, pull the BMCC straight out of the Backplane connector.

3.14.4.2 BMCC Installation

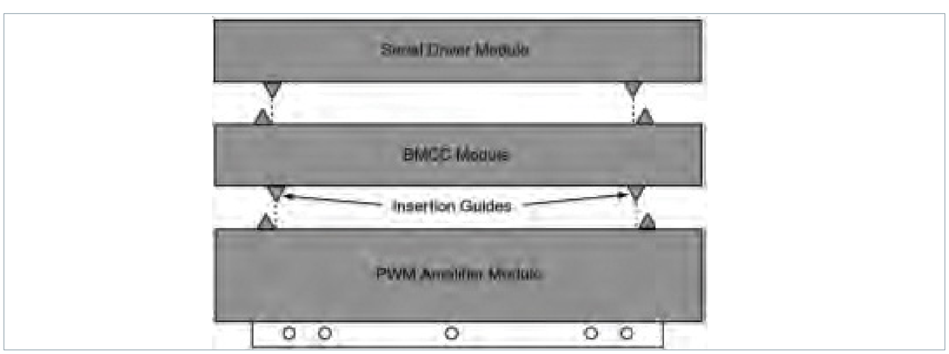
⚠ • • • CAUTION • • •

When replacing the BMCC, a bearing calibration must be performed and saved to electrically erasable programmable read-only memory (EEPROM). This may need to be done up to three times. The BMCC will then use the new values stored in EEPROM to operate the compressor. Using default calibration data from a newly installed BMCC to operate a compressor could cause erratic behavior.

1. Align the two lower insertion guides of the BMCC so that they are on the inside of the two upper insertion guides on the Bearing PWM Amplifier. See Figure 70 (BMCC Insertion Guides).

2. Slide the BMCC straight into the connector until firmly seated in the Backplane connector. See Figure 70 (BMCC Insertion Guides).

Figure 70 - BMCC Insertion Guides



3. Reinstall the Serial Driver.

4. Reinstall Service Side Cover.

5. Reapply power to compressor.

6. If a BMCC that is not original to the compressor is installed, a calibration must be completed and saved to the EEPROM to match the BMCC to the compressor. See Section 4.3 (Bearing Calibration).

3.15 Compressor Interface Module

3.15.1 Function

The Compressor Interface Module (CIM), also referred to as the Compressor I/O Board, allows the user to control the compressor and allows the compressor to return status and sensor information to the user. See Figure 71 (Compressor Interface Module Ports) and Figure 72 (Compressor Interface Module Jumper Locations) for I/O board connection locations.

3.15.2 Connections

Figure 71 - Compressor Interface Module Ports

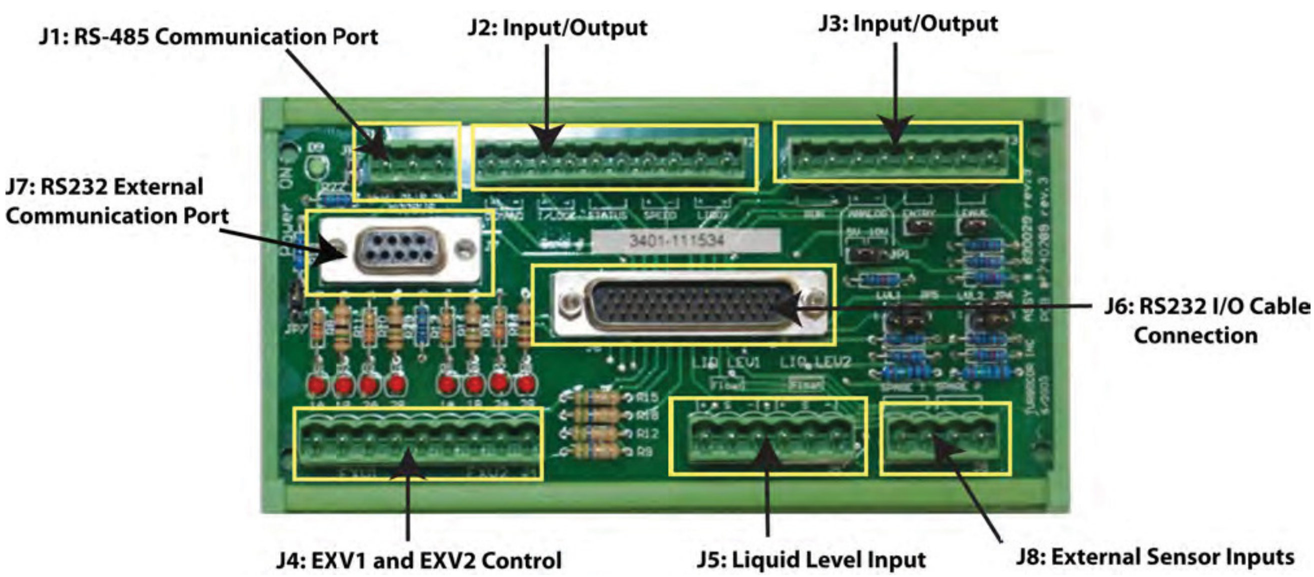
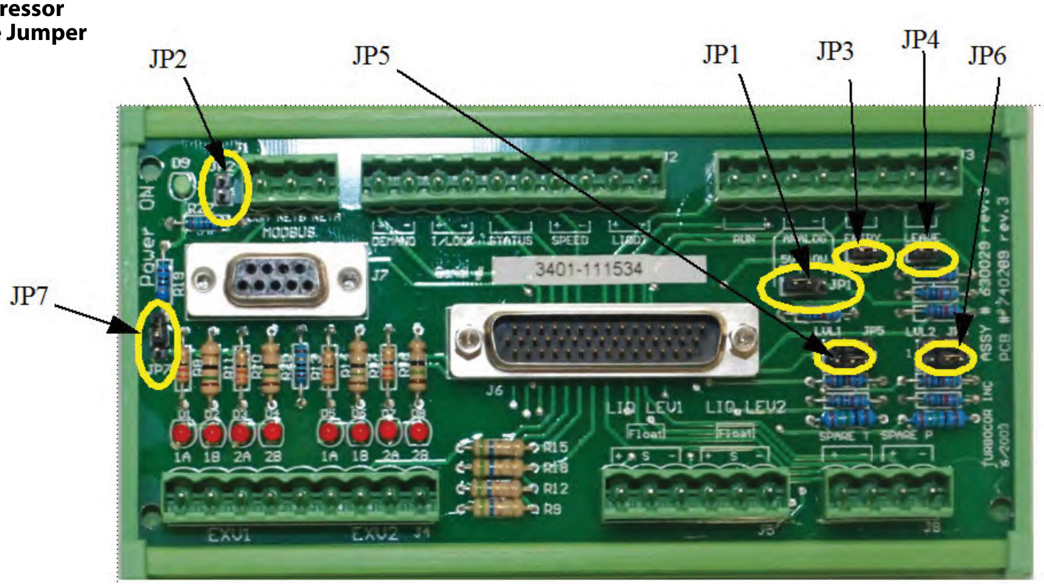


Figure 72 - Compressor Interface Module Jumper Locations



3.15.2.1 Compressor Interface Module Connection Descriptions

J1 – RS-485 communication port

• Jumper JP2 required at end of Modbus line.

J2 – Input/output

• DEMAND – Pin 1 & 2 – Analog input to drive compressor (0-10V).

• I/LOCK – Pin 3 & 4 – Interlock safety switch: must be part of a closed circuit to start compressor.

• STATUS – Pin 5 & 6 – Output; closed circuit: compressor in normal operation; open circuit: compressor in alarm condition.

• SPEED – Pin 7 & 8 – compressor motor speed output (0-5V = 10,000 RPM/volt).

• LIQT – Pin 9 & 10 – Liquid temperature sensor input.

• Refer to the Applications Manual for thermistor specifications.

J3 – Input/output

• RUN – Pin 1 & 2 – compressor running indicator output. Normally Open, closes when RPM reaches specified RPM set in BMCC.

• ANALOG – Pin 3 & 4 – Output dependent on BMCC setting. 0-5V or 0-10V set by jumper JP1.

• ENTRY – Pin 5 & 6 – Entering chilled fluid temperature sensor input.

- Use ENTRY jumper when no sensor connected.

- Refer to the Applications Manual for thermistor specifications.

• LEAVE – Pin 7 & 8 – Leaving chilled fluid temperature sensor input.

- Use LEAVE jumper when no sensor connected.

- Refer to the Applications Manual for thermistor specifications.

J4 – EXV 1 & EXV 2 Control – 15V output

• EXV1 – Pin 6 to 9

• EXV2 – Pin 1 to 4

J5 – Liquid Level input

• LIQ LEV 1 – Pin 4 to 6 – Liquid level sensor driving the electronic expansion valve1 (EXV1).

• LIQ LEV 2 – Pin 1 to 3 – Liquid level sensor driving the electronic expansion valve2 (EXV2).

• Refer to the Applications Manual for further information.

• Jumpers JP5 (LIQ LEV 1) & JP6 (LIQ LEV 2)

- For use with a voltage-type level sensor (with 15V supply and 0-5V signal).

- Install jumpers between LVL pins 2a and 3a, and Pins 2b and 3b.

- Connect the sensor leads to the "+," "S," and "-" terminals on the Compressor I/O Board (consult vendor documentation for sensor lead identification).

- For use with a resistive-type float sensor

- Install jumpers between LVL Pins 1a and 2a, and Pins 1b and 2b.

- Connect the sensor leads to the "-" and "S" terminals on the Compressor I/O Board.

- When using Superheat Control (no sensor connected)

- Install jumpers between LVL pins 2a and 3a, and Pins 2b and 3b.

J6 – RS-232 I/O Cable connection. Communication port with Backplane.

J7 – RS-232 external communication port

• Use jumper JP7 only to supply power at the 9-pin connector when using the Firefly Bluetooth serial adapter.

J8 – External sensor inputs

• Spare T: External temperature sensor input

- Refer to the Application Manual for thermistor specifications.

• Spare P: External pressure sensor input

- Refer to the Application Manual for pressure sensor specifications.

- Refer to the OEM Programming Guide for software implications.

D1 to D8 – EXV LED indicators: Red: 2 sets of 4 LEDs for EXV 1 & EXV 2.

D9 – Power LED: Green: ON: compressor is on (i.e., Compressor I/O Board and BMCC are properly connected to the Backplane).

3.15.3 Verification

3.15.3.1 Determining if Compressor Interface Module is Draining Energy

1. Identify if the D9, green LED is on.

2. Remove the Service Side Cover.

3. Measure the Backplane +5V and +15V test point voltages.

4. Remove all external connections to the I/O board.

5. Measure the Backplane +5V and +15V test point voltages.

6. Isolate compressor power and wait for the Backplane LEDs to turn off.

7. Disconnect the compressor I/O cable from the J6 connector on the CIM.

8. Apply power to the compressor.

9. Measure the Backplane +5V and +15V test point voltages.

10. If voltages do not change, I/O board is not draining energy.

3.15.3.2 Compressor Interface Module Communication Verification

1. Connect the CIM to a computer.

2. Confirm serial port to be used by the computer.

3. Open the SMT software and select the **Compressor Connection Manager** tool. See the Service Monitoring Tools User Manual for use instructions.

4. Click **Connect.**

• If the *Compressor Connection Manager* is able to connect to the compressor, the BMCC is able to communicate with the user interface.

• If the system is not able to connect, verify:

- The D9, green LED is on.

- The cable connection between the Backplane (port J7) and the CIM (port J6) is properly attached.

- The cable connection between the CIM (at port J1 if using RS485 communication or at port J7 if using RS232 communication) and the user's computer is properly attached.

- The BMCC is properly connected to the Backplane.

5. If all connections are properly attached and you still cannot connect to the compressor with the SMT, confirm computer serial port, then use the *Search* function in the *Compressor Connection Manager* to determine the correct baud rate and slave address of the compressor. Refer to the Service Monitoring Tools User Manual for use instructions.

6. If you can still not connect to the compressor, verify the Backplane and the BMCC.

3.15.3.3 Interlock Verification

1. Ensure the compressor interface cable is properly attached to the Backplane and to the CIM and the BMCC is properly attached to the Backplane.

2. Remove the J2 connector from the I/O board.

3. Using a multimeter set for DC voltage, measure the voltage between I/LOCK+ and I/LOCK-.

The voltage should be 2.2 - 3.7VDC.

4. Install the J2 connector to the CIM.

5. Ensure the circuit connected to I/LOCK+ and I/LOCK- on the CIM (port J2) is closed.

6. Measure the voltage at I/LOCK- to the common ground point.

The measured value at I/LOCK- should be 0VDC.

• If the measured value is not 0VDC, locate and remove the source of the voltage.

7. Open the SMT *Compressor Monitor* tool.

8. With the system interlock circuit remaining closed, verify the *Compressor Interlock Status* states “Closed.”

• If the *Compressor Interlock Status* states “Open,” the interlock circuit is damaged and the BMCC needs to be replaced.

9. Isolate compressor power.

10. Remove the J2 connector from the CIM.

11. Using a multimeter for resistance measurement. Place the meter probes on I/LOCK+ and I/LOCK-.

• Resistance should be < 22.2kΩ; if not, the interlock circuit is damaged and the BMCC needs to be replaced.

3.15.4 Removal & Installation

• • • DANGER • • •

Ensure there is no secondary power source connected to the Compressor I/O Board before disconnecting the I/O cable.

3.15.4.1 Compressor Interface Module Removal

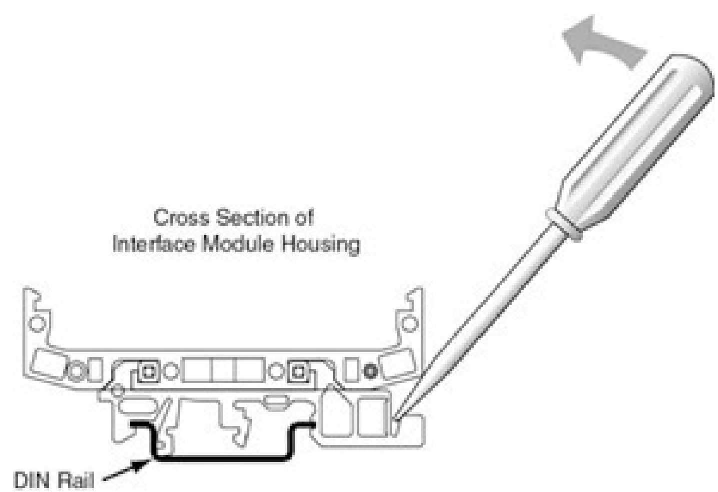
1. Isolate compressor power and wait for the D9 LED to turn off on the CIM.

2. Remove all external connections from the CIM.

3. Using a screwdriver, apply leverage toward the left while lifting the right side of the CIM. See Figure 73 (Removing the Compressor Interface Module From the DIN Rail.

4. Repeat the procedure for the other mounting foot to disengage the CIM from the DIN rail.

Figure 73 - Removing the Compressor Interface Module From the DIN Rail



3.15.4.2 Compressor I/O Board Installation

1. Install the left foot of the replacement board into the rail and press the right side of the board down until it engages the rail.

2. Reconnect all external connections and wiring on the CIM.

3. Reapply power to compressor.

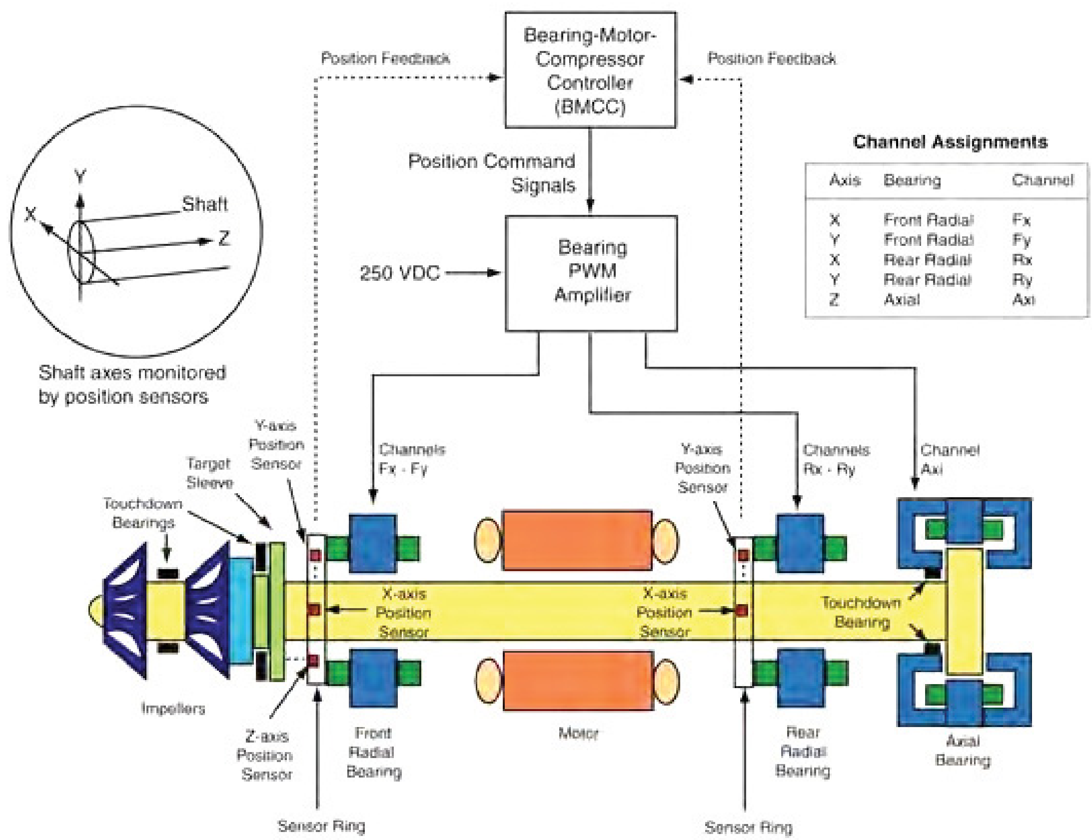
3.16 Bearing Pulse Width Modulator Amplifier

3.16.1 Function

The PWM Amplifier supplies current to the radial and axial magnetic bearing coils as commanded by the BMCC. In return, the PWM passes feedback from the current sensor for the bearing coils to the BMCC. See Figure 74 (Bearing Control Signal Flow).

The Backplane provides the PWM with +5VDC with respect to 0VDC, along with +17VDC and HV+ (at 250VDC) both with respect to HV-.

Figure 74 - Bearing Control Signal Flow



3.16.2 Connections

J1 on the Backplane is the PWM connection port. See Figure 75 (Bearing Power Feed Throughs and PWM Connection Port).

