ENGINEERING TOMORROW

Service Manual - Revision H

Danfoss Turbocor® Twin-Turbine Centrifugal Series Compressors

TT Series Compressors

http://turbocor.danfoss.com | TURBOCOR®

THIS PAGE INTENTIONALLY LEFT BLANK

List of Changes

Revision	Date	Page	Description of Change
F	05-30-2019		Redevelopment of manual to include TTH/TGH and support Revision F and later compressors
F.1	06-10-2019	15/16	Updated Typecode figures 1-1 and 1-2.
F.2	11-10-2019	18-19, & 28	Updated TGS490 compressor with R515B refrigerant.
F.2	11-10-2019	36	Removed helium and changed the inert gas pressure to 15 psi.
F.2	11-10-2019	98	Updated F4 and F5 fuse description.
G	05-27-2020	All	Manual updated to include all Major Revision H changes.
H	12-23-2022	All	Manual edited and improved for content and completeness

THIS PAGE INTENTIONALLY LEFT BLANK

Proprietary Notice

Danfoss Turbocor Compressors Inc.
1769 East Paul Dirac Drive
Tallahassee, Florida 32310
USA
Phone 1-850-504-4800
Fax 1-850-575-2126
http://turbocor.danfoss.com

Encounter an error or see an opportunity for improvements while reading this manual? Email us at turbocor.contact@danfoss.com with a brief description.

* Subject to change without notice.

* Danfoss Turbocor's commitment to excellence ensures continuous product improvements.

THIS PAGE INTENTIONALLY LEFT BLANK

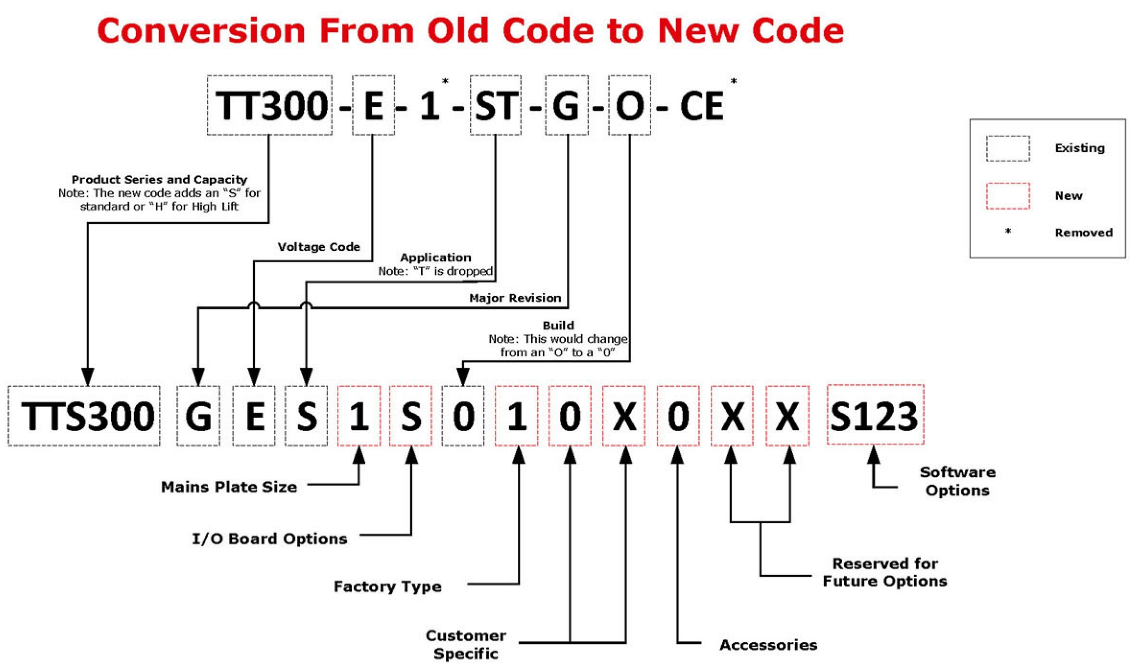
Chapter 1.0 Introduction

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

1.1 Application

As of May 6, 2019, the product nomenclature changed. Figure 1-1 Old to New Type Code maps the old structure of the Type code to the new structure. Additionally, the “Series” indicators have an additional character in order to differentiate the standard compressors from high-lift compressors. Unless the compressor is a high-lift design, an “S” will be added (e.g., TTS350). A high lift compressor will have an “H” in the Series designation (e.g., TTH375). Throughout this manual, it shall be assumed that if a series designation contains neither an "S" or "H" (e.g., TT350) that it is not a high-lift design. Refer to Figure 1-2 New Type Code for a complete description in the new design.

Figure 1-1 Old to New Type Code



Type Code Definition

<u>Product Series and Capacity</u>
TTS300: TT Series 300 Aero Config
TTS350: TT Series 350 Aero Config
TTS400: TT Series 400 Aero Config
TTS500: TT Series 500 Aero Config
TTS700: TT Series 700 Aero Config
TGS230: TG Series 230 Aero Config
TGS310: TG Series 310 Aero Config
TGS390: TG Series 390 Aero Config
TGS520: TG Series 520 Aero Config
TTH375: TT High Lift Series 375 Aero Config
TGH285: TG High Lift Series 285 Aero Config

<u>Major Revision</u>
E: Major Revision E
F: Major Revision F
G: Major Revision G

<u>Voltage Code</u>
E: 380V/50Hz
D: 380V/60Hz
H: 400V/50Hz
J: 400V/60Hz
G: 460V/60Hz
F: 575V/60Hz

<u>Application</u>
S: Standard Application
M: Medium Temperature Application
J: Standard Temp KHK Listed
K: Medium Temp KHK Listed

<u>Mains Plate Size</u>
1: Mains Plate 2.00”
2: Mains Plate 2.48”
3: Mains Plate 3.00”
4: Mains Plate 3.50”

<u>I/O Board Option</u>
S: I/O Board included with 5m cable
M: No I/O Board, 5m cable Included

<u>Build</u>
0: New Compressor
C: Rebuilt Certified Compressor

<u>Factory Type</u>
1: TLH Factory (CE Rated)
2: HYN Factory (CH Rated)
3: TLH Factory (NC Rated)

<u>Customer Specific Configuration</u>
0: Gen Covers/Plate, EN/FR/CH

<u>Customer Engraved Nameplate</u>
X: No CPN (Standard)
Y: CPN on Nameplate

<u>Accessories Configuration</u>
0: No accessories

<u>Future Option</u>
X: Reserved
X: Reserved

<u>Software</u>
S123: Software Revision

Figure 1-2 New Type Code

Turbocor TT/TG Series Type Code

T T S 3 0 0 G E S 1 S 0 1 0 X 0 X X S 1 2 3

1 2 3 4 5 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 20 21 22

Product Series and Capacity (characters 1-6)
- TTS300 : TT Series 300 Aero Config
- TTS350 : TT Series 350 Aero Config
- TTS400 : TT Series 400 Aero Config
- TTS450 : TT Series 450 Aero Config
- TTS500 : TT Series 500 Aero Config
- TTS700 : TT Series 700 Aero Config
- TGS230 : TG Series 230 Aero Config
- TGS310 : TG Series 310 Aero Config
- TGS380 : TG Series 310 Aero Config
- TGS390 : TG Series 390 Aero Config
- TGS490 : TG Series 490 Aero Config
- TGS520 : TG Series 520 Aero Config
- TTH375 : TT High Lift Series 375 Aero Config
- TGH285 : TG High Lift Series 285 Aero Config

Major Revision (character 7)
- E: Major Revision E
- F : Major Revision F
- G : Major Revision G
- H : Major Revision H

Voltage Code (character 8)
- E : 380V/50Hz
- D : 380V/60Hz
- H : 400V/50Hz
- J : 400V/60Hz
- G : 460V/60Hz
- F : 575V/60Hz

Application (character 9)
- S : Standard Application
- M : Medium Temperature Application
- H : High Temperature Application
- J : Standard Temp KHK Listed
- K : Medium Temp KHK Listed

Mains Plate Size (character 10)
- 1 : Mains Plate 2.00 in
- 2 : Mains Plate 2.48 in
- 3 : Mains Plate 3.00 in
- 4 : Mains Plate 3.50 in

I/O Board Option (character 11)
- S : RS232/RS485 I/O Brd - 5m Cable
- M : 5m Cable and No I/O Board

Build (character 12)
- 0 : New Compressor
- C : Rebuilt Certified Compressor

Factory Type (character 13)
- 1 : TLH Factory (CE Rated)
- 2 : HYN Factory (CH Rated)
- 3 : TLH Factory (ETL Rated Only)

Customer Specific Configuration (character 14)
- 0 : Gen Covers/Plate, EN/FR/CH

Customer Engraved Nameplate (character 15)
- X : No CPN (Standard)
- Y : CPN on Nameplate

Accessories Configuration (character 16)
- 0 : No accessories

Future Option (character 17)
- X : Reserved

Future Option (character 18)
- X : Reserved

Software (character 19-22)
- S123 : Software Revision

1.2 Purpose

This Service Manual is intended to provide service procedures specific to the Danfoss Turbocor 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 this manual. Danfoss LLC 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 various components of the compressor
- Fault and calibration interpretations
- System troubleshooting suggestions

NOTE

Bearing and bearing sensor repairs are not covered in this manual as they are not field serviceable. Compressors requiring such repairs must be sent back to the factory for inspection and repair.