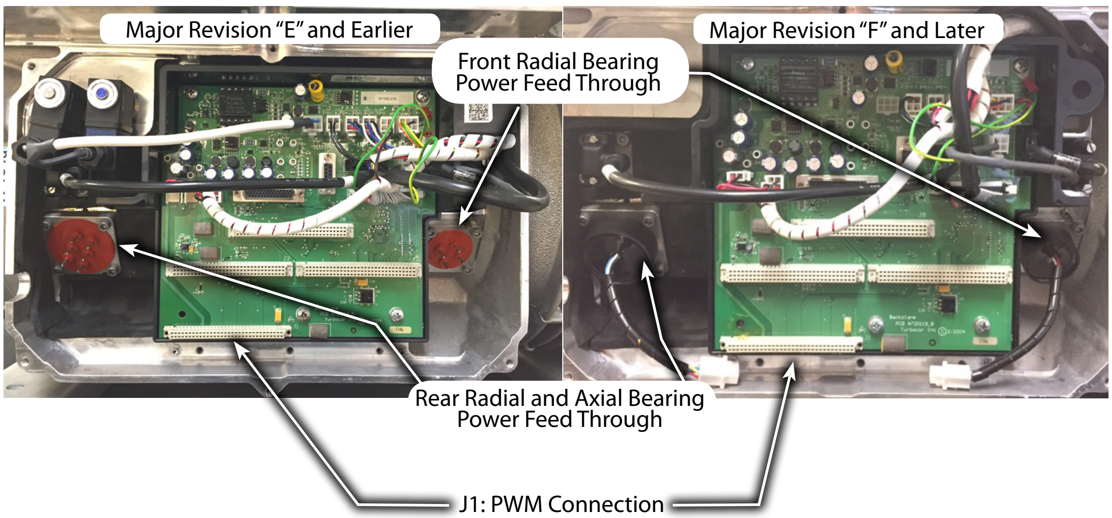
The PWM heat sink is secured with fasteners to the compressor housing below the Backplane.

There are different housings for the Turbocor compressors. The Major Revision "E" and earlier compressors utilize feed throughs with external male pins while the Major Revision "F" and later compressors utilize feed throughs with integrated external pigtails. Figure 75 (Bearing Power Feed Throughs and PWM Connection Port) identifies those differences.

NOTE

There are two different styles of Major Revision "E" and earlier feed throughs. Older versions have a removable black neoprene gasket (not pictured) and this was later replaced with a non-removable red neoprene gasket.

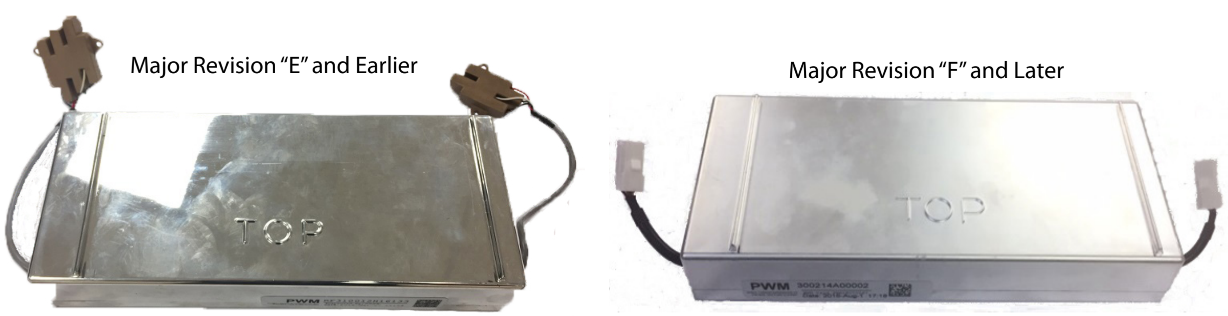
Figure 75 - Bearing Power Feed Throughs and PWM Connection Port



The 6-pin/wire connects to the rear (left) bearing power feed through.

The 4-pin/wire connects to the front (right) bearing power feed through. See Figure 75 (Bearing Power Feed Throughs and PWM Connection Port) and Figure 76 (Bearing Pulse Width Modulator Amplifier).

Figure 76 - Bearing PWM Amplifier



3.16.3 Verification

NOTE

A faulty PWM Amplifier may be the result of a bearing failure and may cause a failure of the DC/DC resulting in a blown F1 fuse on the Soft Start.
If a PWM Amplifier is found to be faulty, the bearing actuator coils, DC/DC and F1 Fuse must also be verified.

Several verification methods are available for the PWM:

• Verify if the PWM is draining energy.

• Verify functionality of the five output channels.

• Verify functionality of the five diode sets.

3.16.3.1 Verify if the Bearing PWM Amplifier is Draining Energy

1. Remove the Service Side Cover.

2. Disable compressor operation while keeping the compressor energized.

3. Measure the voltage at the HV+, +17HV, and +5V test points on the Backplane.

4. Isolate compressor power; wait for the LEDs on the Backplane to completely turn off.

5. Disconnect the rear/axial bearing current output cable and the front bearing current output cable

6. Apply power to the compressor.

7. Measure and record the voltage at the HV+, +17HV, and +5V test points.

8. Isolate compressor power; wait for the LEDs on the Backplane to completely turn off.

9. Remove the PWM from the Backplane.

10. Apply power to the compressor.

11. Measure and record the voltage at the HV+, +17HV, and +5V test points.

12. If the voltages do not change, the PWM is not the source (or not the only source) of energy drain.

3.16.3.2 Verify Functionality Of The Five Output Channels

1. Measure the voltage at the HV+, +17HV, and +5V test points on the Backplane.

2. Verify the bearing coil resistances are within specification.

3. Verify the bearing sensor resistances are within specification.

4. Perform a bearing calibration using the SMT.

NOTE

If one of the PWM output channels has failed, the corresponding bearing channel returns a gain of 0 when a bearing calibration is performed.

5. If all bearing resistances are good and one or more of the gains is/are 0, but not all the gains are 0, the PWM is faulty.

3.16.3.3 Verify Functionality Of The Five Diode Sets

To verify the diode sets within the PWM channels, complete the following steps:

1. Isolate compressor power.

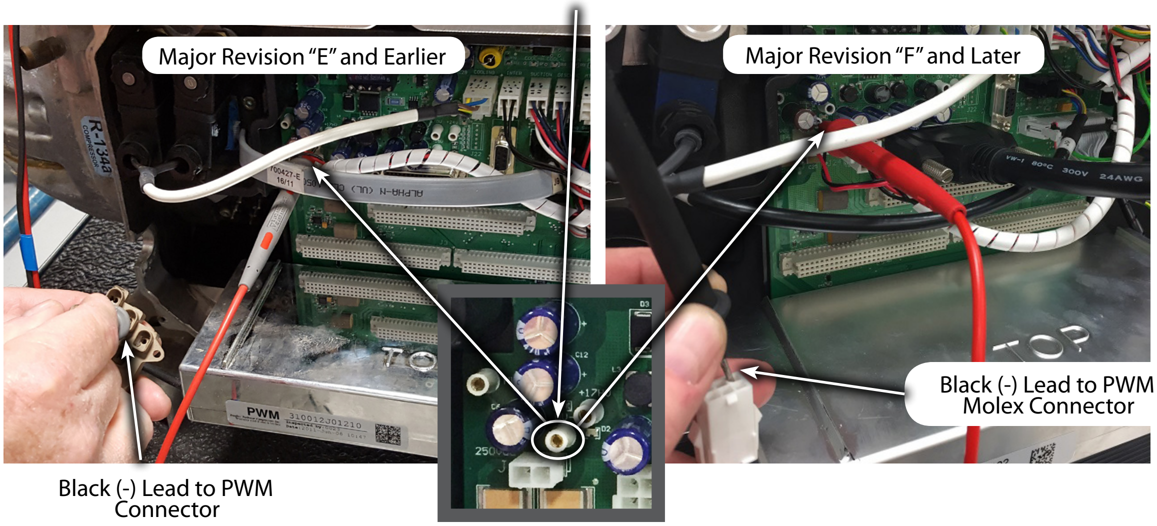
2. Remove the Service Side Cover verifying the LEDs on the Backplane have turned off.

3. Unplug the 250VDC input (J4) from the Backplane. See Figure 66 (Bearing Power Feed Throughs and PWM Connection Port).

4. Disconnect the PWM connectors from the compressor housing bearing feed throughs, keeping the PWM attached to the Backplane.

5. Using a multimeter set for diode measurements, place the red (+) lead on the HV- test point of the Backplane and the black (-) lead in the first pin hole of the PWM connector, ensure the lead makes contact with the clip in the pin hole. See Figure 77 (Connecting Leads to PWM Connector and HV- Test Point). The measured voltage drop should be 0.39-0.46VDC.

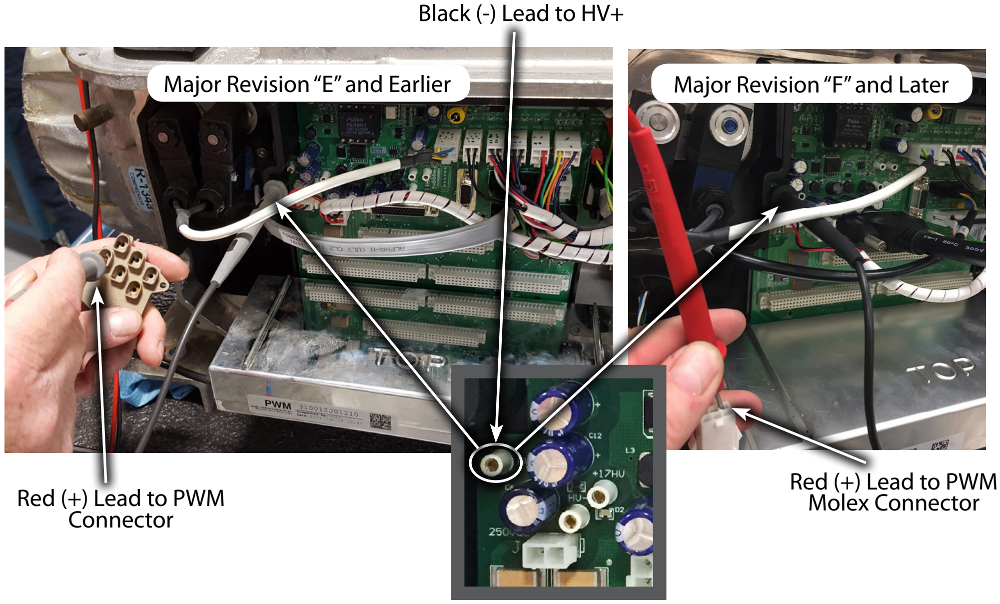
Figure 77 - Connecting Leads to PWM Connector and HV- Test Point



6. Repeat Step 3 for all 10 pin holes on both PWM connectors.

7. Still set on diode measurement, place the black (-) multimeter lead on the HV+ test point of the Backplane and the red (+) multimeter lead in the first pin hole of the PWM connector, ensure the lead makes contact with the clip in the pin hole. See Figure 78 (Connecting Leads to PWM Connector and HV+ Test Point). The measured voltage drop should be 0.39-0.46VDC.

Figure 78 - Connecting Leads to PWM Connector and HV+ Test Point



8. Repeat Step 5 for all 10 pin holes of both PWM connectors.

9. If any of the test results are out of the 0.39 - 0.46 VDC range, the PWM is defective and should be replaced.

3.16.4 Removal and Installation

3.16.4.1 PWM Amplifier Removal

1. Isolate compressor power and wait for the LEDs on the Backplane to turn off.

2. Remove the Serial Driver.

3. Remove the BMCC.

4. Loosen the fasteners that hold the retaining clips over the connectors of the front and rear radial bearing feed throughs.

• If this is a "new" style PWM with Molex connectors (refer to Figure 76 - Bearing PWM Amplifier for identification), you will only need to disconnect the Molex connector for the PWM and bearing feed through.

5. Remove the PWM connectors from the bearing power feed throughs on the front and rear radial bearings.

• Note the orientation of both connectors and ensure this is retained when reinstalling.

6. Remove the fasteners below the PWM that secure the heat sink to the main compressor housing. See Figure 79 (Removing the PWM Amplifier).

Figure 79 - Removing the PWM Amplifier

7. Pull the bearing PWM amplifier from J1 of the Backplane.

3.16.4.2 PWM Amplifier Installation

NOTE

Prior to replacing a PWM, verify the bearing coils.

1. Check that the ground screw at the lower right of the Backplane is tight before replacing the PWM.

2. Align the heat sink of the PWM with the two guide pins in the main compressor housing.

3. Insert the PWM into the J1 connector of the Backplane.

4. Secure the heat sink of the PWM to the main compressor housing with three fasteners.

5. Ensure the heat sink of the PWM is firmly seated against the main compressor housing.

6. Place the two connectors on the front and rear radial bearing feed throughs and secure the retaining clips over them.

• If this is a Major Revision "F" or later PWM with Molex connectors (refer to Figure 76 - Bearing PWM Amplifier for identification), you will only need to connect the Molex connector for the PWM and bearing feed through.

7. Re-install the BMCC.

8. Re-install the Serial Driver.

9. Re-install Service Side Cover.

3.17 Magnetic Bearings

3.17.1 Function

The compressor shaft and impellers levitate during operation and float on a magnetic cushion created by the magnetic bearings. Permanent magnets do most of the work and electromagnets are used for trimming the shaft position within 0.0003" (7 microns). One axial (Z axis) and two radial (X & Y axis) magnetic bearings are used to maintain shaft position. See Figure 80 (Radial Magnetic Bearings) and Figure 72 (Axial Magnetic Bearing). Centered rotation is instantaneously self-corrected and maintained by the bearing control loop. See Figure 65 (Bearing Control Signal Flow).

When not powered, the shaft is supported by carbon composite or roller touchdown bearings.

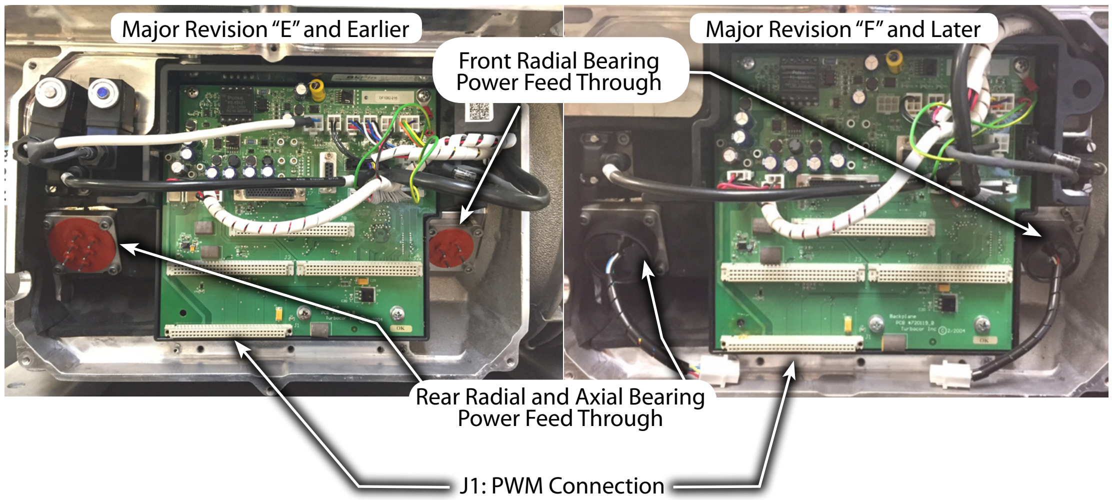
Figure 80 - Radial Magnetic Bearings

Figure 81 - Axial Magnetic Bearing

3.17.2 Connections

PWM connectors supply power at the bearing power feed throughs. See Figure 82 (Bearing Power Feed Throughs).

Figure 82 - Bearing Power Feed Throughs



3.17.3 Verification

3.17.3.1 Bearing Coil Verification

• • • CAUTION • • •

Do not attempt to perform an insulation (megger) test on a component under vacuum. This can cause insulation breakdown or failure during the testing process.

NOTE

To check bearing coil insulation integrity, a Mega ohm meter (megger) set to 1KV should be used. Readings from coils to ground should be greater than 100MΩ, and readings between coils should be greater than 100MΩ.

NOTE

A faulty PWM Amplifier may be the result of a bearing failure and may cause a failure of the DC/DC Converter resulting in a blown F1 fuse on the Soft Start. If a bearing coil is found to be faulty, then the PWM, DC/DC Converter, and Soft Start F1 fuse must be verified as well.

1. Isolate compressor power.

2. Remove the Service Side Cover verifying the Backplane LEDs have turned off.

3. Remove the Serial Driver, BMCC, and PWM.

4. Set multimeter for resistance checks.

5. Test resistance on bearing power feed through pins defined in Table 14 (Magnetic Bearing Coil Resistance Values). See Figure 83 (Rear Bearing 6-Pin Orientation (TT300 Serial Numbers <081015110 Only)), Figure 83 (Rear Bearing 6-Pin Orientation (TT300 Serial Numbers >081015110 and All Other Models)), and Figure 84 (Rear Bearing 6-Pin Orientation (TT300 Serial Numbers > 081015110, and All Other Models) for pin locations.

6. Compare the resistance values to those defined in Table 14 (Magnetic Bearing Coil Resistance Values).

7. Test resistance of each pin to ground.

8. Test insulation of each pin to ground and between coils.

9. If the integrity of the bearing power feed through is in question, isolate the compressor, recover the refrigerant, remove the feed through and repeat the above steps directly at the internal bearing cluster block.

Table 14 - Magnetic Bearing Coil Resistance Values

Compressor Model & Design Sequence				
Connector Location	Bearing Identification	Feed Through Pin Identification	TT300, TT400C, E, F, TG230, & TG390	TT350 TT400P, TT500, TT700, TG310, & TG520
Rear Bearing Connector	Rear Radial Coil	1 & 6	2.70 - 3.25Ω	2.70 - 3.25Ω
		2 & 5	2.70 - 3.25Ω	2.70 - 3.25Ω
	Axial Coil	3 & 4	5.70 - 6.20Ω (TT300/TG230 only) 6.00 - 6.70Ω (TT400C, E, F, TG390 only)	6.00 - 6.70Ω
Front Bearing Connector	Front Radial Coil	1 & 2	2.70 - 3.25Ω	4.70 - 5.20Ω
		3 & 4	2.70 - 3.25Ω	4.70 - 5.20Ω
Notes	See Figure 74, 75, and 76 for pin locations		All resistance values are in ohms. Resistance to ground and between coils should be >100MΩ @1KV	

Figure 83 - Rear Bearing 6-Pin Orientation (TT300 Serial Numbers <081015110 Only)

TT300 Serial Numbers <0810151110 Only

TT300 Serial Numbers >0810151110 and All Other Models

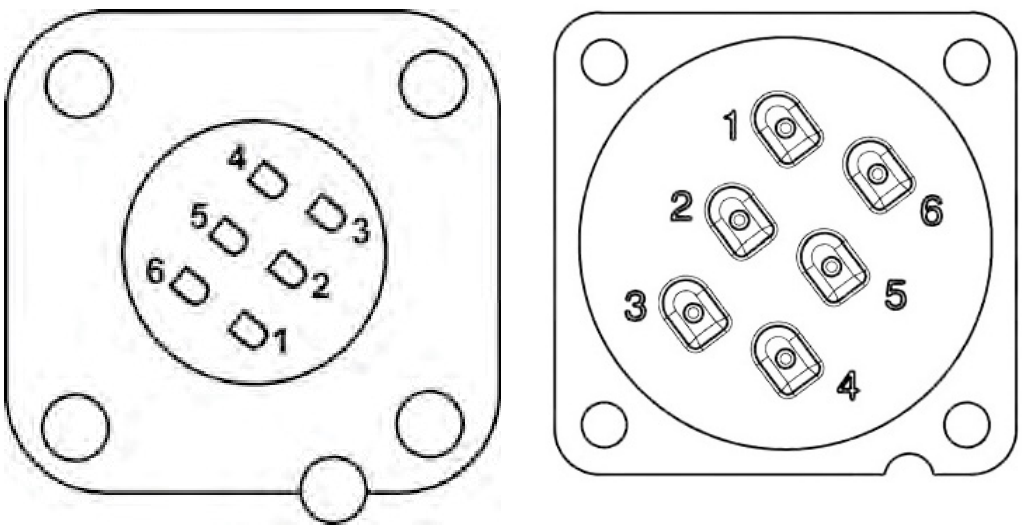


Figure 84 - Front Bearing 4-Pin Orientation

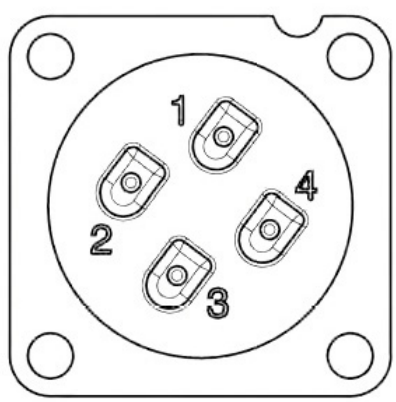


Figure 85 - Front and Rear Bearing Feed Throughs with Molex Connectors

3.17.3.2 Bearing Current Verification

1. Connect to the compressor using the SMT.

2. Open the Compressor Monitor tool. See Figure 86 (Compressor Monitor Tool).

3. In the bearing section, verify the bearing amperages displayed are within the range defined in Table 15 (Bearing Amperage Ranges) during compressor operation.

Figure 86 - Compressor Monitor Tool

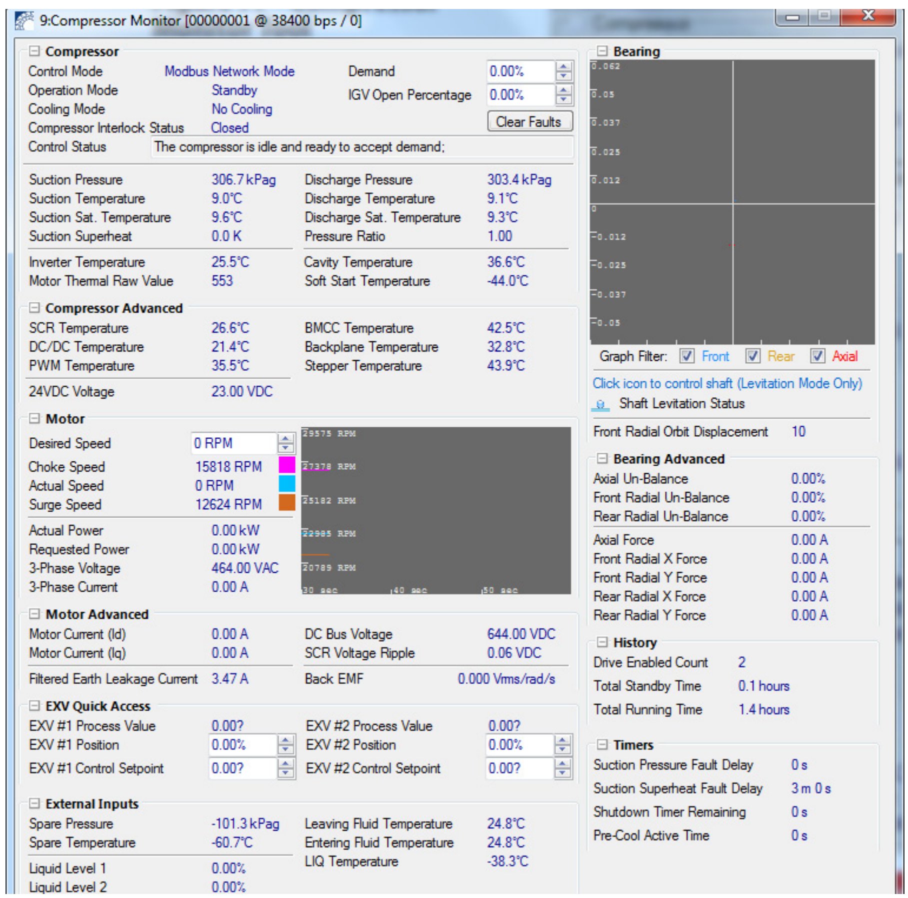


Table 15 - Bearing Amperage Ranges

Bearing Position	Force Range
Axial Force	-1 to 1 Amp
Front X Force	-1 to 1 Amp
Front Y Force	-1 to 1 Amp
Rear X Force	-1 to 1 Amp
Rear Y Force	-1 to 1 Amp

NOTE

The above amperage ranges are a general observation. It is possible to operate outside this range.

3.18 Bearing Sensors

3.18.1 Function

Bearing sensors feed back real-time shaft orbit information to the bearing control loop. See Figure 74 (Bearing Control Signal Flow).

3.18.2 Connections

The Bearing Sensors are connected internally to the Bearing Sensor feed throughs located above the front and rear bearing power feed throughs. See Figure 87 (Bearing Sensor Feed Throughs).

The bearing sensor feed throughs are connected to the bearing sensor cables which connect to J9 and J10 on the Backplane. See Figure 88 (Bearing Sensor Cables).

Figure 87 - Bearing Sensor Feed Throughs

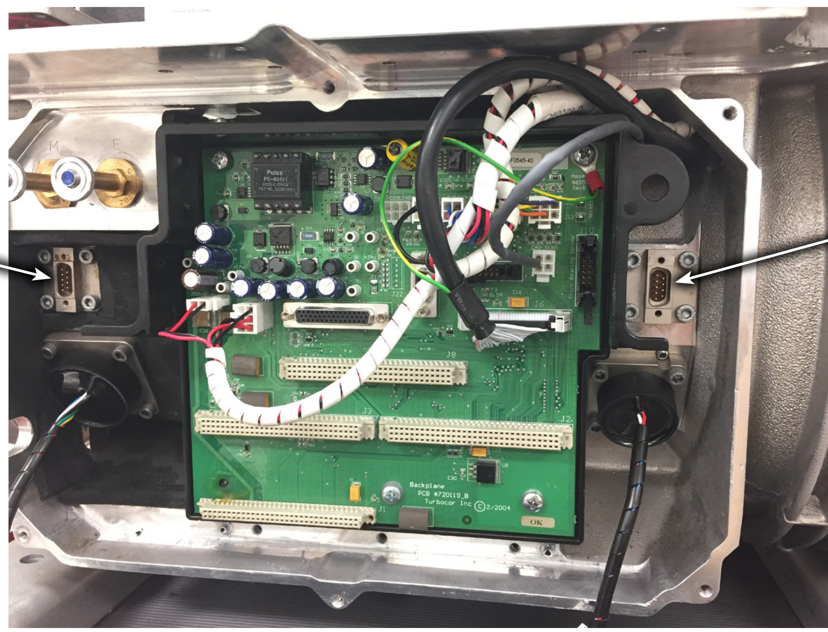
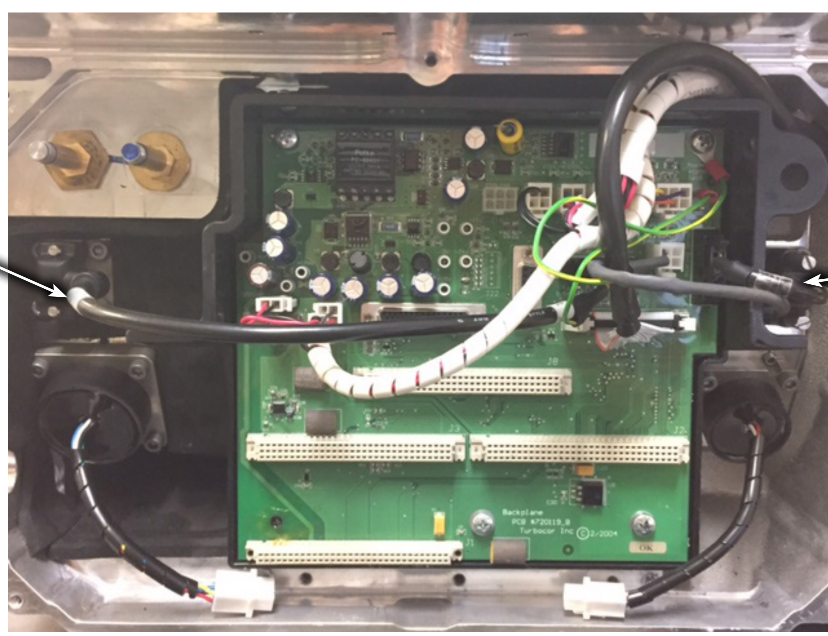


Figure 88 - Bearing Sensor Cables



3.18.3 Verification

3.18.3.1 Bearing Sensor Resistance Verification

1. Isolate compressor power and wait for the LEDs on the Backplane to turn off.

2. Remove the bearing sensor cable from the bearing sensor feed through. See Figure 78 (Bearing Sensor Feed Throughs).

3. Set multimeter for resistance checks.

4. Place meter leads on bearing sensor feed through pins outlined in Table 16 (Bearing Sensor Coil Resistance). See Figure 89 (Bearing Sensor Pin Locations) for pin locations.

• NOTE: *There are no connections on Pins 1 & 4 and 1 & 9 on the rear bearing sensor feed through.*

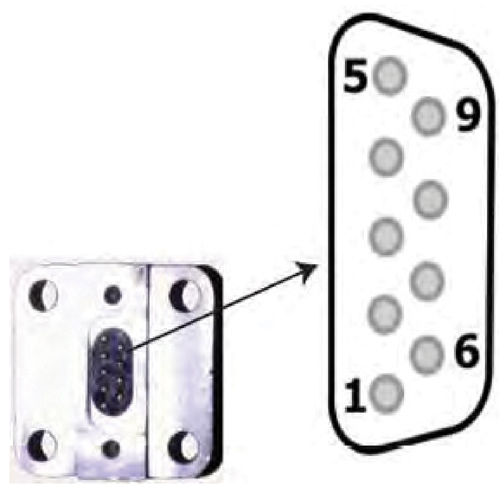
5. Test each pin to ground; reading should be open or infinite.

6. If the integrity of the bearing sensor feed through is in question, isolate the compressor, recover the refrigerant, remove the feed through and repeat the above steps directly at the internal sensor connector.

Table 16 - Bearing Sensor Coil Resistance

Pin Combination	Front Sensor	Rear Sensor
5-2	2.0Ω to 3.5Ω	2.0Ω to 3.5Ω
5-3	2.0Ω to 3.5Ω	2.0Ω to 3.5Ω
6-7	2.0Ω to 3.5Ω	2.0Ω to 3.5Ω
6-8	2.0Ω to 3.5Ω	2.0Ω to 3.5Ω
1-4	2.0Ω to 3.5Ω	Open
1-9	2.0Ω to 3.5Ω	Open

Figure 89 - Bearing Sensor Pin Locations



3.19 Cavity Temperature Sensor

3.19.1 Function

The cavity temperature sensor reads the temperature of the motor cooling gas within the shaft cavity as it exits the Stator.

3.19.2 Connections

The cavity temperature sensor is located behind the Backplane. See Figure 92 (Cavity Temperature Sensor Removal).

The cavity temperature sensor is connected to the J23 connector on the Backplane. See Figure 60 (Backplane Connections and Test Points).

3.19.3 Verification

1. Isolate compressor power.

2. Remove the Service Side Cover, verifying the LEDs on the Backplane have turned off.

3. Disconnect the Cavity Temperature Sensor Cable, J23, from the Backplane.

4. Set multimeter for resistance measurements.

5. Measure the resistance between the Cavity Temperature Sensor terminals 1 and 3. See Figure 90 (Cavity Temperature Sensor Terminal).

- The Cavity Temperature Sensor is a 10KΩ @ 77°F (25°C) NTC thermistor. The resistance value should correspond to Figure 91 (Temperature vs. Resistance).

6. Measure the resistance of the Cavity Temperature Sensor terminals 1 and 3 to ground. See Figure 90 (Cavity Temperature Sensor Terminal).

- The resistance value should be open or infinite.

Figure 90 - Cavity Temperature Sensor Terminal

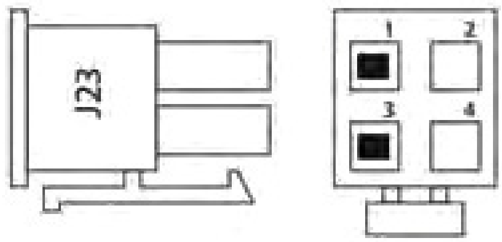
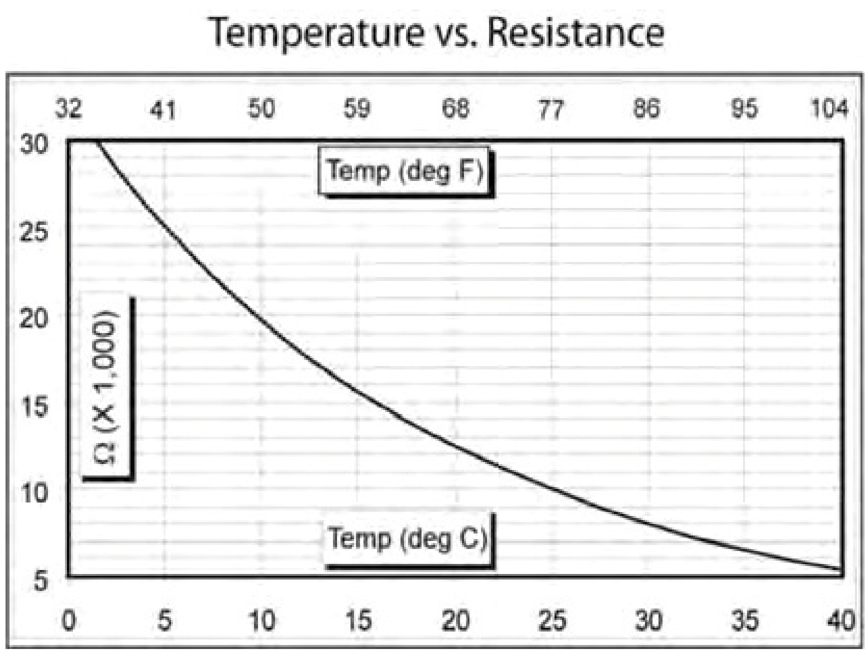


Figure 91 - Temperature vs. Resistance



3.19.4 Removal and Installation

3.19.4.1 Cavity Temperature Removal

1. Isolate compressor power.

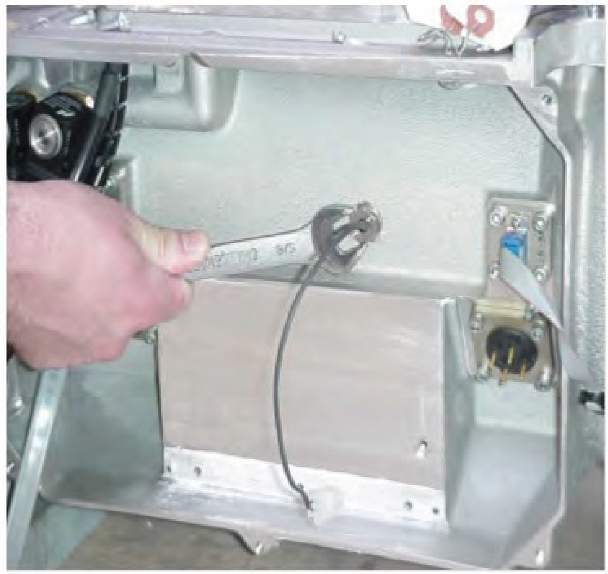
2. Isolate the compressor and recover the refrigerant according to industry standards.

3. Remove the Service Side Cover, verifying the LEDs on the Backplane have turned off..

4. Remove the Serial Driver, BMCC, PWM, and the Backplane.

5. Remove the cavity temperature sensor. See Figure 92 (Cavity Temperature Sensor Removal).

Figure 92 - Cavity Temperature Sensor Removal



6. Ensure housing threads are clean.

3.19.4.2 Cavity - Temperature Sensor Installation

1. (Skip this step for all compressors that are Major Revision "E" and later.) Apply a refrigerant safe thread sealant to the cavity temperature sensor threads (avoid thread-locking substances).

2. Insert the sensor and engage the first few threads by hand.

3. Tighten the sensor to 13 Nm (9.5 ft.lb.).

4. Leak test compressor to appropriate pressure and industry accepted standards.

5. Evacuate compressor to industry accepted standards.

6. Reinstall the service side electronic modules.

7. Reinstall Service Side Cover.

3.20 Pressure/ Temperature Sensor

3.20.1 Function

The suction and discharge pressure/temperature sensors are used to inform the compressor of the operating pressures and temperatures at the suction and discharge ports. These values are used to calculate pressure ratios, saturated temperatures, superheat and the location within the operating envelope where the compressor is running.

3.20.2 Connections

The suction pressure/temperature sensor is secured to the IGV, above the suction port.

The discharge pressure/temperature sensor is secured to the compressor housing, above the discharge port. See either Table 6 (Compressor Sensors, Cables, and Indicators (TT300/TG230)) or Table 8 Compressor Sensors, Cables, and Indicators (TT350/TT400/TT500/TT700/TG310/TG390/TG520)) for the location of the sensor.

The sensor connector clips link to the compressor control cable which then connect to the Backplane at J18 and J19.

3.20.3 Verification

1. Isolate compressor power.

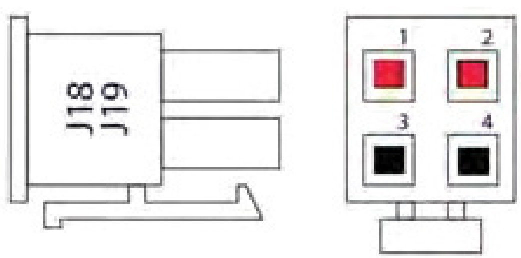
2. Remove the Service Side Cover.

3. Disconnect the pressure/temperature cable clip (SUCTION – J18 or DISCHGE – J19) from the Backplane board. See Figure 93 (Pressure/Temperature Cable Terminals).

4. Using a multimeter set for resistance measurements, place leads on Terminal 1 and Terminal 2 of the pressure/temperature cable clip. See Figure 93 (Pressure/Temperature Cable Terminals).

• The temperature sensor is a 10KΩ @ 77°F (25°C) NTC thermistor. The resistance value should correspond to Figure 91 (Temperature vs. Resistance).

Figure 93 - Pressure/ Temperature Cable Terminals



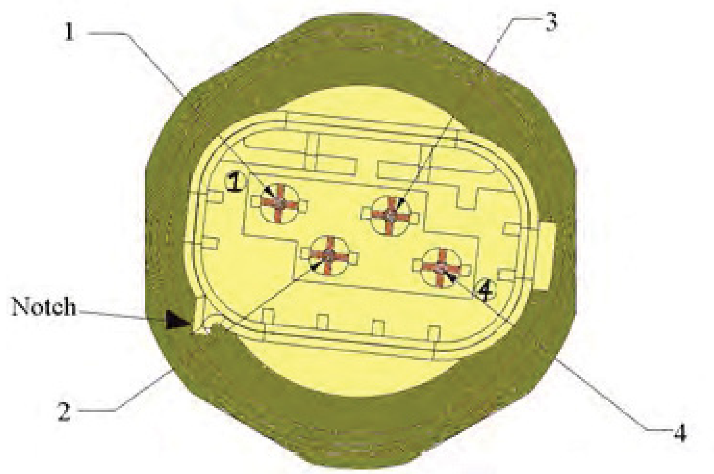
5. If the integrity of the cable is in question, disconnect the compressor controller cable from the pressure/temperature sensor.

6. Place the leads on Terminal 1 & 3 of the pressure/temperature sensor. See Figure 94 (Pressure/Temperature Sensor Pin Locations).

To verify pressure reading, compare the readout of the service monitoring software to a calibrated gauge. Discharge pressure reading should be within 50 kPa (7.25 psig). Suction pressure reading should be within 17 kPa (2.5 psig).