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 original equipment manufacturer (OEM) customer.

Additionally, this manual is written for Major revision F and later compressors. When necessary, particular revision compressors are specified, but the majority of the content remains the same, regardless of the compressor revision. Danfoss LLC does sell various upgrade kits (e.g., Soft Start Upgrade Kit) and those kits may include retrofit cabling or other hardware that are not specifically installed on production compressors. This manual only illustrates components that were installed on production compressors. Always refer to the specific spare part kit instructions during installation.

1.3 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 Removal and Installation** – this section describes the safe practices of removing and installing the compressor
- **Section 4: 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 5: Troubleshooting** – this section describes troubleshooting using signals from the compressor to determine the specific source of faults at the system and compressor level
- **Section 6: 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

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*.
- Internal References – references to sections within this manual are encapsulated in quotes. Example, Isolate the compressor power as described in the "Electrical Isolation of the Compressor" section of this manual.
- External References – references to items not within this manual are underlined. Example; Refer to the TTS/TGS/TTH/TGH Applications Manual for installation procedures.

1.4 Commitment to Quality and the Environment

Danfoss Turbocor Compressors (DTC) is dedicated to leading through innovation and to satisfying our customers with the best quality, value, and on-time delivery of high-efficiency oil-free centrifugal compressors.

We are committed to controlling our impact on the environment demonstrated through setting goals focused on continual improvement and complying with all relevant legislation, regulation, and other requirements to protect the environment.

1.5 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**.

1.5.1 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 1-3 Danger Notification Example.

Figure 1-3 Danger Notification Example

• • • DANGER! • • •

1.5.2 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 1-4 Caution Notification Example.

Figure 1-4 Caution Notification Example

• • • CAUTION • • •

1.5.3 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 1-5 Note Example.

Figure 1-5 Note Example

NOTE

1.6 Precautions

Consideration for personal safety and equipment safety is very important. This chapter contains various sections that cover safety precautions and methods that must be followed when servicing the compressor. Prior to servicing the compressor, carefully read this chapter to ensure familiarity of both personal and equipment safety.

1.7 Refrigerant Type

Turbocor® compressors are designed to be applied only with specific refrigerants. The ANSI/ASHRAE 34 Standard (Safety Classification of Refrigerants) classification should be taken into account when designing and applying Turbocor® compressors. We also strongly recommend following the current ANSI/ASHRAE Standard 15 (Safety Standard for Refrigeration Systems) or other applicable local standards for the mechanical room design and application of all equipment using Turbocor® compressors.

Table 1-1 Refrigerant Type

Compressor Series	Refrigerants	ASHRAE/ANSI Standard 34 Classifications
TTS/TTH	R134a, R513A	A1
TGS/TGH	R515B, R1234ze(E)	A1, A2L

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.

1.8 Electrical Isolation

Before servicing the Compressor, 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 Danfoss LLC equipment.
- Always wear appropriately-rated safety equipment when working around equipment and/or components energized with high voltage.
- Removing the Mains Input Cover will expose the technician to a high voltage hazard of up to 632 VAC. Ensure the Mains Input power is turned off and locked out before removing the Mains Input Cover.

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 reapplication 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 TTS300/TGS230.

3. Remove the Mains Cover only. Refer to Section 4.1.1 Mains Input Cover on page 52.
4. Using an appropriately-rated voltage meter, confirm the absence of AC voltage.

• • • DANGER! • • •

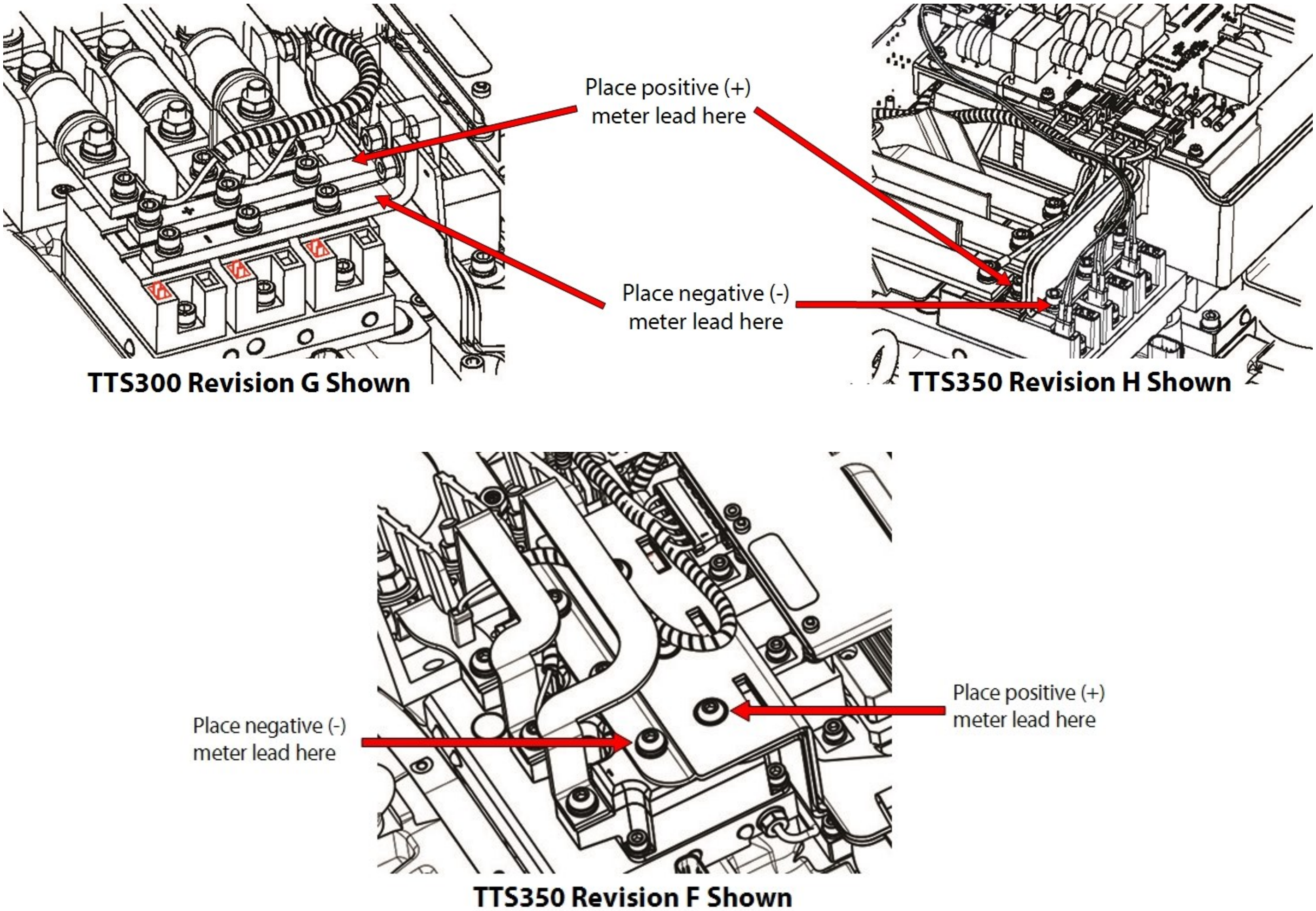
Do not touch any components when removing the Mains Input Cover.

5. If AC voltage is not present, reinstall the Mains Input cover and wait at least 20 minutes before removing either the Mains Input or Top Side Cover. If AC voltage still exists, go back to Step 2 to determine why the compressor voltage is not isolated.
6. Remove the Top Cover, taking particular care not to touch ANY components underneath. Refer to Section 4.1.2 Top Cover on page 53.
7. Using an appropriately-rated voltage meter, check the DC Bus Bars for DC voltage level. If the voltage is above 30 volts direct current (VDC), wait five (5) minutes and recheck until voltage is below 30 VDC. Refer to Figure 1-6 DC Bus Voltage Test Points on page 23.

• • • CAUTION • • •

Even at low voltages, caution should be used around the capacitors to avoid quick discharge events, which can lead to reduced reliability.

Figure 1-6 DC Bus Voltage Test Points



NOTE
Refer to the applicable service procedure as that may require the covers to remain off.

1.9 Handling Static Sensitive Devices

Figure 1-7 ESD Susceptible Caution Label

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.

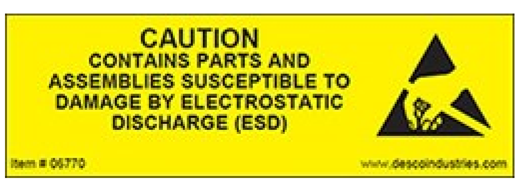
The electronic modules should only be removed from the ESD protective bag at the last moment, just before installation when the operator is ready to do the replacement.