• The temperature sensor is a 10KΩ @ 77°F (25°C) NTC thermistor. The resistance value should correspond to Figure 91 (Temperature vs. Resistance).

Figure 94 - Pressure/ Temperature Sensor Pin Locations



3.20.4 Removal and Installation

3.20.4.1 Pressure/ Temperature Sensor Removal

The following procedure applies to both suction and discharge pressure/temperature sensors.

1. If removing the discharge pressure/ temperature sensor, isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

2. Isolate the compressor; recover the refrigerant according to industry standards.

3. Disconnect the sensor connector.

4. Using a deep socket, remove the sensor.

3.20.4.2 Pressure/ Temperature Sensor Installation

1. Check and clean O-ring, housing thread and O-ring sealing surface in compressor housing. Apply lube to O-ring.

2. Insert the sensor and engage the first few threads by hand.

3. Using a deep socket, tighten the sensor to 10 Nm (7.3 ft.lb).

4. Reconnect the sensor connector.

5. Leak test compressor to appropriate pressure and industry accepted standards.

6. Evacuate compressor to industry accepted standards.

4.1 Alarm and Fault Indications

The first step in troubleshooting is to gather as many facts as possible. Compressor fault and event logs provide factual historical information that will indicate the exact reason that the compressor shut down, the frequency of faults and compressor starts, as well as the value of pertinent parameters at the time of the fault. These logs should be reviewed in detail to gain information to allow efficient troubleshooting for any fault.

4.1.1 Alarm Types

Alarms indicate compressor operating conditions are beyond set limits of the normal operating envelope or set alarm limits. Compressor alarms will allow the compressor to run, but speed is typically reduced to bring the condition under the alarm limit. See Table 17 (Alarm Types).

Table 17 - Alarm Types

Compressor Alarm	Description
Inverter Temperature	The measured Inverter temperature has exceeded the alarm limit.
Discharge Temperature	The measured discharge temperature has exceeded the alarm limit.
Suction Pressure	The measured suction pressure has exceeded the alarm limit.
Discharge Pressure	The measured discharge pressure has exceeded the alarm limit.
3-Phase Over-Current	The calculated 3 phase current has exceeded the alarm limit.
Cavity Temperature	The measured cavity temperature has exceeded the alarm limit.
Leaving Fluid Temperature	The lowest acceptable measured leaving fluid temperature has exceeded the alarm limit.
Pressure Ratio	The calculated pressure ratio of discharge/suction has exceeded the alarm limit.
SCR Temperature	The measured SCR temperature has exceeded the alarm limit.
Superheat	The calculated superheat temperature has exceeded the alarm limit. The difference between the fault limit and the alarm limit is the dead band for the control. The superheat alarm is always set 8°K below the fault limit.

4.1.2 Fault Types

Critical and non-critical faults indicate compressor operating conditions are beyond set limits of the normal operating envelope or set fault limits. Exceeding fault limits will stop the compressor in 10 seconds or less. See Table 18 (Compressor Fault Types), Table 19 (Motor Fault Types) and Table 20 (Bearing Fault Types).

Table 18 - Compressor Fault Types

Compressor	Description
Inverter Temperature	The measured Inverter temperature has exceeded the fault limit.
Discharge Temperature	The measured discharge temperature has exceeded the fault limit.
Suction Pressure	The measured suction pressure has exceeded the fault limit.
Discharge Pressure	The measured discharge pressure has exceeded the fault limit. Instantaneous lock-out at fault level.
3-Phase Over-Current	The calculated 3 phase current has exceeded the fault limit. Instantaneous lock-out at fault level.
Cavity Temperature	The measured cavity temperature has exceeded the fault limit.
Leaving Fluid Temperature	The lowest acceptable measured leaving fluid temperature has been exceeded.
Pressure Ratio	The calculated pressure ratio of discharge/suction has exceeded the fault limit.
Generic Compressor Fault	If a motor fault type or a bearing fault type is present, then the generic compressor fault is triggered. This is not an actual fault, only an indication that a motor or bearing fault has occurred.
Sensor Fault	If the following measured temperatures (in °C) or pressures in (kPa abs) are surpassed, a sensor fault is triggered: Inverter Temperature: >100 or < 0 °C Cavity Temperature: >100 or < -20 °C Suction Temperature: >100 or < -30 °C Discharge Temperature: >110 or < -30 °C Leaving Air/Water Temperature: >100 or < -20 °C Suction Pressure: >1200 or < -30 kPa abs Discharge Pressure: >3500 or < -30 kPa abs
SCR Temperature	The measured SCR temperature has exceeded the fault limit.
Lock Out Fault	Lock-Out faults require power cycle to reset. Instantaneous lock outs: Discharge Pressure 3 Phase Over Current If any (or a combination of) the faults listed below occurs more than 3 times within 30 minutes, a Lock-Out fault occurs: Inverter Temperature SCR Temperature Motor High Current Inverter Error Rotor may be Locked Back EMF is low
Winding Temperature	The measured motor winding temperature has exceeded the fault limit.
Superheat	The calculated Superheat Temperature has exceeded the Fault limit.

Table 19 - Motor Fault Types

Compressor	Description
Motor Single Phase Overcurrent Fault	Measured peak current value of any single phase to motor (from Inverter) exceeds the fault limit.
DC Bus Overvoltage Fault	The measured DC bus voltage has exceeded the Maximum Bus Voltage limit.
Motor High Current Fault	The motor current has exceeded Maximum Motor Current limit.
Inverter Error	Inverter reports a generic error or communication to BMCC is lost.
Bearing Fault Active	If a bearing fault type is present, then the Bearing Error fault is triggered. This is not an actual fault, only an indication that a fault has occurred in the bearing section.
Rotor Starting Torque Fault	Indicates that rotor angular position is not at correct value for given speed causing the Locked Motor Current maximum to be exceeded during compressor start-up.
Low Inverter Current Fault	Measured current to motor (from Inverter) has not reached the Minimum Power limit.
DC Bus Under/Over Voltage Fault	At 0 RPM: The measured DC Bus voltage is measured lower than the Soft Start Bus Voltage limit.
24VDC Under/Over Voltage Fault	The measured 24VDC supply is outside the range of the low or high limit.
Low Motor Back EMF Fault	The calculated motor back EMF has fallen below the minimum Back EMF limit.
EEPROM Checksum Fault	An error (checksum error) occurs reading the data table from the EEPROM.
Generator Mode Active	At greater than 0 RPM and DC bus voltage low, Generator mode is enabled, switching the Inverter to rectifier function to maintain the DC bus voltage until the shaft comes to a stop and delevitates.
SCR Ripple Voltage Fault	The DC bus voltage ripple exceeds the SCR Voltage Ripple Fault limit.
System in Startup mode	The compressor initialization has not finished. Please wait. Compressor is resetting after a power cycle. This is a status message.

Table 20- Bearing Fault Types

Bearing Status	Description
Startup Calibration Check Fault	During initialization, the bearing calibration data is checked for valid values. Automatic calibration during compressor startup failed.
Excessive Axial Orbit	Axial Orbit has exceeded the limit longer than the maximum time allowable.
Axial Overcurrent Fault	Axial Current has exceeded the limit longer than the maximum time allowable.
Front Radial Displacement Fault	Front Radial Orbit has exceeded the limit longer than the maximum time allowable.
Front Radial X Overcurrent Fault	Front Radial X Current has exceeded the limit longer than the maximum time allowable.
Front Radial Y Overcurrent Fault	Front Radial Y Current has exceeded the limit longer than the maximum time allowable.
Rear Radial Displacement Fault	Rear Radial Orbit has exceeded the limit longer than the maximum time allowable.
Rear Radial X Overcurrent Fault	Rear Radial X Current has exceeded the limit longer than the maximum time allowable.
Rear Radial Y Overcurrent Fault	Rear Radial Y Current has exceeded the limit longer than the maximum time allowable.

4.2 Troubleshooting With the Service Monitoring Tools Software

The Service Monitoring Tools (SMT) software package can be used to view detailed compressor information for operational status indications and troubleshooting procedures.

Depending on compressor access level, the following tools may be available from the SMT Tool Suite Launcher Strip. See Figure 95 (SMT Tool Suite Launcher Strip).

Each SMT Tool offers a specific function. See Table 21 (Service Monitoring Tools Icons).

Figure 95 - SMT Tool Suite Launcher Strip

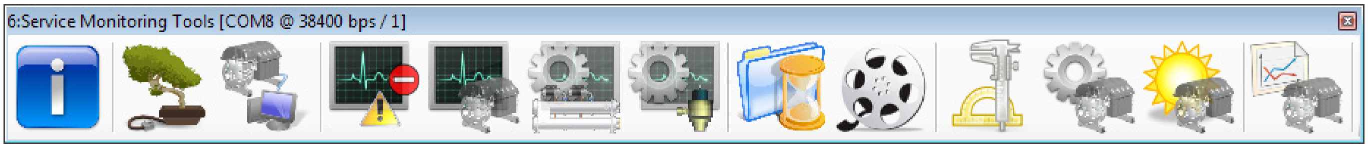


Table 21 - Service Monitoring Tools Icons

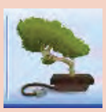
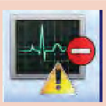
Icon	Tool	Description
	About	The *About* tool displays OS and framework version, SMT software system release product version, and a listing of software assemblies loaded for the SMT software product.
	Compressor Connection Manager	Discover and establish a means of communication with the compressor.
	ModComm Tool	Used for monitoring and modifying register values by providing access to Modbus registers on a raw level.
	Active Alarm/Fault Viewer	Instantaneously monitor the alarm and fault status of a connected compressor and configure the alarm and fault limits.
	Compressor Monitor	Monitor the most commonly desired parameters of the BMCC related to motor, bearing, and compressor operation.
	Chiller and Analog Configuration	View or modify the chiller control and analog output control configuration parameters and settings.
	EXV Configuration Tool	View and configure the electronic expansion valve configuration parameters and settings.
	Logged Event and Fault Viewer	Retrieve logged fault and event data history regarding the operation of a connected compressor for the purpose of troubleshooting and diagnostics.
	Compressor Data Recording and Playback	Start and stop recording of all variables on the BMCC, as well as launch a server partially simulating an actual compressor using previously recorded data. Use this tool for training, testing, evaluation, and compressor troubleshooting purposes.
	Bearing Calibration	Execute a bearing calibration procedure and analyze the outcome.

Table 21- Service Monitoring Tools Icons (Continued)

Icon	Tool	Description
	Compressor Configuration	View and configure the compressor operation, shutdown configuration, IGV startup, communication configuration, surge/choke, and other operational configuration parameters.
	Compressor Commissioning	View, modify and commit site-specific compressor parameter values of a connected compressor, as well as import and export configurations between portable files. Minor guidance is provided to the user by presenting any number of configuration pages which are necessary for consideration during the deployment of a compressor system.
	Compressor Data Trending	Graphically monitor selected compressor parameter values and load or save user-configurable watch configurations.

4.2.1 Compressor Fault Troubleshooting

When troubleshooting a compressor fault, detailed analysis of this data should be made (in conjunction with a Yenta compressor recording file, if possible) to determine the specific fault and determine the root cause of fault occurrence.

Downloading fault and event logs every time a compressor is visited is useful for documenting compressor operational history.

Fault and event history can be extracted from the compressor memory in the *SMT Logged Event and Fault Viewer* tool. See the latest Service Monitoring Tools User Manual for user instructions.

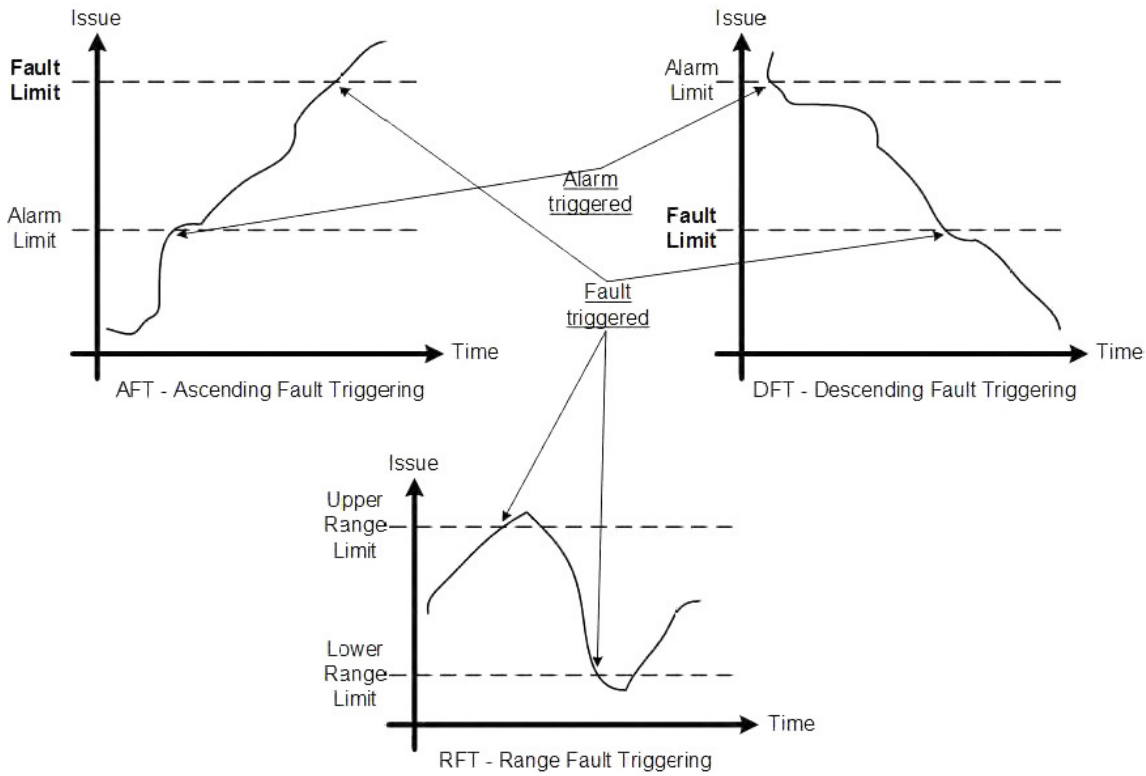
Active compressor fault and alarm messages can be viewed in the *SMT Active Alarm/Fault Viewer* tool. See the latest Service Monitoring Tools User Manual for user instructions.

Compressor Alarm and Fault settings can be found in the *Configure Alarms/Faults* menu option of the *Active Alarm/Fault Viewer tool.*

The *Compressor Data Recording and Playback* tool provides a method of reviewing operational conditions without a connection to the compressor. It also creates a file to electronically transmit for peer review. See the latest Service Monitoring Tools User Manual for use instructions.

The following principle is applied when having both a fault and/or an alarm limit as triggers. In the following explanations for faults and alarms, the trigger method terminology is used: Instant fault triggering (INS), Ascending Fault Triggering (AFT), Descending Fault Triggering (DFT) and Range Fault Triggering (RFT).

Figure 96 - Fault Trigger Methods



Fault Reset: A fault that does not require a power cycle to clear (non-critical) can be reset in the following manner: Interlock must be closed, set the Demand to 0 and afterwards to a value greater than 0. Now the fault is reset and the compressor is ready to run. The assumption is that the cause of the fault has been rectified.

A fault demanding a power cycle (Lock-Out Fault) is resettable by cycling the mains power to the compressor. The assumption is that the cause of the fault has been rectified. See Table 22 (Compressor Faults).

Table 22 - Compressor Faults

Compressor Fault Description	Trigger Method	Troubleshooting
High Inverter Temperature Fault	AFT	Indicates the Inverter cooling is insufficient. If this fault occurs three times within a 30-minute period, a Lock-Out Fault will occur. **CAUTION:** Repeated occurrences of this alarm can result in Inverter failure. Ensure the liquid motor-cooling line has sufficient liquid supply and is not blocked. Prevent prolonged operation at a pressure ratio less than 1.5. Verify the solenoids are operational and not blocked. See Section 3.12.3. Verify the solenoid actuators. See Section 3.12.3. Verify the Serial Driver. See Section 3.11.3. The measured Inverter temperature must drop below the Maximum Drive Startup Temperature before a restart can be attempted, otherwise the Compressor Monitor Tool Control Status message "Above drive temperature limit - waiting to cool down" will be displayed. Review the fault log for actual Inverter temperature and other conditions that are recorded at the time of fault. The temperature sensor embedded in the Inverter requires a replacement of the Inverter if determined faulty.
High Discharge Temperature Fault	AFT	Suggests insufficient charge (i.e., low gas), the condenser temperature has increased, check valve has failed to open or the compressor has been running in surge condition for an extended period of time. Check the chiller gas charge, entering condenser air/water conditions and operational settings. Verify check valve opens during compressor operation. Verify the discharge pressure/temperature sensor. See Section 3.20.3. Review the fault log for actual discharge temperature; compare actual speed to surge speed, and other conditions that are recorded at the time of fault.
Low Suction Pressure Fault	DFT	Suggests insufficient charge, insufficient system load, or a sudden drop in evaporator entering air/water temperature. Check the charge, system load and entering air/water conditions. Review the fault log for actual suction pressure, entering air/water temperature (if available) and other conditions that are recorded at the time of fault.
High Discharge Pressure Fault	AFT	Suggests the condenser may be faulty or insufficient water flow. Check the condenser and water flow. Review the fault log for actual discharge pressure and other conditions that are recorded at the time of fault. Results in an Instantaneous Lock-Out Fault.
3-Phase Over-Current Fault	AFT	Indicates the compressor is drawing current greater than the 3-Phase Current Fault Limit. Review the fault log for recorded 3-Phase Current level, demand, entering air/water temperature (if available) and other conditions that are recorded at the time of fault. Usual causes are Start speed set too high (particularly in conjunction with IGV start position setting too low), minimum pressure ratio set high, power control integral (loop) gain set too high. Can also be related to sudden increase in load/demand or system changes. During startup mode, all alarms are ignored by the control system, but faults are not. Therefore, when the FLA current (3-Phase Alarm Limit) is reached, the compressor will continue to accelerate if startup requirements are not satisfied. After Startup is complete, alarms will slow the compressor speed. Results in an Instantaneous Lock Out Fault. Requires a power cycle to reset.
High Cavity Temperature Fault	AFT	Indicates the motor cooling is insufficient. **CAUTION:** Repeated occurrences of this fault can result in shaft demagnetization or Back EMF is low faults. Ensure the liquid motor-cooling line has sufficient liquid supply and is not blocked. Prevent prolonged operation at a pressure ratio less than 1.5. Verify the solenoids are operational and not blocked See Section 3.12.3. Verify the solenoid actuators. See Section 3.12.3. Verify the Serial Driver. See Section 3.11.3. Verify cavity temperature sensor. See Section 3.19.3.
Low Leaving Fluid Temperature Fault	DFT	Suggests insufficient water flow or insufficient system load. Check water flow and system load. Verify leaving fluid temperature sensor. Ensure LEAVE jumper is installed on the I/O board. Review the fault log for entering and leaving air/water temperature (if available) and other conditions that are recorded at the time of fault.
High Pressure Ratio Fault	AFT	Suggests the condenser may be faulty, not enough load on the evaporator, or insufficient water flow in either condenser or evaporator. Check the condenser, evaporator loads and water flow. Review the fault log for suction and discharge pressures and other conditions that are recorded at the time of fault.
Bearing/Motor Fault Active	INS	If a Motor Fault type or a Bearing Fault type is present, the Generic Compressor Fault is triggered. This is not an actual fault, only an indication that a fault has occurred in the Motor or Bearing section. See Table 23 (Motor Faults) and Table 20 (Bearing Fault Types).

Table 22 - Compressor Faults (Continued)

Compressor Fault Description	Trigger Method	Troubleshooting
Sensor Fault	RFT	Review fault log for indication of values out of specified ranges recorded at time of fault. Verify the questionable sensor and related connections for failure. Inverter temperature: The sensor embedded in the Inverter requires a replacement of the Inverter if determined faulty. Cavity Temperature: Verify cavity temperature sensor. See Section 3.19.3. Suction Temperature: Verify suction pressure/temperature sensor. See Section 3.20.3. Discharge Temperature: Verify discharge pressure/temperature sensor. See Section 3.20.3. Leaving Water Temperature: Verify LEAVE jumper is installed on I/O board. Suction Pressure: Review fault log for recorded value. Discharge Pressure: Review fault log for recorded value.
High SCR Temperature Fault	AFT	Indicates the SCR cooling is insufficient. If this fault occurs three times within a 30-minute period, a Lock-Out Fault will occur. Ensure the liquid motor-cooling line has sufficient liquid supply and is not blocked. Prevent prolonged operation at a pressure ratio less than 1.5. Verify the solenoids are operational and not blocked See Section 3.12.3. Verify the solenoid actuators. See Section 3.12.3. Verify the Serial Driver. See Section 3.11.3. Verify SCR temperature sensor. See Section 3.5.3.3. Verify SCRs. See Section 3.5.3.
Lock Out Fault	INS	If any (or a combination of) the faults listed below occurs more than 3 times within 30 minutes, a Lock-Out fault occurs: Inverter Temperature SCR Temperature Motor High Current Inverter Error Rotor may Be Locked Back EMF is low Review fault log for indication of faults recorded at time of lock out fault. Determine cause of the faults and repair as necessary. Cycle power to clear Lock-Out Fault. Active alarm/Fault Viewer in SMT allows the Lock Out counter to be monitored
High Winding Temperature Fault	AFT	Indicates the Raw Motor Thermal Readout in the Compressor Monitor Tool has exceeded the maximum limit. Ensure the liquid motor-cooling line has sufficient liquid supply and is not blocked. Prevent prolonged operation at a pressure ratio less than 1.5. Verify the solenoids are operational and not blocked. See Section 3.12.3. Verify the solenoid actuators. See Section 3.12.3. Verify the Serial Driver. See Section 3.5.3. Verify the motor thermistor.
High Suction Superheat Fault	AFT	Based on the compressor suction pressure and temperature values. Suggests high evaporator temperature combined with low evaporator pressure, insufficient refrigerant charge, check valve has failed to open or the compressor has been running in surge condition for an extended period of time. Check the charge, system load and entering air/water conditions. Verify check valve opens during compressor operation. Review the fault log for actual suction pressure and temperature, entering air/water temperature (if available) and other conditions that are recorded at the time of fault. Verify suction pressure/temperature sensor. See Section 3.20.3.
Suction Pressure Sensor Fault	RFT	Indicates the Suction Pressure Sensor is out of range. >1200 or < -30 kPa abs
Discharge Pressure Sensor Fault	RFT	Indicates the Discharge Pressure Sensor is out of range. >3500 or < -30 kPa abs
Suction Temperature Sensor Fault	RFT	Indicates the Suction Temperature Sensor is out of range. >100 or < -30 °C
Discharge Temperature Sensor Fault	RFT	Indicates the Discharge Temperature Sensor is out of range. >110 or < -30 °C
Inverter Temperature Sensor Fault	RFT	Indicates the Inverter Temperature Sensor is out of range >100 or < 0 °C
Cavity Temperature Sensor Fault	RFT	Indicates the Cavity Temperature Sensor is out of range >100 or < -20 °C

4.2.2 Motor Faults/System Status

Table 23 - Motor Faults

Motor Fault Description	Trigger Method	Troubleshooting
Motor Single Phase Overcurrent Fault	AFT	One phase of the Inverter to motor is generating high current. Review Fault and Event Log details to determine conditions related to the fault. This fault can be a result of liquid carryover, a loss of shaft magnetic strength, see Back EMF is Low fault, or Inverter failure, see Inverter Error fault. Verify the Stator. See Section 3.8.4. Verify the Inverter and the Inverter cable connections. See Section 3.7.3. This fault can be related to BMCC Inverter switching control. Verify the BMCC. See Section 3.14.3. If fault/event logs show occurrence of Single Phase Over-Current fault after one Inverter Error, the Inverter should be verified and may require replacement.
DC Bus Overvoltage Fault	AFT	Suggests that the DC bus voltage is above the Maximum DC Bus Voltage. Measure the incoming main AC voltage. Measure the DC bus voltage using the DC Bus Test Harness. See Section 3.6.3.1. Compare the measured voltages to the displayed readings in the Compressor Monitor Tool and details in the Fault and Event Log to determine conditions related to the fault. Correct the incoming main AC voltage if it is higher than the maximum recommended value for the application. If the measured DC bus voltage exceeds the Maximum DC Bus Voltage and incoming main AC voltage is correct, verify the Soft Start. See Section 3.4.3.1. All 3-phase voltage information displayed in the SMT is calculated from DC bus voltage, as measured by the Inverter, verify the Inverter and its connections. See Section 3.7.3.1.
Motor Overcurrent Fault	AFT	Suggests AC input voltage is too low or the compressor is overloaded. If this fault occurs three times within a 30-minute period, a Lock-Out Fault will occur. Verify the 3-phase AC input voltage is above the minimum recommended value for the application. Heavy, saturated gas can cause the motor to overwork and generate high current. Ensure superheated gas is entering the compressor suction port. Verify the Inverter. See Section 3.7.3.1. Verify the Stator. See Section 3.8.4.
Inverter Error	INS	Indicates there is an error within the Inverter Control Board or no BMCC communication with the Inverter. If this fault occurs three times within a 30-minute period, a Lock-Out Fault will occur. Verify the Inverter and the Inverter cable connections. See Section 3.7.3.1. If the Inverter Error fault persists after the Inverter is verified, it should be replaced. Review the Fault and Event Log for recorded occurrences of this fault. Any occurrence of Single Phase Over-current, Back EMF is Low or Rotor May Be Locked faults immediately following an Inverter Error fault most likely indicates a bad Inverter.
Bearing Fault Active	INS	If a bearing fault type is present, the Bearing Error is triggered. This is not an actual fault, only an indication that a fault has occurred in the Bearing section. See Table 21 (Bearing Fault Types).
Rotor Starting Torque Fault	INS	At low speed (startup) rotor angular position is not at correct value for a given speed, caused by low shaft magnet strength, liquid flooded compressor or damaged touchdown bearings/physical contact of rotating components. If this fault occurs three times within a 30-minute period, a Lock-Out Fault will occur. If fault or event logs show occurrence of Rotor May Be Locked fault after one Inverter Error, the Inverter should be verified and may require replacement. See Inverter Error or Single Phase Over-Current. Verify the bearing calibration and levitation. Verify the Inverter. See Section 3.7.3.1. Verify the Stator. See Section 3.8.4. Review Fault and Event Log details to determine conditions related to the fault.
Low Inverter Current Fault	AFT	Suggests the compressor has no load, verify load is available. Minimum magnetizing power not absorbed for given speed at the Inverter. Compressor is not pumping. Usually seen in open-air run. Review the Fault Log for the level of Motor Current in the fault record. Zero motor current at zero RPM indicates a problem with the Inverter. Verify the Inverter. See Section 3.7.3.1. Verify the Stator. See Section 3.8.4.
DC Bus Under/Over Voltage Fault	DFT	At 0 RPM: If the measured DC Bus voltage is lower than Soft Start charge voltage, a DC bus voltage fault is recorded. All 3-phase voltage information displayed in the SMT is calculated from DC bus voltage, as measured by the Inverter. Typically, this fault is recorded when power to the compressor is removed. Measure the incoming main AC voltage. Compare the measured voltages to the displayed readings in the Compressor Monitor Tool and Fault and Event Log details to determine conditions related to the fault. Measure the DC bus voltage using the DC Bus Test Harness. See Section 1.9.2. Verify the Soft Start. See Section 3.4.3. Verify the SCRs. See Section 3.5.3. Verify the connections to the Inverter.

Table 23 - Motor Faults (Continued)

Motor Fault Description	Trigger Method	Troubleshooting
24VDC Under/Over Voltage Fault	RFT	Suggests the measured 24VDC supply voltage is out of range. Measure the 24VDC test points at the Backplane. Compare the measured voltages to the displayed readings in the Compressor Monitor Tool and Fault and Event Log details to determine conditions related to the fault. If the measured voltage is incorrect, verify the DC/DC Converter. See Section 3.9.3. Determine that one of the modules is not draining energy. See Section 4.5.2. If the fault occurs when the compressor is given the demand to run, the Inverter may be causing the 24VDC fault.
Low Motor Back EMF Fault	DFT	The calculated magnetic strength of the shaft has fallen below the minimum limit. This can be a temporary effect due to high load and elevated temperatures (will recover when cavity temperature cools) or due to a permanent demagnetization of the shaft. If this fault occurs three times within a 30-minute period, a Lock-Out Fault will occur. Compare the Back EMF value to the displayed readings in the Compressor Monitor Tool and Fault and Event Log details to determine conditions related to the fault. Permanent damage to Back EMF can be caused by insufficient motor cooling, repeated overheating of cavity, faulty Inverter, faulty BMCC, repeated Rotor May Be Locked or Single phase Over-Current faults. See Inverter Error. Verify the Inverter. See Section 3.7.3.1. Verify the Stator. See Section 3.8.4.
Generator Mode Active	DFT	Indicates, at greater than 0 RPM, the measured actual DC Bus voltage has fallen below the Generator Mode Enabled Level value. Also, could be electronic "noise" when no actual drop in voltage has occurred. Measure the incoming main AC voltage. Measure the DC bus voltage using the DC Bus Test Harness. Compare the measured voltages to the displayed readings in the *Compressor Monitor Tool* and Fault and Event Log details to determine conditions related to the fault. Typically, this fault is recorded when power to the compressor is removed while it is running.
EEPROM Checksum Fault	INS	Indicates there is an error reading the EEPROM in the BMCC. Perform a bearing calibration and save to EEPROM, cycle the power. If the error is still present, the BMCC must be replaced.
SCR Ripple Voltage Fault	AFT	Indicates that a voltage imbalance may exist between the incoming AC phases. Measure the difference in current and voltage between the phases. If there is a current imbalance (more than 5%) between the phases, verify the incoming AC power supply. Review the Compressor Monitor Tool for SCR Voltage Ripple readings at the time of the fault. Phase imbalance can be caused by a faulty SCR, SCR Gate, Gate control from the Soft Start Board or a faulty power capacitor. Verify the SCRs. See Section 3.5.3. Verify the Soft Start Board. See Section 3.4.3.

4.2.3 Bearing Status

Table 24 - Bearing Status

Bearing Fault Description	Trigger Method	Troubleshooting
Startup Calibration Check Fault	INS	During compressor start-up, the stored bearing calibration is verified. Indicates that the calibration failed during compressor start-up. Manually calibrate the bearings and save to EEPROM, cycle the power. Review the calibration report to determine conditions related to the fault. If the bearings cannot pass calibration after three attempts, verify the PWM (see Section 3.16.3), bearing sensors (see Section 3.18.3) and bearings (see Section 3.17.3).
Bearing Displacement Fault	INS	The shaft position has been measured outside the bearing displacement maximum in one of the five bearing positions. This fault can be the result of system-related issues, such as EXV control issues (i.e., starving the evaporator or pumping liquid), operating at the surge line, check valve failure, or IGV failure. Review *Fault and Event Log* details to determine conditions related to the fault. Using the *Compressor Configuration tool*, set the Control Mode to Manual. Using the *Compressor Monitor*, levitate the shaft and record the bearing forces. Greater than 2A indicates a bearing issue. Manually calibrate the bearings, save to EEPROM and identify if bearing forces improve. If the bearings cannot be calibrated after three attempts, verify the PWM (see Section 3.16.3), bearing sensors (see Section 3.18.3) and bearings (see Section 3.17.3). Review the calibration report to determine conditions related to the fault.
Bearing Overcurrent Fault	INS	Indicates that the current drawn by the bearing exceeds the maximum amps in one of the five bearing positions. **Using the** *Compressor Configuration* **tool, set the Control Mode to Levitate Only Mode. Using the** *Compressor Monitor*, **levitate the shaft and record the bearing forces. Greater than 2A indicates an issue. Manually calibrate the bearings, save to EEPROM and identify if bearing forces improve.** If the bearings cannot be calibrated after three attempts, verify the PWM (see Section 3.16.3), bearing sensors (see Section 3.18.3) and bearings (see Section 3.17.3). **Review the calibration report to determine conditions related to the fault.**

4.3 Bearing Calibration

4.3.1 When to Calibrate the Bearings

4.3.1.1 Calibration When Commissioning

A bearing calibration can be performed at commissioning for the purpose of comparing current calibration values to factory saved calibration values. After the calibration has been performed, a calibration report should be created and saved for future comparison. There is no requirement to save the calibration to EEPROM when commissioning the compressor.

4.3.1.2 Regular Maintenance Calibration

Calibration can be performed during regular maintenance visits for the purpose of comparing the values stored in EEPROM to the latest current calibration values to determine changes over time. There is no benefit to save the calibration to EEPROM if the compressor has been operating normally.

A calibration report should always be created for future comparison.

4.3.1.3 Calibration when Troubleshooting

Troubleshooting procedures that require a bearing calibration to be performed will need to be saved to EEPROM. Click on the "Save to EEPROM" button even if a message indicating values are out of range is displayed. Ensure that "Stored" values are updated to be identical to "Latest" values. Cycle power to the compressor ensuring the green LED on the I/O board turns off. This may need to be repeated multiple times. Create a calibration report before any change is made and after each calibration. Ensure the shaft levitates correctly by clicking "Validate" after calibration values have been saved to EEPROM.

NOTE

The compressor performs an automatic startup check bearing calibration after a power cycle.

4.3.1.4 BMCC Change

If a replacement BMCC is installed in a compressor, a calibration must to be performed and saved to EEPROM, and repeated to match the BMCC to the specific compressor.

4.3.2 Performing a Calibration

Once opened, the Calibration Tool will automatically change the Compressor Control Mode to Calibration Mode and send a delevitate shaft signal to the bearing control. It is necessary to verify the control mode of the compressor after completing the calibration process.

A manual validation can be performed by clicking the **Validate** button. Validation uses the stored calibration values to momentarily levitate the shaft and compares the values to tolerance limits.

4.3.2.1 Before Performing a Calibration

- Interlock must be open
- RS485 or other external compressor communication connection must be disconnected.

4.3.2.2 Calibration

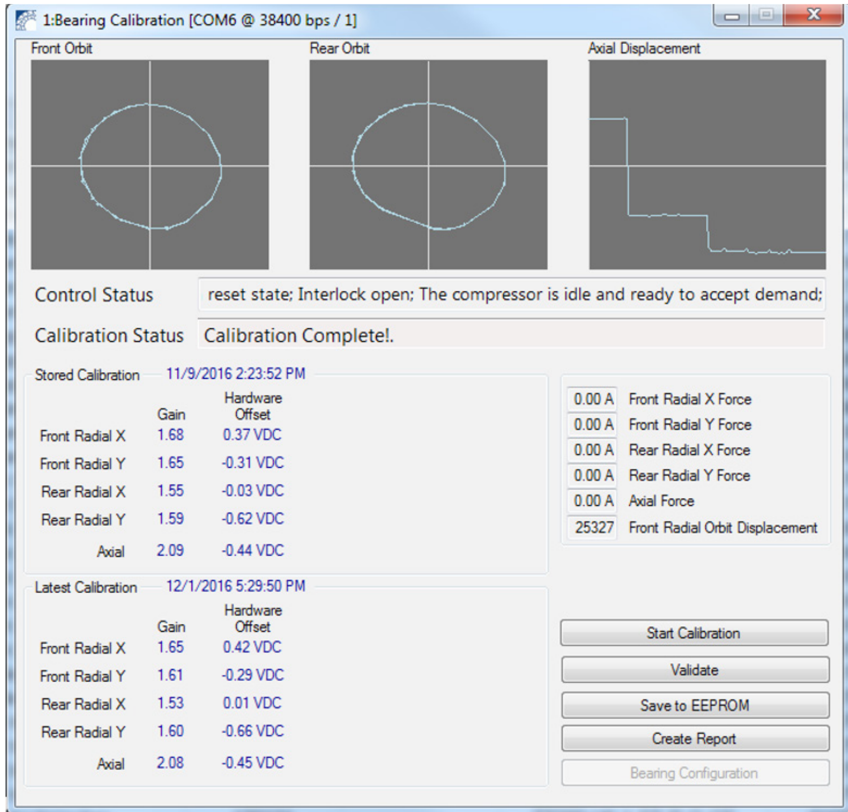
1. Open the SMT and connect to the compressor.

2. Open the Bearing Calibration tool. The Bearing Calibration tool displays. See Figure 97 (Bearing Calibration Tool).

3. Click on the Start Calibration button.

- See the current Service Monitoring Tools User Manual for further instructions on performing a calibration and validation.

Figure 97 - Bearing Calibration Tool



If the message "Calibration Failed" or "Levitation Failed" appears when attempting to calibrate, it indicates the steps expected by the SMT have not been completed. To determine the cause of failure, verify the following:

• Ensure there are no faults present; the shaft will not levitate for validation if a fault is present.

•Ensure the RS485 at J1 on the I/O board is disconnected from external communication; if the chiller controller automatically sets the control mode, it will stop the calibration process prematurely.

• Ensure Interlock is open.

4.3.3 After Calibration is Complete

The message "Calibration Complete" appears when all SMT calibration steps are complete, regardless of the results. There will be three options available after the calibration has completed.

• Validate

• Save to EEPROM (If the Save to RAM & EEPROM radio button is selected on the Connection Manager Window)

• Create Report

Each of these are described in separate sections below.

4.3.3.1 Validate

By validating the calibration, you are levitating the shaft using the current stored calibration data. If you validate before Saving to EEPROM, the latest calibration data has no impact on the shaft position.

A bearing calibration is not required to have been performed in order to validate (levitate) the shaft. Using the validation process in this manner will allow the technician to know if the shaft can levitate freely using the current stored calibration data.

4.3.3.2 Save to EEPROM

When saving to the EEPROM, the "latest" calibration values overwrite "stored" values.

There is no requirement to save calibrations to EEPROM after performing a bearing calibration. Comparing original factory calibration values stored in EEPROM to the latest calibration allows determination of long term changes.

Saving to EEPROM permanently overwrites existing stored calibration values. "Stored" values are used for startup check at the next power cycle. The previous values cannot be recovered once the new values are saved to EEPROM.

Original calibration values should only be overwritten when replacing a BMCC in the field, or when required for troubleshooting a bearing issue with a compressor.

NOTE

If the latest calibration values differ from the stored values outside of the tolerances set in the SMT, a warning message will appear when saving to the EEPROM.
This compares changes from the stored calibration to the latest and may be an indicator of shaft/bearing alignment changes over time.

4.3.4 Create a Calibration Report

The calibration report compares current bearing calibration values to stored values. There is no requirement to perform a bearing calibration before creating a calibration report. There is also no requirement for saving a bearing calibration (if performed) to EEPROM before creating a calibration report.

Perform the following steps to create a report:

1. Click the Calibration Report button.

2. Select a location to save the report. The report will be generated as a Portable Document Format (PDF) document.

4.3.5 Calibration Report Analysis

1. **Data in Report:** The difference between the "Latest Calibration" and "Stored Calibration" is less than 30 percent.