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

1.9.1 ESD Protection/Grounding

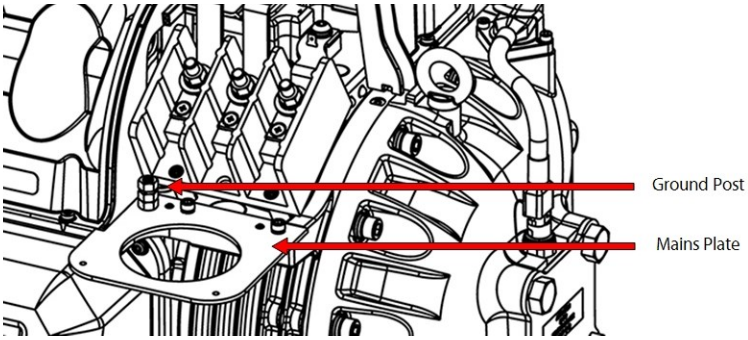
All parts that are susceptible to damage by ESD will be marked using the following label. Refer to Figure 1-8 ESD Label. Please follow the instructions below to ensure safety and to protect the parts from ESD damage.

Figure 1-8 ESD Label



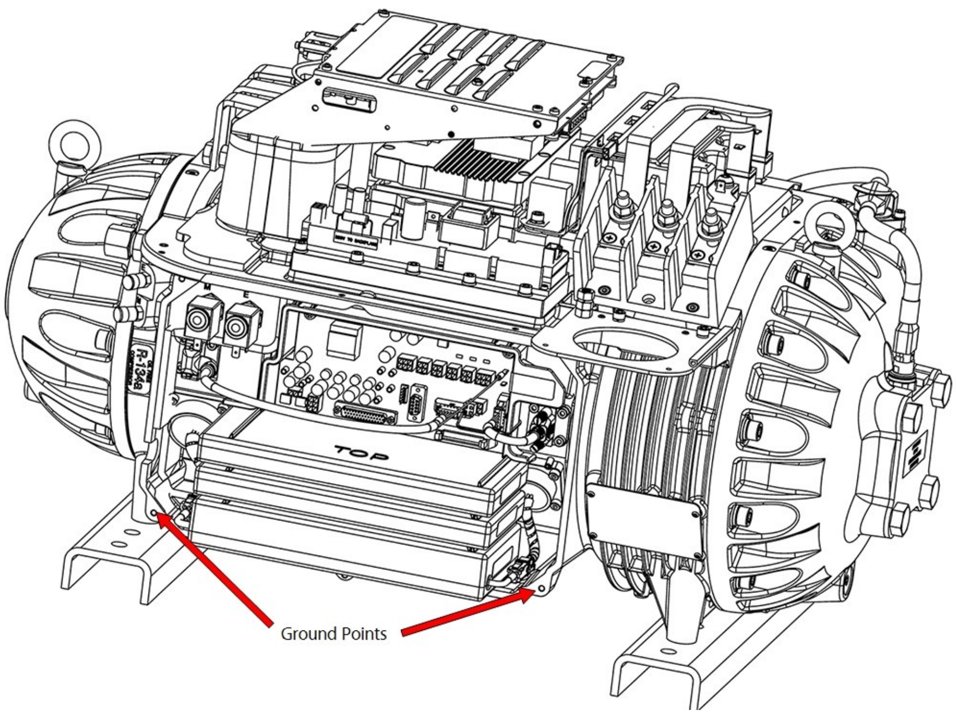
1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Clip the ESD strap ground clip to the compressor ground post. Refer to Figure 1-9 Mains Plate and Ground Post on page 25.

Figure 1-9 Mains Plate and Ground Post



3. If you need to remove the Soft Start, clip the ESD strap ground clip to the mains plate. Refer to Figure 1-9 Mains Plate and Ground Post.
4. If you only need to remove the Service Side Cover, clip the ESD strap ground clip to the cover screw hole that is part of the compressor housing. Refer to Figure 1-10 Compressor Grounding Points on page 25.
5. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.

Figure 1-10 Compressor Grounding Points



1.10 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. There are two (2) different Soft Start versions referenced within these instructions. The steps below are organized based on which Soft Start is installed on the compressor. To identify the installed Soft Start, refer to Section 4.14 Soft Start on page 113.

All versions of the DC Bus Test Harness have male/female plugs to allow piggyback connection to the required voltage measurement points on the Soft-Start. Refer to Figure 1-11 DC Bus Test Harness Diagram (Closed-Top Soft Start) and Figure 1-12 DC Bus Test Harness Diagram (Open-Top Soft Start) on page 26. for an example of the two current harnesses. Voltage measurements are made via shrouded multimeter jacks on the opposite end of the cables. Cable and personal protection are provided by inline fast-acting fuses (1/4 x 1 1/4, 62 milliamp 250V) and current-limiting 100kΩ 3W resistors.

Figure 1-11 DC Bus Test Harness Diagram (Closed-Top Soft Start)

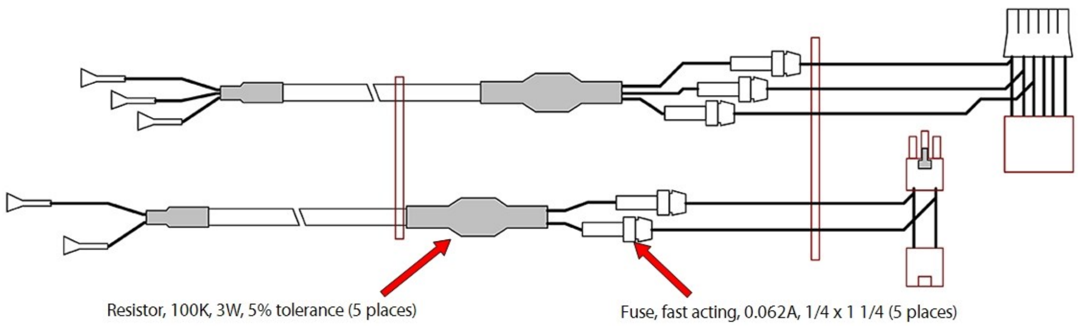
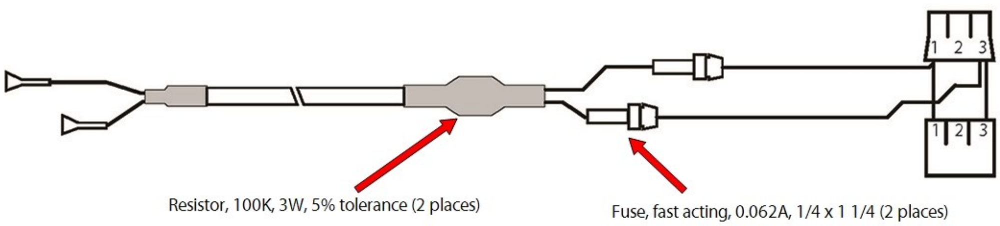


Figure 1-12 DC Bus Test Harness Diagram (Open-Top Soft Start)



• • • CAUTION • • •

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

1.10.1 General Verification and Installation of the DC Bus Test Harness

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.

• • • CAUTION • • •

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

2. Use an ESD strap and attach it the compressor housing while installing the Test Harness.
3. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.

• • • CAUTION • • •

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

NOTE

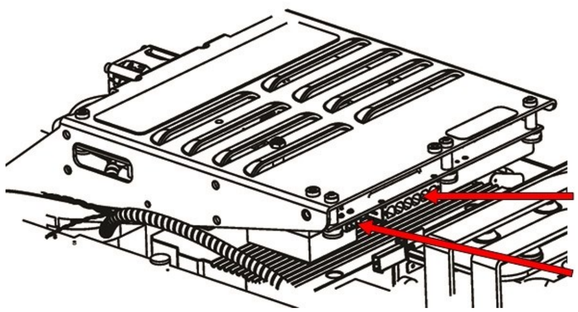
This would be a good time to perform a visual inspection of the top-side electronics to determine if there is any visual damage present. Also at this time, it is suggested to verify the integrity of the fuses if you have a Closed-Top Soft Start.

4. Confirm the integrity of the fuses and resistors in the DC bus test harness by using a multimeter set to resistance. Check each cable individually. Refer to Figure 1-11 DC Bus Test Harness Diagram (Closed-Top Soft Start) on page 26 and Figure 1-12 DC Bus Test Harness Diagram (Open-Top Soft Start) on page 26 for harness fuse and resistor locations. The reading for the resistor should be approximately 100kΩ and the reading for the fuse should be 29Ω.
5. Continue to the appropriate section below based on the particular Soft Start.

1.10.2 DC Bus Test Harness Installation for Closed-Top Soft Start

1. Disconnect the J1 and J7 connectors on the Soft Start Board. Refer to Figure 1-13 Soft Start (Closed Top).

Figure 1-13 Soft Start (Closed Top)



2. Connect the two (2) plugs of the compressor cable harness into the corresponding sockets of the DC bus test harness. Refer to Figure 1-14 Connect DC Bus Test Harness (Closed-Top Soft Start)for this and the following step.

Figure 1-14 Connect DC Bus Test Harness (Closed-Top Soft Start)

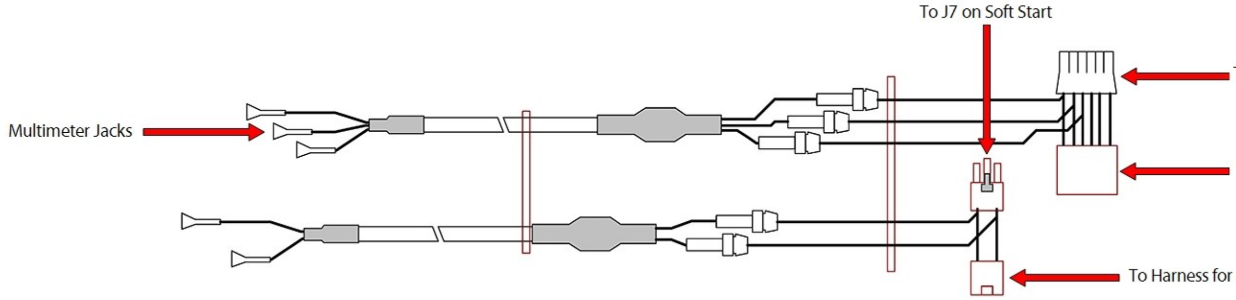
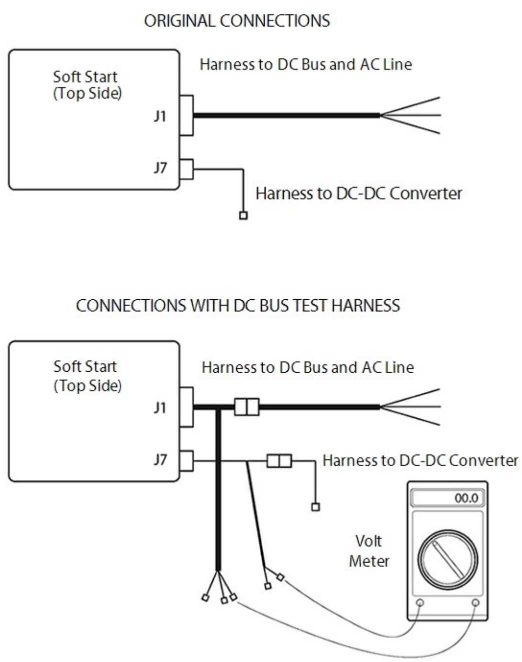


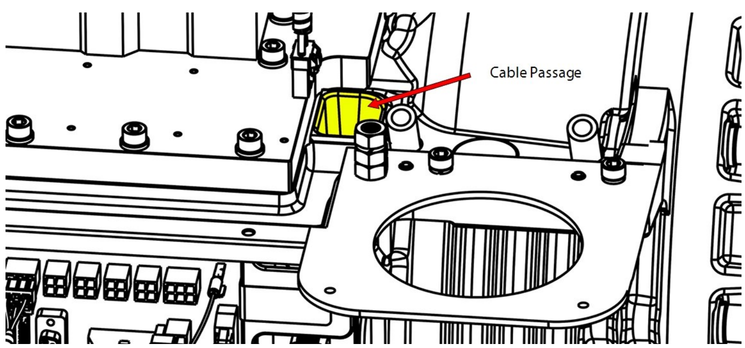
Figure 1-15 DC Bus Test Harness Connection Diagram (Closed-Top Soft Start)



3. Connect the two (2) plugs of the DC bus test harness into the Soft Start. Refer to Figure 1-13 Soft Start (Closed Top) on page 27.
4. Route the cables through the cable passage on either side of the DC-DC Converter, down into the service side. Refer to Figure 1-16 Cable Passage.

NOTE
• For clarity purposes, several components have been removed from Figure 1-16 Cable Passage

Figure 1-16 Cable Passage



5. Carefully adjust the connectors and harness so that the Top Cover can be reinstalled.
6. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
7. Remove ESD strap from the compressor and yourself.
8. Reapply AC power to the Compressor.

9. 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. If the voltage corresponds toTable 1-2 Expected DC Bus Voltage, the DC bus voltage is correct and HV DC (F1) fuse on the Soft Start is intact. This would imply that the Soft Start and Silicon-Controlled Rectifiers (SCRs) are functioning correctly; proceed to Step 12. If voltage reads 0, go to Step 10.

Table 1-2 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

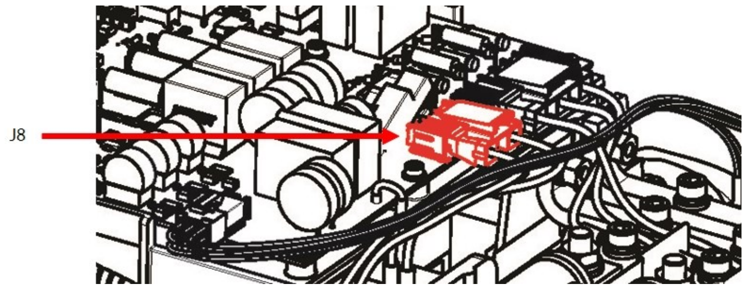
10. Leaving the DC(-) test lead in place, relocate the positive (+) test lead to DC(+). If DC voltage is consistent with Table 1-2 Expected DC Bus Voltage, this would imply that the Soft Start and SCRs are working correctly, but the HV DC fuse (F1) on the Soft Start is an open circuit, refer to Section 4.24 High Voltage DC-DC Converter on page 204 to verify the DC-DC Converter.
11. If the DC voltage is not present or is not consistent with Table 1-2 Expected DC Bus Voltage, the incoming AC voltage should be verified to be between the acceptable AC Voltage Range listed in Table 1-2 Expected DC Bus Voltage. Additionally the F2, F3, F4, F5, and F6 fuses need to be verified as well as the SCR Diodes and SCR Gates. Refer to Section 4.18 Silicone-Controlled Rectifier on page 141 for testing details.
12. For the Potted DC-DC, reset multimeter scaling to read 15VAC and connect to the 15VAC leads of the DC Bus Test Harness. If the reading is zero, isolate the three-phase supply in accordance with Section 1.8 Electrical Isolation on page 22. When access is safe, remove the four (4) fasteners that hold the Soft Start in position, and check fuses F2, F3, F4, F5, and F6 for continuity. If any fuse is found to be an open circuit, replace it and return to Step 6.
13. If the 15VAC is not present for the Potted DC-DC, replace the Soft Start (refer to Section 4.14.3 Soft Start Removal and Installation on page 117). If the 15VAC is correct, proceed to the next step.
14. When finished, remove the DC Bus Test Harness. Refer to Section 1.10.4 General DC Bus Test Harness Removal on page 31.

• • • 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.

1.10.3 DC Bus Test Harness Installation for Open-Top Soft Starts

1. Disconnect the J8 connector from the Soft Start. Refer to Figure 1-17 J8 Soft Start Connection (Open Top).

Figure 1-17 J8 Soft Start Connection (Open Top)



2. Connect the plug of the compressor cable harness into the corresponding socket of the DC bus test harness. Refer to Figure 1-18 Connect DC Bus Test Harness (Open-Top Soft Start) and Figure 1-19 DC Bus Test Harness Connection Diagram (Open-Top Soft Start) for this and the following step.
3. Connect the plug of the DC bus test harness into the Soft Start.

Figure 1-18 Connect DC Bus Test Harness (Open-Top Soft Start)

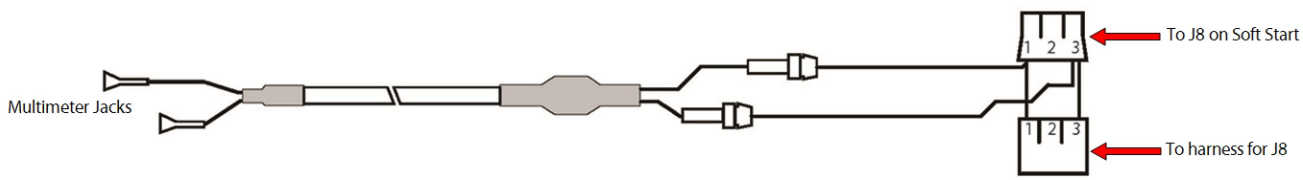
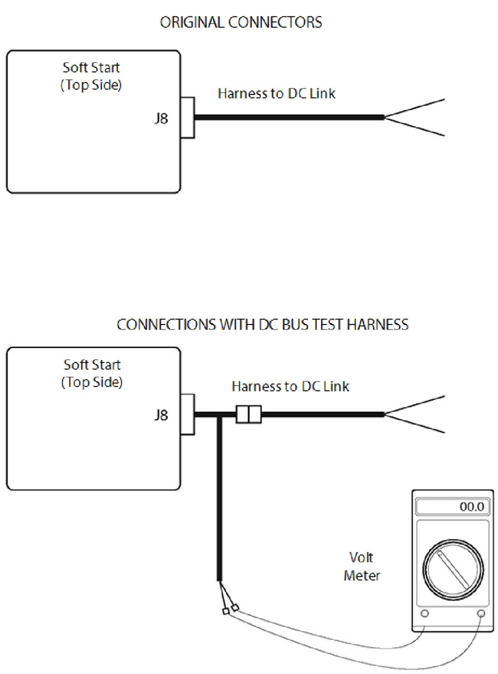


Figure 1-19 DC Bus Test Harness Connection Diagram (Open-Top Soft Start)



4. Route the cables through the cable passage beside the DC-DC Converter, down into the service side. Refer to Figure 1-16 Cable Passage on page 28.