• **Interpretation:** Successful calibration.

2. **Data in Report:** Only one of the gain values equals zero.

• **Interpretation:** Bearing or bearing sensor electrical fault, or one channel of the PWM Amplifier is faulty.

• **Action:** Verify the PWM.

• **Action:** Verify the bearings.

• **Action:** Verify the bearing sensors.

3. **Data in Report:** More than one of the gain values is zero.

• **Interpretation:** Incorrect calibration procedure performed, bearing or bearing sensor electrical fault, or more than one channel of the PWM Amplifier is faulty.

• **Action:** Before beginning the calibration, verify the Interlock is open and all external communication is disconnected.

• **Action:** Verify the PWM.

• **Action:** Verify the bearings.

• **Action:** Verify the bearing sensors.

4. **Data in Report:** One or more of the gain values exceeds 3.0.

• **Interpretation:** Bearing electrical fault or shaft is obstructed.

• **Action:** Verify the bearings.

• **Action:** Verify the bearing sensors.

See Figure 98 (Bearing Calibration Flow).

5. **Data in Report:** One or more of the bearing Force Current values exceeds 1.5A in Validation Results.

• **Interpretation:** Bearing electrical fault or shaft is obstructed.

• **Action:** Verify the bearings.

• **Action:** Verify the bearing sensors.

See Figure 98 (Bearing Calibration Flow) .

6. **Data in Report:** The difference between the "Latest Calibration" and "Stored Calibration" is greater than 30 percent.

• **Interpretation:** Bearing/Shaft position has changed from stored to latest.

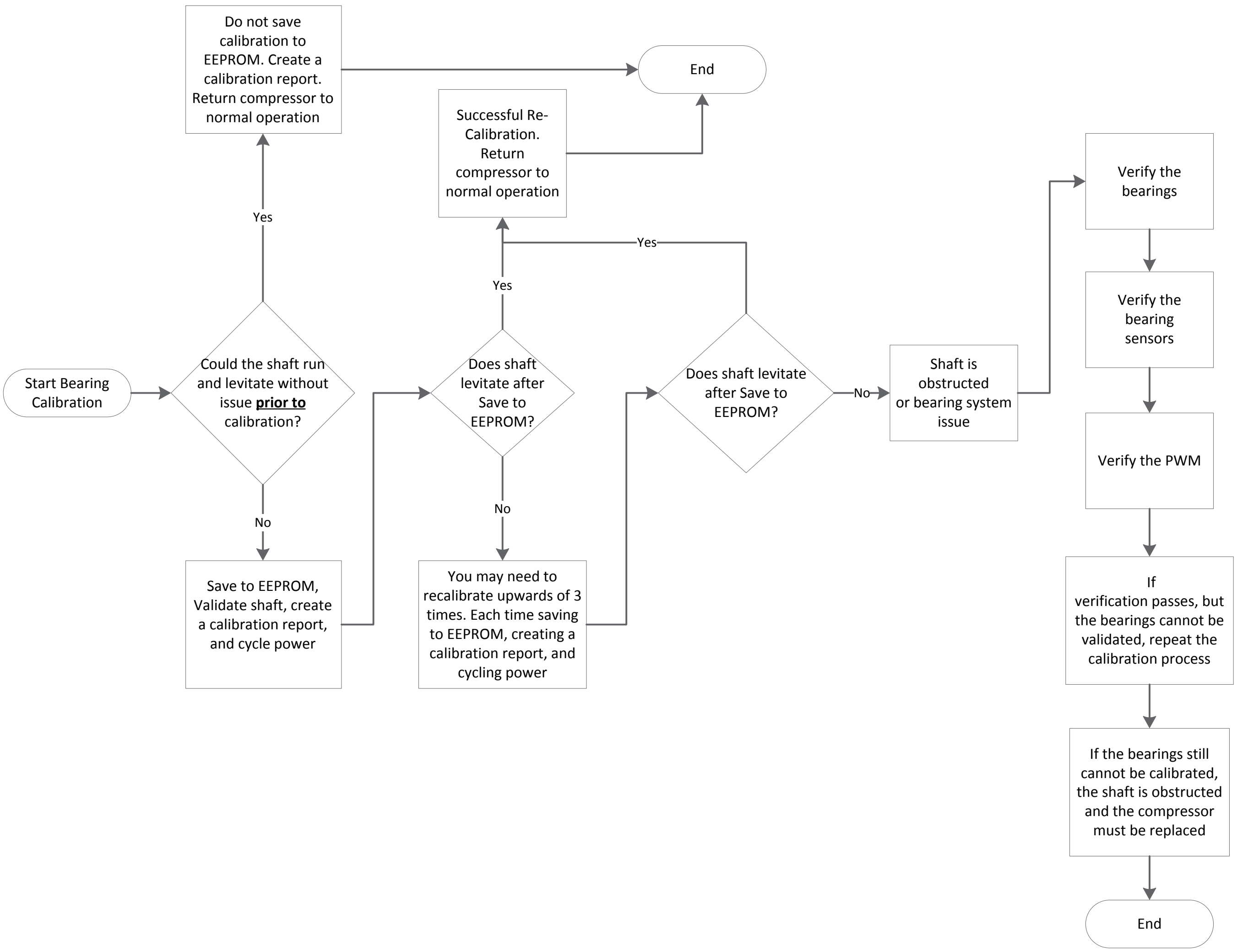
• **Action:** Save to EEPROM and cycle power; test run compressor with new values.

• **Action:** Verify the bearings.

• **Action:** Verify the bearing sensors.

See Figure 98 (Bearing Calibration Flow).

Figure 98 - Bearing Calibration Flow



4.4 Compressor Connection Status Indications

• Disconnected: no connection exists with a compressor or remote compressor host

• Ready to Connect: a connection with a remote host (if applicable) has been established, but no compressor connection has yet been established

• Compressor is starting up: The currently connected compressor is in startup mode

• Connected: There has been established a connection with a remote host (if applicable) and a connection with a compressor has been established and verified

• No compressor found: Any serial ports or connections have been established, but a valid compressor was not able to be detected

• Error opening port: There was an error opening the specified serial port (either the port is already in use, the port name doesn't exist, or there was some other error attempting to open the serial port)

• Server not found: Could not connect to remote host

4.5 System and Compressor Level Troubleshooting

4.5.1 Compressor Voltage Troubleshooting

1. Carefully, remove the Mains Input Cover.

2. Verify all three phases of voltage before the mains fuses. See Section 3.3.3.

• If the name plate rated voltage is present, proceed to Step 3.

• If the voltage is (+/- 10%) outside of the nameplate rated voltage, restore correct voltage.

3. Verify all three phases of voltage after the mains fuses.

• If the name plate rated voltage is present proceed to Step 4.

• If any of the three phases are not present, isolate compressor power then replace the fuses.

4. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

5. Inspect all electronics for visible damage

• If no visible damage is present, proceed to Step 6.

• If there is any type of visible damage, replace the damaged component(s).

6. Verify all of the Soft Start fuses. See Section 3.3.3.

• If all of the fuses are ok, proceed to Step 7.

• If any of the fuses are blown, replace the fuse(s) and review the cause of the blown fuses. See Section 4.5.3.

7. Verify the Inverter cable to the Inverter connector is installed correctly.

8. Verify the DC/DC Converter resistances. See Section 3.9.3.

• If DC/DC Converter resistances are correct, proceed to Step 9.

• If DC/DC Converter resistances are not correct, replace the DC/DC Converter then verify the PWM and bearings.

9. Install the DC Bus test harness. See Section 1.9.2.

10. Disconnect the J2 (250VDC) and J3 (24VDC) outputs from the DC-DC Converter.

11. Re-install the Top Cover then re-apply the compressor power.

12. Verify the DC Bus voltage through the test harness. See Section 3.6.3.

• If DC Bus voltage is correct, proceed to Step 13.

• If DC Bus voltage is not correct, verify the SCRs.

• If the SCRs pass test, replace the Soft Start then repeat Step 13.

• If one or more of the SCRs test faulty, replace all three of the SCRs then repeat Step 12.

13. Verify the 15VAC through the test harness.

• If the 15VAC is present, proceed to Step 14.

• If the 15VAC is not present, replace the Soft Start then repeat Step 13.

14. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

15. Remove the DC-Bus test harness and re-install the J2 (250VDC) and J3 (24VDC) outputs to the DC-DC Converter.

16. Re-install the top covers and remove the Service Side Cover.

17. Re-apply compressor power.

18. Verify the 250VDC and 24VDC test points on the Backplane.

• If both voltages are within +/- 10%, all supply voltages are good.

• If either voltage is not within +/- 10%, proceed to Step 19.

19. Isolate the compressor power and wait for the LEDs on the Backplane to go out.

20. Remove all connectors from the Backplane, leaving only the J6 (Inverter cable), J4 (250VDC) and J24 (24VDC) inputs connected.

21. Remove the Serial Driver (see Section 3.11.4.1) , BMCC (see Section 3.14.4.1) and PWM (see Section 3.16.4.1).

22. Re-apply compressor power.

23. Verify the HV+ and the +24 VDC test points on the Backplane.

• If all voltages are within +/- 10%, proceed to Step 26.

• If either voltage is not within +/- 10%, isolate compressor power and wait for the LED's on the Backplane to go out, then disconnect the J4 and J24 connectors from the Backplane.

24. Re-apply compressor power.

25. Verify the 250VDC and 24VDC at the J4 and J24 DC/DC Converter output connectors.

• If either voltage is not within +/- 10%, replace the DC/DC Converter.

• If all voltages are within +/-10%, replace the Backplane.

26. Verify the +17V, +15, +5 and -15 VDC test points on the Backplane.

• If all voltages are within +/- 10%, proceed to Step 27.

• If any voltages at the +17V, +15, +5 and -15 VDC test points are not within +/- 10%, replace the Backplane.

27. Isolate the compressor power and wait for the LEDs on the Backplane to turn off, then re-install all connectors and the PWM (see Section 3.16.4.2) , BMCC (see Section 3.14.4.2) and Serial Driver (see Section 3.11.4.2) to the Backplane.

28. Re-apply the compressor power.

29. Verify the +17V, +15, +5 and -15 VDC test points on the Backplane.

• If all voltages are within +/- 10%, all supply voltages are good.

• If any of these voltages are not within +/- 10%, see Section 4.5.2.

4.5.2 Determining the Cause of an Energy Drain

4.5.2.1 Determining if Serial Driver is Draining Energy

1. Remove the Service Side Cover.

2. Test the Backplane voltages at the +24V, +15, +5, and -15 VDC test points.

• If all voltages are within +/- 10%, the Serial Driver is not draining energy.

• If any of these voltages are not within +/- 10%), proceed to Step 3.

3. Isolate the compressor power and wait for the LEDs on the Backplane to turn off.

4. Remove the Serial Driver.

5. Re-apply the compressor power

6. Test the Backplane voltages at the +24V, +15, +5, and -15 VDC test points.

• If all voltages are within +/- 10%, the Serial Driver is draining energy.

• If any of these voltages are not within +/- 10%, another component is draining energy.

4.5.2.2 Determining if BMCC is Draining Energy

1. Remove the Service Side Cover.

2. First, follow procedure Section 4.5.2.1.

3. Isolate the compressor power and wait for the LEDs on the Backplane to turn off and then remove the Serial Driver. See Section 3.11.4.1.

4. Re-apply the compressor power and test the Backplane voltages at the +24V, +15, +5, and -15 VDC test points.

• If all voltages are within (+/- 10%) the BMCC is not draining energy.

• If any of these voltages are not within (+/- 10%) proceed to Step 5.

5. Isolate the compressor power and wait for the LEDs on the Backplane to turn off.

6. Remove the BMCC (see Section 3.14.4.1) (ensure the Inverter cable remains connected).

7. Re-apply the compressor power

8. Test the Backplane voltages at the +24V, +15, +5, and the -15 VDC test points.

• If all voltages are within (+/- 10%) the BMCC is draining energy.

• If any of these voltages are not within (+/- 10%) another component is draining energy.

4.5.2.3 Determining if PWM is Draining Energy

1. Remove the Service Side Cover.

2. First, follow procedure Section 4.5.2.1 and Section 4.5.2.4.

3. Isolate the compressor power and wait for the LEDs on the Backplane to turn off and then Remove the Serial Driver (see Section 3.11.4.1) and BMCC (see Section 3.14.4.1).

4. Re-apply the compressor power and then test the Backplane voltages at the HV+, +17HV, +24V, +15, +5, and -15 VDC test points.

• If all voltages are within (+/- 10%) the PWM is not draining energy.

• If any of these voltages are not within (+/- 10%) proceed to Step 5.

5. Isolate the compressor power and wait for the LEDs on the Backplane to turn off.

6. Verify the PWM diodes. See Section 3.16.3.3.

7. Remove the PWM (Section 3.16.4.1) (keep the Inverter cable connected).

8. Verify the bearings and bearing sensors (see Section 3.18.3).

9. Re-apply the compressor power

10. Test the Backplane voltages at the HV+, +17HV, +24V, +15, +5, and -15 VDC test points.

• If all voltages are within (+/- 10%) the PWM is draining energy.

• If any of these voltages are not within (+/- 10%) another component is draining energy.

4.5.2.4 Determining if Inverter is Draining Energy

1. Remove the Service Side Cover.

2. Test the Backplane voltage at the +24V test point.

3. While measuring the +24V test point voltage, give the compressor the demand to run.

• If the +24V reading drops below 22VDC at the moment the demand to drive is given, the Inverter is faulty.

• If the +24V reading does not change at the moment the demand to drive is given, another component is draining energy.

4.5.2.5 Determining if Compressor I/O Board is Draining Energy

See Section 3.15.3.1.

4.5.3 Determining the Cause of Blown Soft Start Fuses

NOTE

Refer to Section 3.4.3 for details on verifying Soft Start fuses.

1. Verify the Soft Start fuses (see Section 3.4.3.2).

2. An open F1 fuse may indicate a problem with the DC/DC.

a. Using the DC Bus Test Harness, verify the DC/DC Converter high voltage input (see Section 3.9.3.1).

b. Verify the DC/DC Converter (see Section 3.9.3).

c. Verify the PWM (see Section 3.16.3).

d. Verify the bearings (see Section 3.17.3).

3. An open F2 fuse may indicate a problem with the DC/DC Converter.

• Verify the DC/DC Converter 15VAC input resistance (see Section 3.9.3.3).

4. An open F3 fuse may indicate a problem with the Soft Start Circuit Board.

a. Verify the SCRs and SCR gates. (see Section 3.5.3).

b. Replace the fuse.

NOTE

When replacing the F3 Nano fuse, use the original rated fuse or higher, up to the 1.0A Nano fuse, on all Soft Start versions. Do not use a lower rated fuse than the original.

c. Reapply power.

d. If the fuse fails again, replace the Soft Start.

5. An open F4 or F5 fuse may indicate a problem with the Soft Start Transformers, Soft Start Circuit Board, or DC/DC Converter.

a. Verify the DC/DC 15VAC input resistance (see Section 3.9.3.3).

b. Verify the SCRs and SCR gates (see Section 3.5.3).

c. If no faulty component is identified, replace the fuse and reapply power.

d. If the fuse fails again, replace the Soft Start (see Section 3.4.4).

4.5.4 Troubleshooting an Open Interlock

1. Verify the interlock, see Section 3.15.3.3.

2. Ensure there is 0VDC (no external power applied) on the interlock circuit.

3. If the Interlock circuit is determined damaged and will not close, remove the wire from the I/LOCK-(neg) at the J2 connector of the I/O Board.

4. Move the wire to the SPEED-(neg) at the J2 connector of the I/O board.

5. This will allow the interlock circuit to close until a replacement BMCC is installed.

6. After replacing the BMCC (see Section 3.14.4), replace the wire to the I/LOCK-(neg) at the J2 connector of the I/O board.

4.5.5 Troubleshooting the Inverter

⚠ • • • CAUTION • • •

Repeated rotor may be locked or single phase over current faults can cause shaft demagnetization. It is important to repair an Inverter failure before the compressor is damaged beyond field repair.

1. Download the fault and event log.

2. Review the fault and event log for any "Inverter Error Signal Active" faults.

• Presence of an "Inverter Error Signal Active" fault indicates failure of the Inverter. Replace the Inverter.

• If no "Inverter Error Signal Active" fault is present, continue with the next step.

3. Verify the Inverter.

4. If the Inverter verification passes, but he compressor will not run, refer to Stator insulation verification and Stator resistance verification.

5.1 Preventive Maintenance Tasks

Table 25 (Preventative Maintenance Tasks) lists tasks that should be performed on a regular basis to maintain optimal performance of the system.

Table 25 - Preventive Maintenance Tasks

Item	Task	Frequency		
		6 Mos	12 Mos	Other
General Inspections	Check physical condition of compressor.	√		
	Check for excessive vibration from other rotating equipment.	√		
	Check for oil in the system. The compressor *must* operate in an oil-free environment. Ensure all oil is removed from the system.		√	
Compressor Inspections	Connect to the compressor using the Service Monitoring Tools software and download fault and event logs. Review and save logs for future reference.	√		
	Connect to the compressor using the Service Monitoring Tools software and perform a calibration. Do not save the calibration to EEPROM if the compressor has been operating correctly. Create and save a Calibration Report for future reference.		√	
Electrical Inspections	Check main power supply voltages.	√		
	Ensure electrical terminals are tight.		√	
	Check for signs of hot spots/discoloration on power cables.	√		
	Check amperages during operation are as per design.	√		
	Check DC bus voltage.		√	
	Replace DC Capacitor Assembly.			Energized: 10 years De-energized: 5 years
	Check operation of all system safety devices and interlocks.		√	
	Perform moisture-prevention measures.		√	
	Replace Soft Start fan.			5 Years, Refer to Customer Notification B-CN-041-EN
Electronic Inspections	Ensure all communication cables are secure.	√		
	Ensure all electronic modules are secure.		√	
	Check physical condition of all exposed printed circuit boards (PCBs).		√	
	Check all exposed PCBs for dust build-up and clean if necessary.		√	
	Check discharge and suction pressure/temperature sensors for accuracy against calibrated pressure/temperature gauges.		√	
Refrigeration	Check operation of IGV assembly.		√	
	Check system refrigeration charge.	√		
	Check superheat/level control, if applicable.		√	
	Check system and motor-cooling liquid line to ensure sufficient sub-cooling.	√		
	Verify discharge check valve operation. If there is backward gas flow immediately after stopping the compressor, replace the check valve.	√		
	Check operating conditions external to the compressor.	√		
	Inspect/clean motor-cooling strainer (if service has taken place).	As required		

5.2 Moisture Prevention Measures

5.2.1 Required Items

This section applies to all TT and TG compressors.

The following steps are recommended to prevent condensate infiltration and stagnation in the electrical connections. Condensation issues may become exaggerated in hot and humid conditions.

Consumables:

- Lint-free cloth or clean rags
- Soft-bristle brush
- Small wire brush
- Greaseless lubricant spray
- Rust inhibitor spray
- Dielectric grease (DTC part # 901982 or equivalent)
- Dielectric grease spray

NOTE

The DTC part # 901982 Dielectric Grease is a natural lanolin-based product which is non-toxic.

Application of Dielectric grease

The dielectric grease can be applied by:

- Finger
- Small brush

• • • DANGER • • •

Be sure to follow the manufacturer's usage and safety recommendations when using the aforementioned chemicals.