NOTE
When checks are complete, disconnect and remove the test harness.

5. Reinstall the Top Cover and Mains Input Cover. Refer to 4.1 Compressor Covers on page 52.
6. Reapply AC power to the Compressor.
7. 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 1-2 Expected DC Bus Voltage on page 29 for the expected DC bus voltage. If the DC bus voltage is not present, or if it is outside the “Expected DC Bus Voltage” range shown in Table 1-2 Expected DC Bus Voltage on page 29, verify proper incoming AC input, verify SCR Gates, and verify SCR Diodes. If incoming AC power is correct, and the SCRs pass the diode and gate tests, replace the Soft Start.

NOTE
There are no replaceable fuses present in the Open-Top Soft Start.

8. When finished, remove the DC Bus Test Harness. Refer to Section 1.10.4 General DC Bus Test Harness Removal.

1.10.4 General DC Bus Test Harness Removal

1. Isolate the compressor power as described in 1.8 Electrical Isolation.

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

2. Use an ESD strap and attach it the compressor housing while removing the Test Harness.
3. Continue to the appropriate section below based on the particular Soft Start.

1.10.5 DC Bus Test Harness Removal for Closed-Top Soft Starts

1. Remove the DC bus test harness from the cable passage.
2. Disconnect the two (2) plugs of the DC Bus Test Harness from the Soft Start.
3. Disconnect the two (2) plugs of the compressor cable harness from the corresponding sockets of the DC Bus Test Harness.
4. Reconnect the J1 and J7 connectors into the Soft Start.
5. Remove ESD strap from the compressor and yourself.
6. Install all covers on the compressor. Refer to Section 4.1 Compressor Covers on page 52.
7. Return the compressor to normal operation.

1.10.6 DC Bus Test Harness Removal for Open-Top Soft Starts

1. Remove the DC Bus Test Harness from the cable passage.
2. Disconnect the plug of the DC Bus Test Harness from the Soft Start.
3. Disconnect the plug of the compressor cable harness from the socket of the DC Bus Test Harness.
4. Reconnect the compressor cable harness into the J8 connector on the Soft Start.
5. Remove ESD strap from the compressor and yourself.

6. Install all covers on the compressor. Refer to Section 4.1 Compressor Covers on page 52.
7. Return the compressor to normal operation.

1.11 Compressor Fasteners

• • • CAUTION • • •
Only replace fasteners with exact replacements. Failure to do so could lead to fastener corrosion and/or failure.

1.12 General O-ring Handling

Various O-rings are utilized throughout the TTSeries Compressors to contain the refrigerant. Prior to the removal of any component utilizing an O-ring, the refrigerant must be properly recovered per industry-standard procedures. Upon O-ring replacement, a leak test should be performed. The following O-ring-specific steps are required when replacing any compressor O-ring:

1. Remove each O-ring to be installed from its package and inspect for defects such as blemishes, abrasions, cuts, or punctures.
2. Slight stretching of the O-ring when it is rolled inside out will help to reveal some defects not otherwise visible.
3. After inspection and prior to installation, lubricate the O-ring with a light coat of Super-O-Lube.
4. Avoid rolling or twisting the O-ring when maneuvering it into place.
5. Keep the position of the O-ring mold line constant.

NOTE
It is strongly suggested that anytime an O-ring is removed, that a new O-ring is used in its place.

Chapter 2.0 Compressor Fundamentals

Compressor operation begins with a demand signal applied to the compressor. The startup sequence is configurable in the startup settings. See the OEM Programming Manual 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 2-1 Compressor Fluid Paths

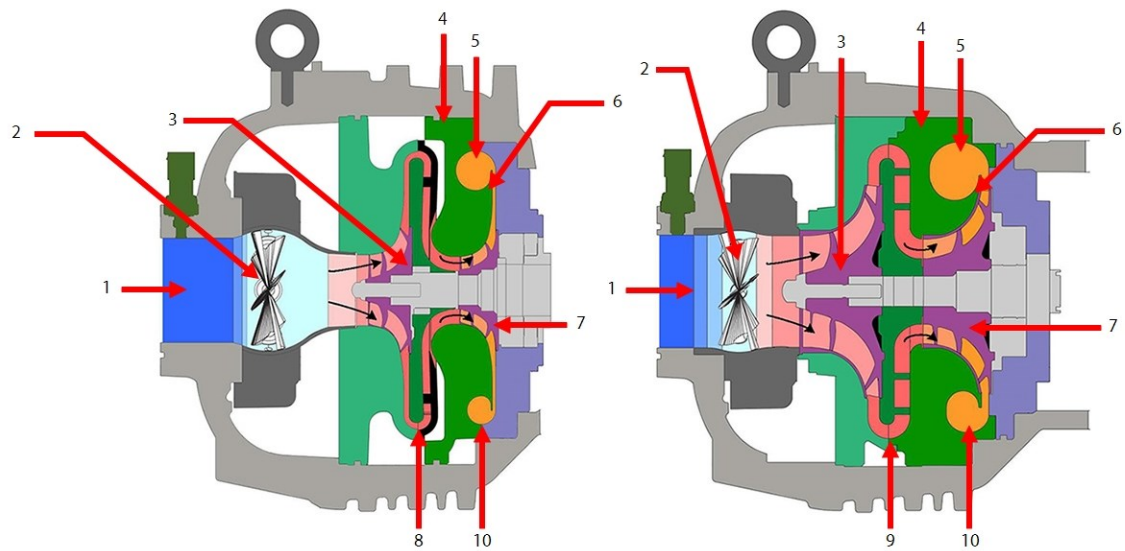


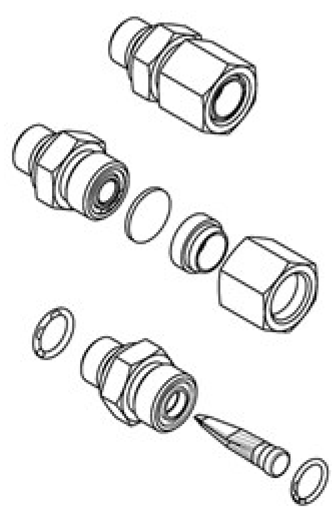
Table 2-1 Compressor Fluid Paths

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 3.5° Kelvin/ 6.3° Rankine sub-cooling at connection point, must be piped to the compressor cooling inlet connection. This connection is a 1/2 inch O-ring face seal (ORFS) connection with a built-in strainer. Refer to Figure 2-2 Cooling Inlet Adapter on page 34 for an example of the cooling inlet adapter.

Figure 2-2 Cooling Inlet Adapter



Liquid refrigerant is internally channeled to two (2) solenoid valves. These valves have integral orifices that act as expansion devices to cool the compressor motor, shaft (rotor) and power electronics. TTS300 and TGS230 compressors have these solenoids arranged so that all components are cooled in series with each other and the solenoids act as two (2) stages of cooling capacity. The TTS350, TTS400, TTS450, TTS500, TTS700, TTH375, TGS310, TGS380, TGS390, TGS490, TGS520, and TGH285 compressors have separate cooling paths for motor and power electronics. These cooling methods are identified as serial or split cooling.

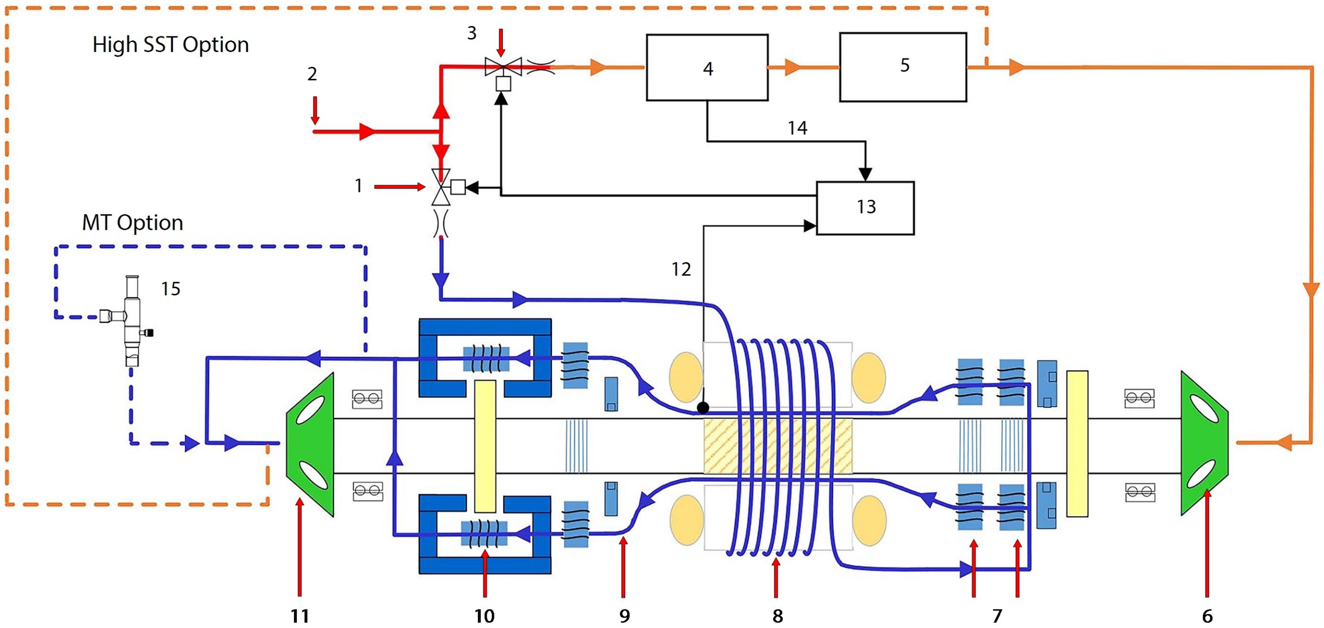
Serial cooling has its return point to the inlet of the first-stage impeller, thus cooling all components with refrigerant evaporating at the saturated suction temperature. In serial cooling versions, Solenoid One (1) is opened if any temperature reaches its “turn on” point and Solenoid Two (2) is opened if any temperature reaches a second “turn on” point value. Refer to Figure 2-5 Compressor Cooling Path - TTS300/TGS230 on page 37.

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 One (1) is opened if either the cavity temperature or the motor temperature reaches its “turn on” point and Solenoid Two (2) is opened if the Inverter or SCR temperature reaches its “turn on” point. Refer to Figure 2-4 Split Cooling Path - (TTS/TGS (Except TTS300/TGS230 Serial Cooling)) on page 36.

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 0.8°C (34°F). Refer to the TTS/TGS/TTH/TGH Applications Manual for further details.

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 (2). These 1/4 inch flare connections access the refrigerant feeds to the components being cooled and bypass the solenoid valves. A minimum pressure ratio of 1.5 and a full liquid seal at the compressor is required to ensure proper and correct compressor cooling.

Figure 2-3 Split Cooling Path - TTH375/TGH285



No.	Description	No.	Description
1	Solenoid M	9	Radial Bearing
2	Liquid Refrigerant Inlet	10	Axial Bearing
3	Solenoid E	11	Impeller - 1st Stage
4	Inverter	12	Motor Cavity Temp. Sensor
5	SCR	13	BMCC
6	Impeller - 2nd Stage	14	Inverter Temp Sensor
7	Radial Bearing	15	PRV (pressure regulating valve)
8	Stator/Rotor		

Figure 2-4 Split Cooling Path - (TTS/TGS (Except TTS300/TGS230 Serial Cooling))

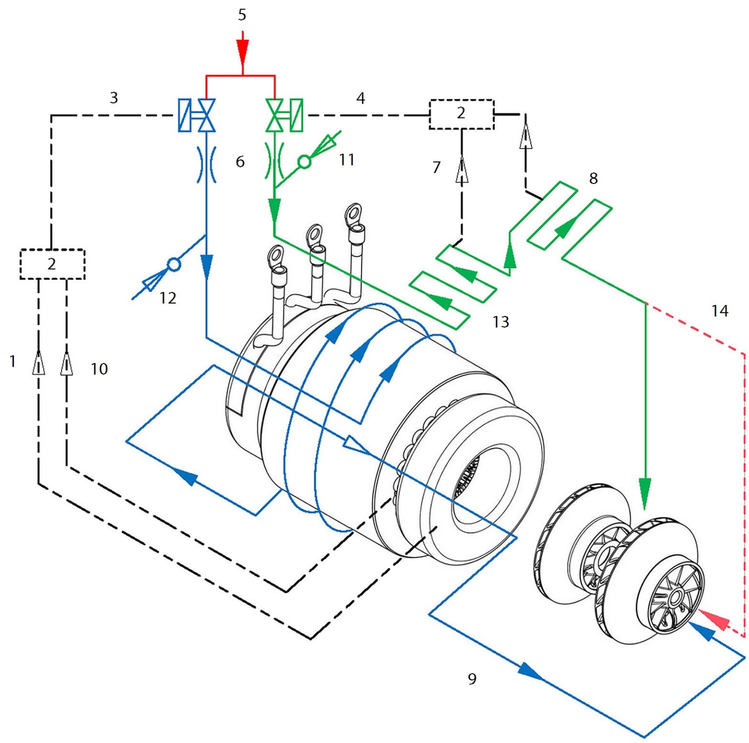


Table 2-2 Split Cooling Path - (TTS/TGS (Except TTS300/TGS230 Serial Cooling)

No.	Description	No.	Description
1	From Motor Winding Temp Sensor	8	SCR Manifold
2	BMCC	9	Motor/Rotor Cooling Gas
3	Solenoid M	10	From Motor Cavity Temp. Sensor
4	Solenoid E	11	E Schrader Valve
5	Liquid Refrigerant Inlet	12	M Schrader Valve
6	Orifices	13	Inverter
7	Inverter Temp Sensor	14	High SST Option

Figure 2-5 Compressor Cooling Path - TTS300/TGS230

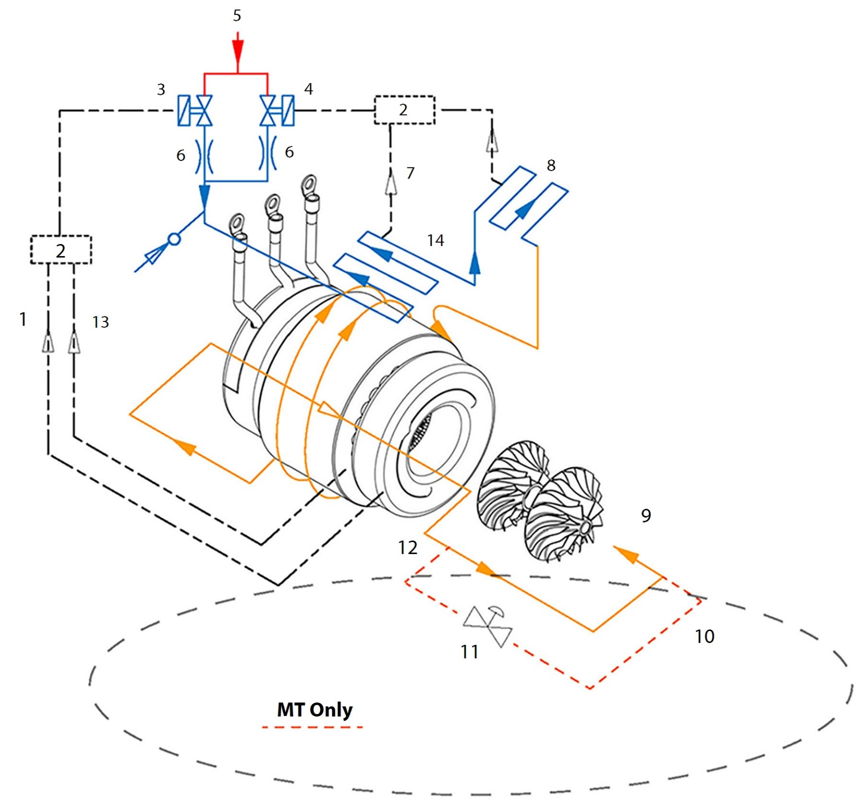


Table 2-3 Compressor Cooling Path - (TTS300/TGS230)

No.	Description	No.	Description
1	From Motor Winding Temp Sensor	8	SCR Manifold
2	BMCC	9	Motor/Rotor Cooling Gas
3	Solenoid M	10 *MT Only	Cooling path re-enters at the suction line of the chiller
4	Solenoid E	11 *MT Only	Pressure Regulating Valve
5	Liquid Refrigerant Inlet	12 *MT Only	Cooling path redirects outside of the compressor
6	Orifice	13	From Motor Cavity Temp. Sensor
7	From Inverter Temp Sensor	14	Inverter