5.2.1.1 Service Side Disassembly

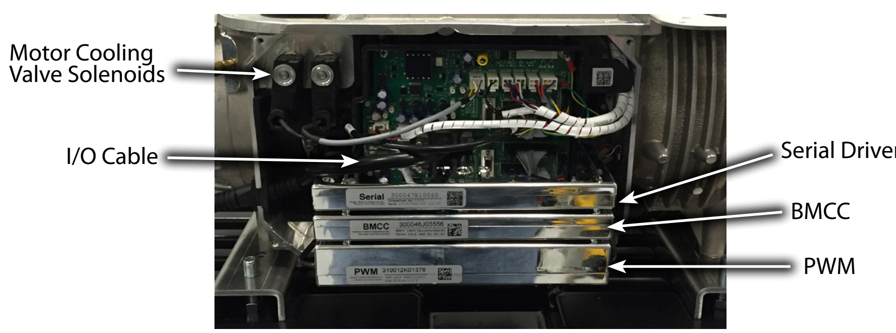
1. Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.

2. Allow time for the compressor to reach ambient temperature.

3. Remove the Service Side Cover from the compressor.

4. Remove the I/O Cable, Serial Driver, BMCC, and PWM from the Backplane Board. Make sure the board assemblies do not come in contact with electric or static sources.

Figure 99 - Module Removal



5. Remove the Motor-Cooling Valve Solenoid Coils by removing the screws on each solenoid.

• • • CAUTION • • •

The solenoid actuators are dedicated on all models except TT300/TG230. Provide a position reference mark before removal.

6. Dry off any condensate around the solenoids.

Figure 100 - Motor Cooling Valve Solenoids

7. Remove any debris or dust from Backplane Board and solenoids using a soft-bristle brush.

8. Remove both PWM cables from the feed throughs.

9. If the neoprene gasket is black, remove the gasket and remove any rust or debris. Note the orientation of pins for gasket re-insertion (holes are numbered on gasket).

NOTE

There are different styles of bearing power feed throughs. Older versions have a removable black neoprene gasket. This was later replaced on Mjor Revision "E" compressors with a non-removable red neoprene gasket. Perform the following steps if the compressor has either the black or red neoprene gaskets. There is also a new sealed harness that does not require any preventative maintenance. This process is not used on Major Revision "F" and later compressors.

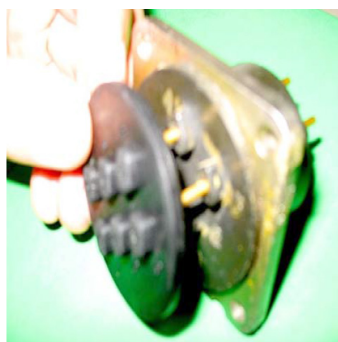


Figure 101 - Neoprene Gasket Removal

10. Remove both bearing sensor cables.

11. Dry off any condensate around the bearing sensor feed throughs.

12. Using a soft-bristle brush, clean the bearing feed through connections and PWM connectors and screws.

13. Spray greaseless lubricant on exposed metal surfaces, exposed feed through pins, solenoids, and Backplane Board to remove any trace of moisture.

14. Wipe off excess lube with a lint-free rag.

15. Wait for surfaces to dry completely.

16. Once they are dry, apply a coat of rust inhibitor spray on exposed metal surfaces, exposed feed through pins, solenoids, and Backplane Board.

17. Apply thin coating of dielectric grease to the underside of bearing power feed through gaskets. See Figure 102 (Dielectric Grease Under Gasket).

Figure 102 - Dielectric Grease Under Gasket

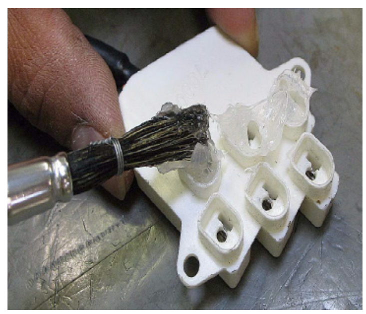
18. Install the greased neoprene gaskets over the feed through pins.

19. Clean off excess grease.

20. Using a lint-free rag, carefully wipe off any dielectric grease from the exposed power feed through pins.

21. Apply a thin coating of dielectric grease to the PWM harness connectors (female) as shown in Figure 103 (PWM Connectors) and clean off any excess grease.

Figure 103 - PWM Connectors

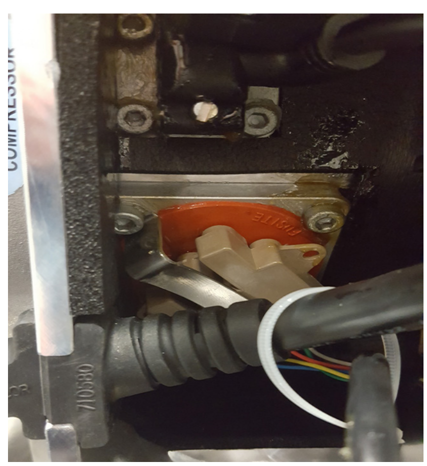


22. Apply dielectric grease to all of the feed through 4-pin and 6-pin screws.

NOTE

This process is not used for Major Revision "F" and later compressors with Molex connectors as shown in Figure 76 (Bearing PWM Amplifier)

Figure 104 - Dielectric Grease on Screws



5.2.1.2 Service Side Assembly

1. Install the bearing sensor cables.

2. Apply a thin coating of dielectric grease to the exterior of the bearing sensor feed through connectors.

⚠ • • • CAUTION • • •

Do not apply any dielectric grease directly to bearing sensor feed through DB9 pins, only apply grease around bearing sensor feed through connectors after the cables are connected to prevent moisture from entering the pin area.

3. Install the Motor-Cooling Valve Solenoid Coils.

4. Connect the solenoid actuator and bearing sensor cables to the Backplane.

5. Reinstall all three modules: PWM, BMCC, and Serial Driver, and connect the I/O Cable into the Backplane Board.

6. Reconnect the PWM harness connectors to the appropriate feed throughs (in the correct orientation), then remove the connectors once more. Wipe the excess dielectric grease from the bearing feed through pins and reconnect the PWM harness connectors to the appropriate feed throughs in the correct orientation..

7. Reinstall Service Side Cover on compressor.

5.2.1.3 Top Side

1. Remove the top covers from the compressor.

2. Dry off any condensate around the motor winding sensor terminals, high power feed throughs and motor bus bars.

3. Using a soft-bristle brush, remove any debris or dust from the motor winding sensor terminals, high power feed through and motor bus bar screws.

4. Spray greaseless lubricant on the terminals, power feed throughs and bus bar screws to remove any trace of moisture.

5. Wipe off excess lube with a lint-free rag.

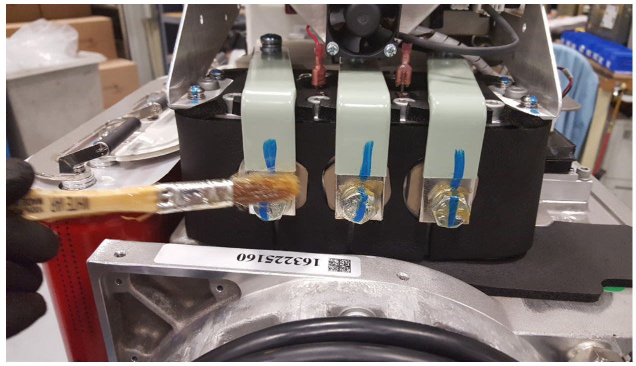
6. Wait for surfaces to dry completely.

7. Once they are dry, apply a coat of rust inhibitor spray on the terminals, power feed throughs and bus bar screws.

8. Spray or apply dielectric grease on exposed metal surfaces on the bus bar screws and motor winding sensor terminals. (Figure 105 – Motor-Winding Sensor Dielectric Grease Application)

Figure 105 - Motor-Winding Sensor Dielectric Grease Application

Figure 106 - Motor Bus Bar Screws



9. Dry off any condensate around the SCR screws.

10. Remove any debris or dust from the SCR screws.

11. Spray greaseless lubricant on the SCR screws to remove any trace of moisture.

12. Wipe off excess lube with a lint-free rag.

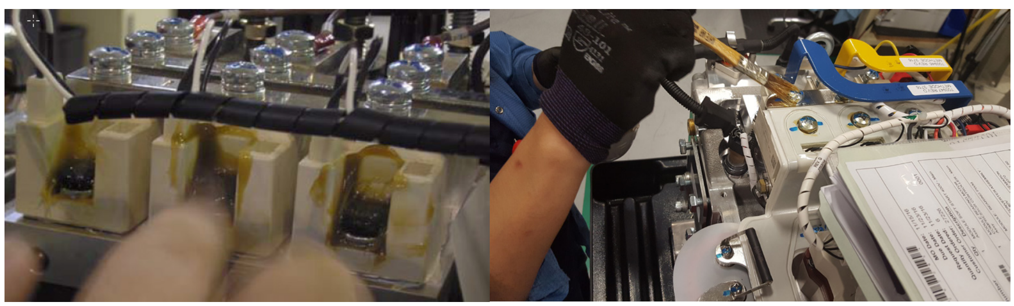
13. Wait for surfaces to dry completely.

14. Once they are dry, apply a coat of rust inhibitor spray on the SCR screws.

15. Apply dielectric grease to the SCR retaining screws.

16. Clean off excess dielectric grease.

Figure 107 - SCR Screw Dielectric Grease Application



17. Inspect all electrical connections.

18. Reinstall top covers on compressor.

19. Reconnect compressor power.

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The following is a glossary of product-specific terminology.

Table 26 - Acronyms/Terms

Acronym / Term	Definition
ADC	Analog Digital Converter.
AFT	Ascending Fault Triggering; see Section 4.2.1 (Compressor Fault Troubleshooting).
Alarms	Alarms indicate a condition at the limit of the normal operating envelope. Compressor alarms will still allow the Compressor to run, but speed is reduced to bring the alarm condition under the alarm limit.
ASHRAE	American Society of Heating Refrigeration and Air-Conditioning Engineers (www.ashrae.org).
AVC	Automatic Vibration Control; a part of the compressor magnetic bearing control system.
AWG	American Wire Gauge.
Backplane	A PCB for the purpose of power and control signal transmission. Many other components connect to this board.
Balance Piston	Component within the Compressor that provides primary counter to impeller thrust. Impeller thrust is trimmed by the axial bearing.
BMC	Bearing and Motor Control section of software held in the BMCC.
BMCC	Bearing Motor Compressor Controller. The BMCC is the central processor board of the Compressor. Based on its sensor inputs, it controls the bearing and motor system and maintains Compressor control within the operating limits.
Boolean	A value of either 0 (FALSE/NO) or 1 (TRUE/YES).
Cavity Sensor	NTC temperature sensor located behind the Backplane for the purpose of sensing motor-cooling vapor temperature. Provides overheat protection to motor windings.
CC	Compressor Controller; section of software held in BMCC.
CE	CE marking ensures the free movement within the European market of products that conform to the requirements of EU legislation (e.g., safety, health and environmental protection and is a key indicator of a product's compliance with legislation. The CE marking is affixed by manufacturers to their products. By placing CE marking on a product, manufacturers declare on their sole responsibility that the products comply with all the legal requirements in force in Europe. Citation: European Commission; Directorate-General for Enterprise and Industry; ww.ec.europa.eu/CEmarking.
Choke	Definitive point on Compressor map where mass flow rate is at maximum for Compressor speed and lift conditions.
CIM / I/O-board	Compressor Interface Module; the part of the compressor electronics where the user connects all field connection wiring such as RS-485, EXV, and analog / digital wiring. Also known as the I/O board.
Compression Ratio	The absolute discharge pressure divided by the absolute suction pressure.
Configuration	A DTC predetermined set of registers necessary to configure a compressor for a general or particular customer. It is also known as the Part Number (PN) or parameter revision.
CPU	Central Processing Unit; can be a dedicated type like a Digital Signal Processor (DSP) or a more general type like a Micro Controller Unit (MCU).
DSP	Digital Signal Processor; a specific Central Processing Unit (CPU) dedicated for special applications like video handling or electric motor control.
D-Sub	A type of connector/plug (male and female) for control wiring. The RS-232 and large connectors on either side of the I/O cable are both types of D-Sub connectors.
DC Bus	High DC voltage simultaneously connected to multiple compressor components including the capacitors.
DC Capacitor Assembly	An assembly of four DC capacitors, four bleed resistors, and bus bars.
DC-DC Converter	DC-DC converters supply and electrically isolate the high and low DC voltages that are required by the control circuits.
DFT	Descending Fault Triggering; see Section 4.2.1 (Compressor Fault Troubleshooting).
Dielectric	A dielectric is a nonconducting substance.
Diffuser	Part of a centrifugal compressor in the fluid module that transforms the high-velocity, low-pressure gas exiting the impeller into high-pressure, low-velocity gas discharged into the condenser.
Down-Trip Voltage	A voltage threshold where, if the incoming AC voltage drops below it, the Soft Start will shut down.
DTC	Danfoss Turbocor Compressors Inc.

Table 26 - Acronyms/Terms (Continued)

Acronym / Term	Definition
EEPROM	Electrical Erasable Programmable Read Only Memory: A type of non-volatile memory used in computers and other electronic devices to store small amounts of data that must be saved when power is removed. It has a limited number of times it can be reprogrammed and an unlimited number of reads.
EMC	ElectroMagnetic Compatibility Refers to the use of components in electronic systems that do not electrically interfere with each other Citation: http://encyclopedia2.thefreedictionary.com/EMC.
EMF	Electromotive Force; the principle of electromagnetic induction states that a time-dependent magnetic field produces a circulating electric field. An EMF is induced in a coil or conductor whenever there is change in the flux linkages. Depending on the way in which the changes are brought about, there are two types: When the conductor is moved in a stationary magnetic field to procure a change in the flux linkage, the EMF is *statically induced*. The electromotive force generated by motion is often referred to as *motional emf*. When the change in flux linkage arises from a change in the magnetic field around the stationary conductor, the EMF is *dynamically induced*. The electromotive force generated by a time-varying magnetic field is often referred to as *Transformer EMF*.
EMI Filter	A circuit or device that provides electromagnetic noise suppression for an electronic device.
Event Log	A record of events occurring during the Compressor's life cycle, indicating when events and faults occur and in what order. The event log is held in the BMCC.
EXV	Electronic Expansion Valve. Pressure-independent refrigerant metering device driven by electrical input.
Fault	An intolerable or unsafe condition that will result in equipment failure. Faults will cause the compressor controller to reduce shaft speed and shut down the system within 10 seconds requiring a manual or auto reset from the chiller controller.
Feed Through	An insulated conductor connecting two circuits on opposite sides of a barrier such as a Compressor housing or PCB.
FLA	Full Load Ampere.
Genlanolin	A type of grease. Genlanolin is applied to certain parts of the compressor to prevent moisture accumulation.
Harmonics	Harmonics are multiples of the fundamental frequency distortions found in electrical power.
Id	The part of the motor current generating torque.
IGBT	Insulated Gate Bipolar Transistor. See Inverter.
Impeller	Rotating part of a centrifugal compressor that increases the pressure of refrigerant vapor from the evaporator pressure to the condenser pressure.
Inverter	Converts the DC bus voltage into an adjustable frequency, three-phase simulated AC voltage.
I/O Board	Input/Output Board facilitating a connection between the Compressor controller and/or PC and the Compressor. It allows the user to control the Compressor and allows the Compressor to return status and sensor information to the user.
Iq	The part of the motor current magnetizing field.
LBV	Load Balance Valve. A modulating valve that can be installed to bypass discharge gas to the inlet of the evaporator to provide gas flow at certain conditions such as startup, surge, and further unloading of the Compressor.
LED	Light-Emitting Diode
Levitation	The elevation or suspension of the Compressor shaft in the magnetic field created by the magnetic bearings.
Line Reactor	A line reactor is a special form of inductor that is typically used between the line and the load to smooth current inrush, reduce harmonics and noise, and buffer the systems connected to it. Specifically it is an inductor that adds inductive impedance to a circuit. Citation: http://www.control-transformer.com/transformer-terms-faq.asp?id=50&action=view&msgid=27.
Mid Bus	A connection between the capacitors allowing them to be connected in series and in parallel simultaneously. Two capacitors in a series make up the DC- and two in a series make up the DC+, and those two sets of two are connected in parallel.
Modbus	www.modbus.org, Modbus is a serial communications protocol published by Modicon in 1979 for use with its programmable logic controllers (PLCs). It has become a de facto standard communications protocol in industry, and is a commonly available means of connecting industrial electronic devices.
Motor Back EMF	Back electromotive force is a voltage that occurs in electric motors where there is relative motion between the armature of the motor and the external magnetic field. It is used to evaluate the strength of the permanent magnets of the shaft.
MS1, MS2	MS1 = Milestone1 MS2 = Milestone 2 specific HW/SW design series from DTC.
NIST	National Institute of Standards and Technology, www.nist.gov.
NTC	Negative Temperature Coefficient. Refers to a thermistor characteristic. Decrease in temperature equating to an increase in resistance of the sensor.

Table 26 - Acronyms/Terms (Continued)

Acronym / Term	Definition
Permanent Magnet Motor	Type of motor that uses permanent magnets to produce torque.
PDF	Portable Document Format. A format created by *Adobe Systems, Inc*. that uses *Adobe Acrobat* software to create documents that can be shared for reading and printing without needing the source document's creation tool. The documents can be read using the free *Adobe Reader*, available at http://get.adobe.com/reader/. PDF has become the de facto standard for sharing documents.
Power Cycle	A reset of the compressor electronics caused by turning off the main power supply, allowing the capacitor bank to discharge until the power to the Backplane is lost, followed by reapplying main power.
Pressure Ratio	The absolute discharge pressure divided by the absolute suction pressure.
Proximity Sensor	Sensors that are able to detect the presence of nearby objects without any physical contact. A proximity sensor often emits an electromagnetic or electrostatic field, or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal.
PWM	Pulse Width Modulation. A method of switching voltage on and off at fixed but variable frequencies.
RAM	Random Access Memory, when powering off a device with RAM, all that memory is lost.
REFPROP	Reference Fluid Thermodynamic and Transport Properties, see NIST.
Reset of fault	To reset a non critical compressor fault, the interlock circuit must be closed and the reason for fault activation corrected. set demand to 0 (zero) by either writing 0 if control mode is modbus or reducing demand voltage to 0 if control mode is analog input. Close the interlock, then set demand greater than 0% and fault will reset allowing compressor to restart. (Note IGV may need to reset before compressor will restart).
Resistor	A resistor is an electrical component that limits or regulates the flow of electrical current in an electronic circuit.
RFT	Range Fault Triggering; see Section 4.2.1 (Compressor Fault Troubleshooting)
RMS	Root Mean Square.
SCR	Silicon Controlled Rectifier. The SCR is a semi-controlled, solid-state device that controls current and converts AC to DC.
Serial Driver	A PCB plug-in responsible for the operation of the IGV stepper motor and optional expansion valves. It contains four relays for the solenoid valves, compressor status and Compressor run status.
SH	Superheat: The sensible heat added to a refrigerant thus increasing its temperature following evaporation of all liquid present.
Shrouded Impeller	An impeller with boxed in, or "shrouded," impeller blades, as opposed to an open impeller.
SI	System International, the International System of Units, http://www.bipm.org.
Single-Stage Centrifugal Compressor	Type of centrifugal compressor having one impeller.
Slip Compensation	Though the compressor utilizes a permanent magnet motor where slip is normally not an issue, the compressor does compensate for the motor slip by giving the frequency a supplement that follows the measured motor load according to the implemented motor control algorithms.
SMT	Service Monitor Tools, a PC program provided by DTC. A user friendly way of displaying compressor data to the user and offer adjustment of predetermined parameters. The user interface adjusts itself according to the active access level at the compressor.
Snubbers	Capacitors responsible for eliminating electrical noise/harmonics from the DC Bus before it reaches the Inverter.
Soft-Start Board	The Soft Start Board limits in-rush current when power is applied to the compressor by progressively increasing the conduction angle of the voltage through the SCRs to charge the DC capacitors.
Thrust Bearing	A bearing that absorbs the axial forces produced in a centrifugal Compressor by the refrigerant pressure differential across the impeller.
Touchdown Bearings	Carbon races or ball bearing for the purpose of preventing mechanical interference between the shaft and the magnetic bearings.
Two-Stage Centrifugal Compressor	Type of centrifugal compressor having two impellers. The first-stage impeller raises the pressure of the refrigerant vapor approximately halfway from the cooler pressure to the condenser pressure, and the second-stage impeller raises the pressure the rest of the way. With a two-stage compressor, an interstage economizer may be used to improve the refrigeration cycle efficiency.
TXV	Thermal Expansion Valve. A pressure-dependent refrigerant metering device that operates independently and is controlled by temperature.
Vaned Diffuser	An assembly of plates with curved vanes that serve to slow, compress, and reduce refrigerant rotation as it enters the second-stage impeller.