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

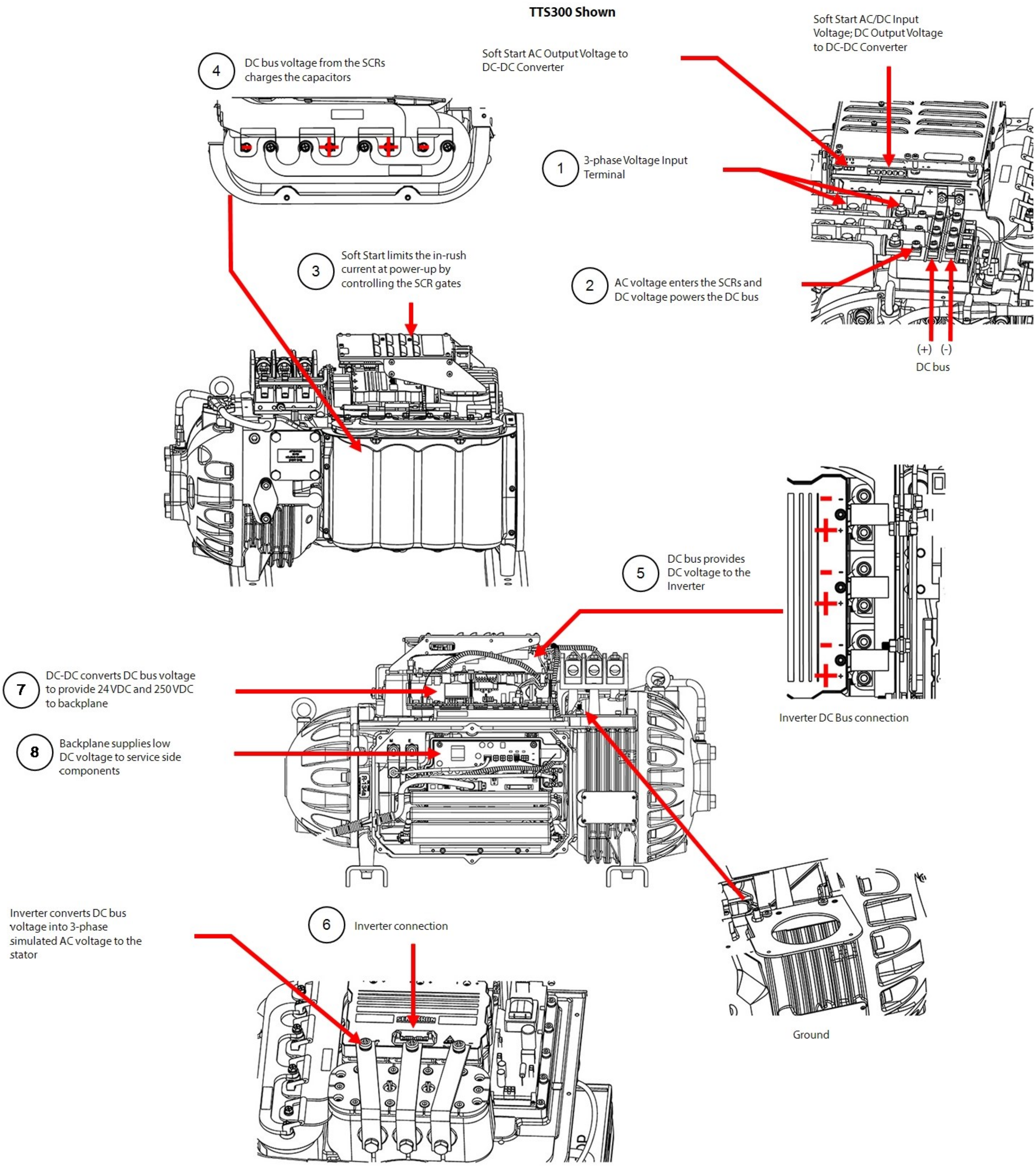
During normal operation, 3-phase power is required to be connected to the compressor at all times, even if it is not running. Power is distributed through the following components to maintain compressor operation:

- Silicon-Controlled Rectifier (SCR)
- Soft Start Board
- DC Capacitor Bus Bar 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

The order of power and signal flow through the compressor components is as follows. Refer to Figure 2-6 Compressor Energy and Signal Flow Connections on page 39:

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 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.

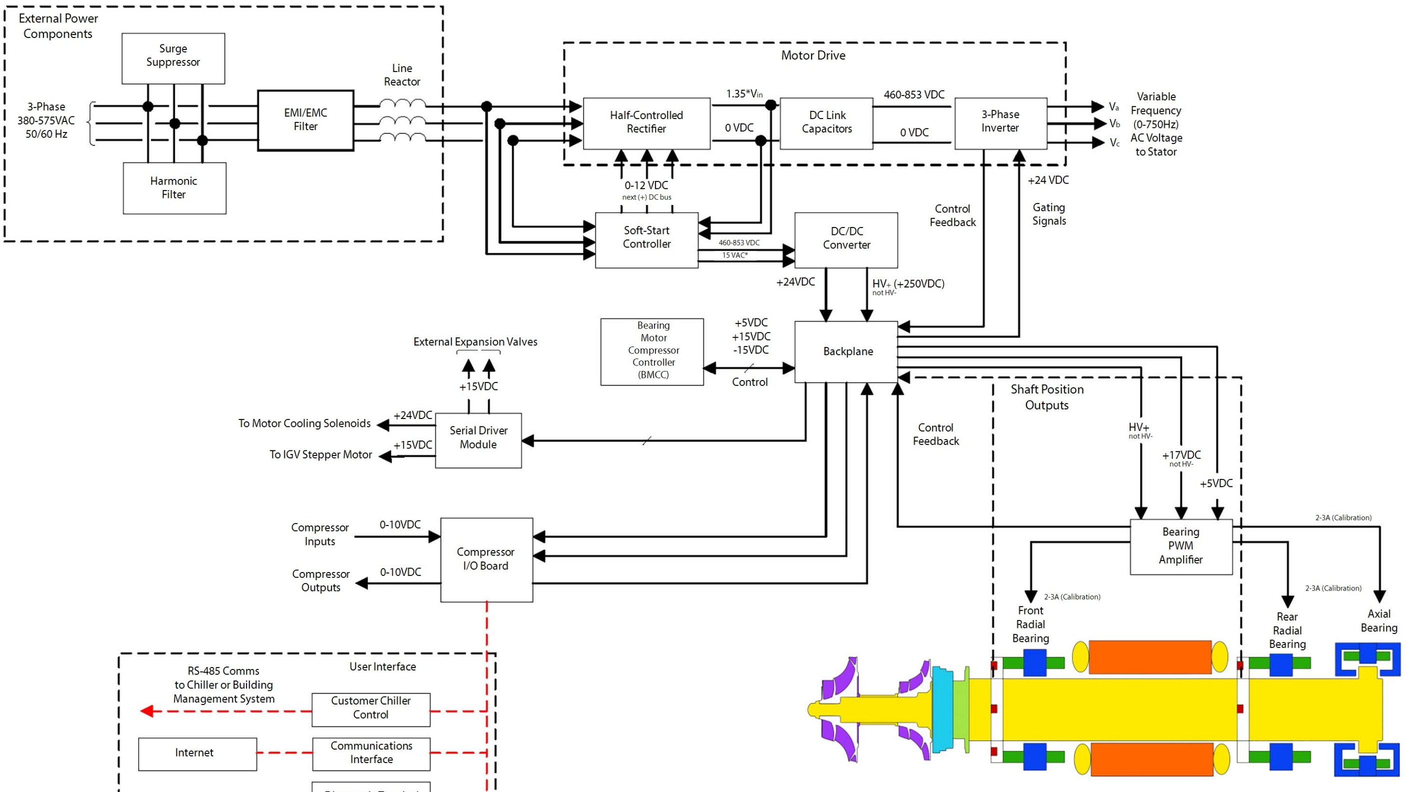
Figure 2-6 Compressor Energy and Signal Flow Connections



Refer to Figure 2-7 Compressor Energy and Control Flow Block Diagram - TT Series Compressors for a block diagram summary of the energy and voltage signal flow through the compressor.

NOTE
TTH/TGH Compressors are very similar to Figure 2-7 Compressor Energy and Control Flow Block Diagram - TT Series Compressors.

Figure 2-7 Compressor Energy and Control Flow Block Diagram - TT Series Compressors



Note:
All voltage levels shown have the following error tolerance:
DC (except the DC bus): ±5%
AC : ±10%
* The 15VAC signal is only required when DC-DC 1000040-*(potted) is used.
Not applicable for DC-DC 100379 (Open Frame).
There is no 15VAC signal coming from the Open-Top Soft Start.

Chapter 3.0 Compressor Removal and Installation

3.1 Refrigerant Containment

• • • CAUTION • • •

Isolation and recovery of the refrigerant must be performed by a qualified service technician adhering to industry/ASHRAE standards. Always wear proper safety equipment when handling refrigerants.

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

3.2 Compressor Removal

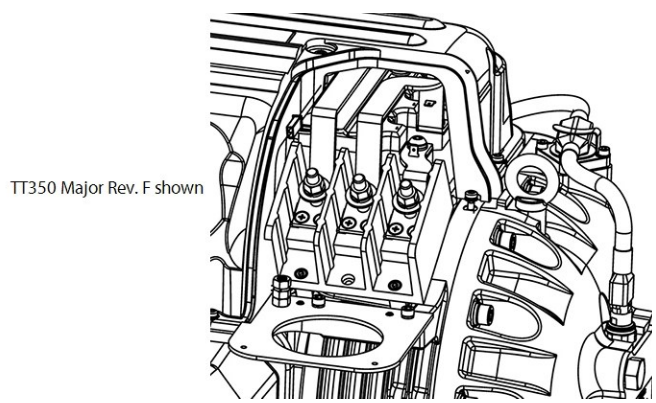
1. Isolate the Compressor power as described in Section 1.8 Electrical Isolation on page 22.

• • • CAUTION • • •

Ensure that there is no secondary power source connected to the compressor before disconnecting the following cables:

2. Remove the AC power cables from the Mains Input Bus bars.
3. Remove the ground wire from the ground post.
4. Remove the conduit from the Mains Plate.

Figure 3-1 Compressor Power Cable Removal



5. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
6. Disconnect the I/O cable from the Backplane I/O connector (J7) and remove the cable from the compressor.
7. 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.
8. Install the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
9. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
10. Position the lifting hoist/crane with the 2-point spreader bar directly above the lifting points.