This appendix contains flowcharts for Compressor Operation Troubleshooting (Figure 108) and Compressor Voltage Troubleshooting (Figure 109 and Figure 110).

Figure 108 - Compressor Operation Troubleshooting Flowchart

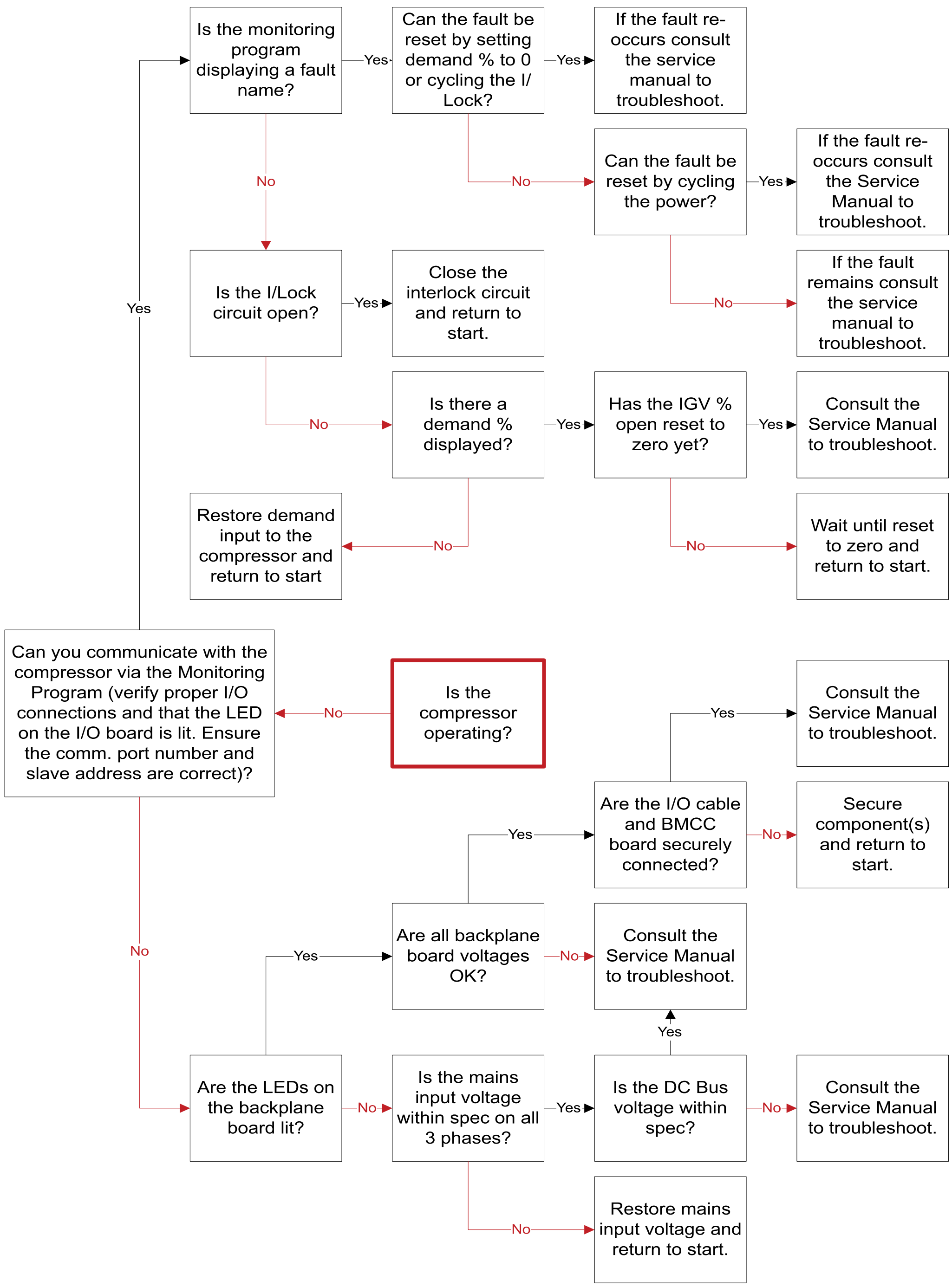


Figure 109 - Compressor Voltage Troubleshooting Chart 1

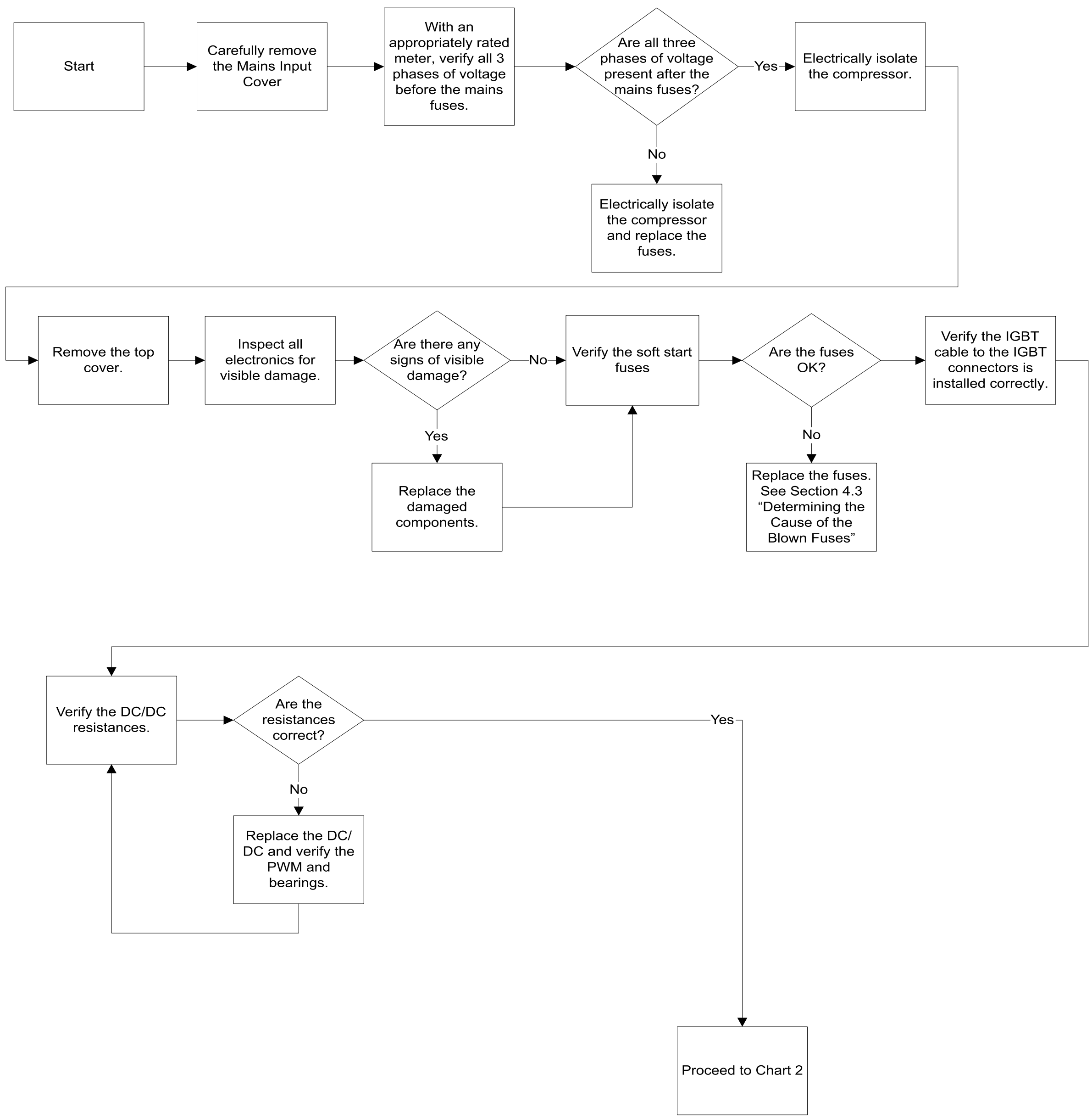
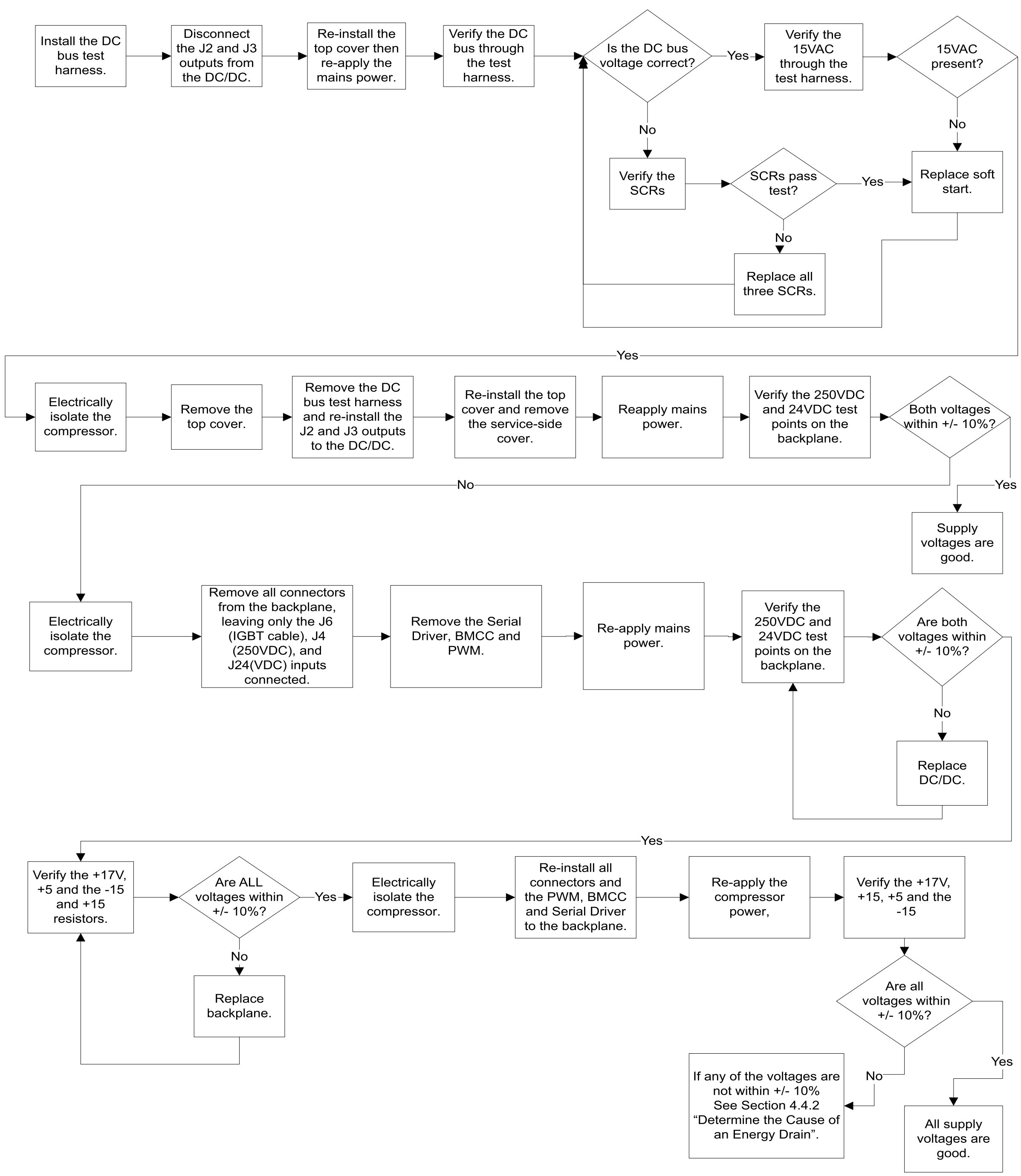


Figure 110 - Compressor Voltage Troubleshooting Chart 2



Component	Test Point	Expected Value	Verification Section	Measured Value
Backplane DC Voltage	0V to 24V	22 to 26 VDC	3.10.2.2	
	0V to +15V	14.75 to 15.25 VDC	3.10.2.2	
	0V to -15V	-14.75 to -15.25 VDC	3.10.2.2	
	0V to 5V	4.75 to 5.25 VDC	3.10.2.2	
	HV- to HV+	220 to 280 VDC	3.10.2.2	
	HV- to +17V	16.5 to 17.85 VDC	3.10.2.2	
Cavity Temperature Sensor Resist	Positive to Negative	10KΩ @ 77°F (25°C)	3.19.3	
DC Bus Test Harness	DC Bus	462-853VDC	1.9	
	DC Bus F	462-853VDC	1.9	
	15VAC	12 – 25VAC	1.9	
DC/DC Resistance	J1	open or >150kΩ	3.9.3.3	
	J2	Charging or discharging Ω	3.9.3.4	
	J3	Charging or discharging Ω	3.9.3.4	
	J4	>1MΩ	3.9.3.3	
Front Bearing Feed Through Resistance	TT300, TT400 C, E, & F/ TG230, & TG390: 1 to 2	2.7 to 25Ω	3.17.3	
	TT300, TT400 C, E, & F/ TG230, & TG390: 3 to 4	2.7 to 25Ω	3.17.3	
	TT350, TT400 P, TT500, TT700, TG310, & TG520: 1 to 2	4.7 to 5.20 Ω	3.17.3	
	TT350, TT400 P, TT500, TT700, TG310, & TG520: 3 to 4	4.7 to 5.20 Ω	3.17.3	
Front Bearing Sensor Feed Through Resistance	5 to 2	2.0Ω to 3.5Ω	3.18.3	
	5 to 3	2.0Ω to 3.5Ω	3.18.3	
	6 to 7	2.0Ω to 3.5Ω	3.18.3	
	6 to 8	2.0Ω to 3.5Ω	3.18.3	
	1 to 4	2.0Ω to 3.5Ω	3.18.3	
	1 to 9	2.0Ω to 3.5Ω	3.18.3	
Inverter Diode	Phase 1: + Lead on AC Output to - DC input	Open	3.7.3	
	Phase 1: + Lead on AC Output to + DC input	0.275v - 0.4v	3.7.3	
	Phase 2: + Lead on AC Output to - DC input	Open	3.7.3	
	Phase 2: + Lead on AC Output to + DC input	0.275v - 0.4v	3.7.3	
	Phase 3: + Lead on AC Output to - DC input	Open	3.7.3	
	Phase 3: + Lead on AC Output to + DC input	0.275v - 0.4v	3.7.3	
	Phase 1: - Lead on AC Output to - DC input	0.275v - 0.4v	3.7.3	
	Phase 1: - Lead on AC Output to + DC input	Open	3.7.3	

Component	Test Point	Expected Value	Verification Section	Measured Value
	Phase 2: - Lead on AC Output to - DC input	0.275V – 0.4V	3.7.3	
	Phase 2: - Lead on AC Output to + DC input	Open	3.7.3	
	Phase 3: - Lead on AC Output to - DC input	0.275V – 0.4V	3.7.3	
	Phase 3: - Lead on AC Output to + DC input	Open	3.7.3	
IGV Motor Resistance	1 to 2	46Ω to 59Ω	3.13.3	
	3 to 4	46Ω to 59Ω	3.13.3	
Interlock	Power On: I/Lock - to Ground	0VDC	3.15.3.3	
	Power On: J2 Removed I/Lock - to I/Lock +	2.2 to 3.7 VDC	3.15.3.3	
	Power Off: J2 Removed I/Lock - to I/Lock +	< 22 kΩ	3.15.3.3	
Pressure/Temperature Sensor Resistance	1 to 3 (1 to 2 of the plug)	10KΩ @ 77°F (25°C)	3.20.3	
PWM Diode	Lead in HV-; - lead in PWM connector	0.39-0.46VDC	3.16.3.3	
	- Lead in HV+; +C47 lead in PWM connector	0.39-0.46VDC	3.16.3.3	
Rear Bearing Feed Through Resistance	All models 1 to 6	2.7 to 3.25Ω	3.17.3	
	All models 2 to 5	2.7 to 3.25Ω	3.17.3	
	TT300/TG230 3 to 4	5.7 to 6.2Ω	3.17.3	
	All models except TT300: 3 to 4	6.0 to 6.7Ω	3.17.3	
Rear Bearing Sesor Feed Through Resistance	5 to 2	2.0Ω to 3.5Ω	3.18.3	
	5 to 3	2.0Ω to 3.5Ω	3.18.3	
	6 to 7	2.0Ω to 3.5Ω	3.18.3	
	6 to 8	2.0Ω to 3.5Ω	3.18.3	
SCR Diode	positive (+) on 1 negative (-) on 2	∞ or open	3.5.3	
	positive (+) on 1 negative (-) on 3	∞ or open	3.5.3	
	positive (+) on 2 negative (-) on 1	∞ or open	3.5.3	
	positive (+) on 3 negative (-) on 1	0.3V to 0.45V	3.5.3	
SCR Gate Resistance	Gate Terminals	>1Ω and <25Ω (all models)	3.5.3.2	
SCR Temperature Sensor	J17 Sensor connector	10KΩ @ 70°F (21°C)	3.5.3.3	
Soft Start Fuses	F1	around 0.25Ω	3.4.3.2	
	F2	around 1Ω	3.4.3.2	
	F3	around 0.5Ω	3.4.3.2	

Appendix C Compressor Test Sheet

Component	Test Point	Expected Value	Verification Section	Measured Value
	F4 & F5	30-38Ω	3.4.3.2	
Solenoid Actuators	4.8 W	108Ω – 132Ω	3.12.3	
	9.3 W	56.25Ω – 68.75Ω	3.12.3	
Stator Resistance	Phase 1:2	> 0.0Ω and < 1Ω	3.8.4.2	
	Phase 1:3	> 0.0Ω and < 1Ω	3.8.4.2	
	Phase 2:3	> 0.0Ω and < 1Ω	3.8.4.2	
Stator Thermistor Resistance	+ to -	150-300 Ω at 70°F (21°C)	3.8.4.3	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We have 40 years of experience within the development of hermetic compressors which has brought us amongst the global leaders in our business, and positioned us as distinct variable speed technology specialists. Today we operate from engineering and manufacturing facilities spanning across three continents.

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Danfoss Inverter Scrolls

Danfoss Scrolls

Danfoss Optyma Condensing Units

Danfoss Maneurop Reciprocating Compressors

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