11. Using a properly rated chain/cable, connect the spreader bar to the compressor lifting points.
12. Confirm that all lifting points are secured in accordance with relevant safety procedures and standards.
13. Connect an appropriate lifting device to the eyebolts provided on each side of the compressor.
14. Remove the four (4) compressor mounting fasteners and associated hardware from the base of the compressor.
15. Lift the compressor approximately 100 mm (4"). Confirm that the compressor and spreader bar are properly balanced between the lifting points and the lifting hoist.
16. Continue the removal of the compressor and lower to the desired location in order to remove the chains/cables.
17. Using the blanking plates and bolts provided with the new compressor, seal the compressor and charge to 15 psi with a nontoxic inert gas (e.g., nitrogen) for shipment (this will prevent moisture and foreign material from entering the compressor).

3.3 Compressor Installation

NOTE

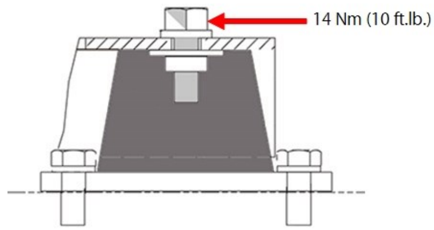
Blanking plates should not be removed from the new compressor until you are ready to place the new compressor in operation. New compressors are pressurized with nitrogen to 15 psi. Pressure should be relieved through the Schrader valve, located next to the motor cooling connection, prior to removing the blanking plates.

NOTE

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

1. Relieve the inert gas pressure through the motor cooling exit port Schrader valve.
2. Remove the suction, discharge, and economizer (if applicable) blanking plates from the compressor.
3. Remove the motor cooling inlet adapter cap. Refer to Section 3.4 Compressor Replacement Considerations for Motor Cooling Adapter on page 43.
4. Ensure that all connections have protective covers to prevent foreign object damage during installation.
5. Attach the spreader bar to the two (2) lifting hooks (eye bolts) on the top of the compressor and confirm that all lifting points are secured in accordance with relevant safety procedures and standards.
6. Position an appropriate lifting hoist/crane and connect to the spreader bar.
7. Confirm that the compressor and spreader bar are properly balanced between the lifting points and the lifting hoist.
8. Slowly lower the compressor until it is positioned within approximately 5 mm (¼") of the compressor mounts.
9. Loosely install the rubber mounts and mounting fasteners to the base of the compressor.
10. Slowly release the load from the crane so that compressor weight is supported by the compressor mounts.
11. Install and tighten the suction flange fasteners to 75 Nm (55 ft.lb.).
12. Install and tighten the discharge flange fasteners to 32 Nm (24 ft.lb.).
13. Install and tighten the economizer flange fasteners (if applicable) to 32 Nm (24 ft.lb.).
14. Torque the compressor mounting base fasteners to 14 Nm (10 ft.lb.).

Figure 3-2 Compressor Mounting Fasteners



15. Torque the motor cooling line connection (Nut) to 11 Nm (8 ft.lb.).
16. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
17. Install the I/O strain relief to the compressor housing.
18. Connect the compressor I/O cable to the Backplane I/O connector (J7).
19. Install the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.

• • •DANGER! • • •

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

20. Remove the Mains Input Cover. Refer to Section 4.1.1.1 Mains Input Cover Removal and Installation on page 52.
21. Connect the cable gland that secures the Mains Input cable conduit to the Mains Input bracket.
22. Install the Mains Input ground wire to the ground post and torque the top nut to 10 Nm (7 ft.lb.).
23. Attach the AC mains cables to the terminals and torque to specification.
    - TTS300/TGS230 Compressors - 20 Nm (15 ft.lb.)
    - All Compressors (excluding TT300/TG230) - 21 Nm (15 ft.lb.)
24. Install the Mains Input Cover. Refer to Section 4.1.1.1 Mains Input Cover Removal and Installation on page 52.
25. Leak test and evacuate in accordance with standard industry practices.
26. Return the compressor to normal operation.

Changes to the compressor software settings may be necessary to align with the chiller requirements.

3.4 Compressor Replacement Considerations for Motor Cooling Adapter

The housing connection seal is an ISO standard O-ring seal and the external pipework connection is an ORFS. In addition, the line size is 1/2 inch for all models and the fitting includes a built-in (removable) strainer.

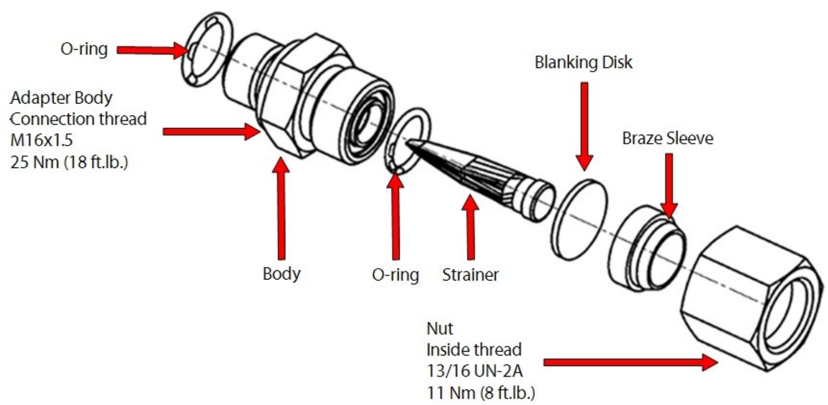
Refer to Figure 3-3 Motor Cooling Fitting on page 44.

Table 3-1 Cooling Adapter Detail

Component	Notes
Body	Includes both O-rings - Body to compressor housing thread is M16 x 1.5.
Strainer	-
Blanking Disk	-
1/2" Braze Sleeve	Steel for all connecting 1/2 copper tube

Component	Notes
Nut	Tube connection thread is 13/16-16 UN-2A. Strainer recess is Ø 9.5.

Figure 3-3 Motor Cooling Fitting



Flexible Line

1. If the connection is a flexible hose to 3/8 or 1/2 inch flare, the entire hose will require replacement with the current style.
2. Isolate the compressor and recover the refrigerant according to industry standards. Refer to Section 3.1 Refrigerant Containment on page 41.
3. Source appropriate OEM specified and procured flexible line.
4. Remove the nut from the connection fitting body. Discard the blanking disc, nut, and braze sleeve.
5. Before installation of the OEM supplied flexible line, inspect the O-ring face to ensure it is clean and free from scratches or other damage. Lightly coat O-ring lube on the O-ring face of the line and install using two (2) wrenches; one to hold body of fitting and one to tighten the nut. This is done to prevent over torqueing the fitting in the compressor housing.

NOTE
Flexible lines are not supplied by Danfoss LLC. Selection of appropriate hose and fitting is the responsibility of OEM/installer. This information is readily available from various sources.

Rigid 1/2 inch copper connection

1. If the connection is 1/2 inch rigid copper, a length of 1/2 inch copper must be brazed into the braze sleeve.
2. Isolate the compressor and recover the refrigerant according to industry standards. Refer to Section 3.1 Refrigerant Containment.
3. Remove the nut from the connection-fitting body. Discard the blanking disc. Slide the nut over the pipe, threaded side toward the outlet.
4. Locate the braze sleeve and clean. Ensure removal of all oil and surface debris. Braze as per the OEM standard process for copper/steel joint.
5. Place an appropriate length of 1/2 inch copper tube into the braze sleeve. Pretreat/flux joint area as per the OEM standard procedure. Braze the pipe to the sleeve ensuring the nut can be fitted after brazing or otherwise position as required. Clean flux and any excess filler from joint.

6. Clean the O-ring face of the sleeve ensuring no scratches or debris are present. Apply a light amount of O-ring lube to the face of the sleeve and assemble to the fitting. Tighten the nut using two (2) wrenches; one (1) to hold body of fitting and one (1) to tighten the nut. This is done to prevent over torqueing the fitting in the compressor housing.

Rigid 3/8 inch copper connection - TTS300/TGS230

- If the connection is 3/8 inch rigid copper, a length of 1/2 inch copper must be brazed into the braze sleeve as described above. A transition fitting should be brazed to connect the 3/8 to 1/2 inch tubes. Follow the 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.

3.5 Exterior Connection Torque Specifications

Table 3-2 Exterior Connection Torque Specifications

Description	Thread Depth (mm)	Nm	Ft. Lb.	In.Lb.
Power Cable Nut (excluding TTS300/TGS230 compressors)	-	21	15	186
Input Pressure Screws (TTS300/TGS230 compressors)	-	20	15	177
Motor Cooling Body, E-housing and later	-	25	18	221
Motor Cooling Compression Nut, E-housing and later	-	11	8	97
Ground Post, Top Nut	-	10	7	89
Ground Post, Second (Jam) Nut	-	7	-	62
Ground Post, Lower Nut	-	20	15	177
Suction Flange Fastener	34.5	75	55	664
Discharge Flange Fastener	20	32	24	283
Economizer Flange Fastener	20	32	24	283
Schrader Valve	-	15	11	133
Base Mounting Bolt	24	22	16	195
Cover Fastener	-	1.5	-	13
Compressor Mounting Fastener	-	14	10	124

THIS PAGE INTENTIONALLY LEFT BLANK

Chapter 4.0 Component Identification

This section identifies the major parts of the compressor.

Figure 4-1 Compressor Components Identification (Covers On)

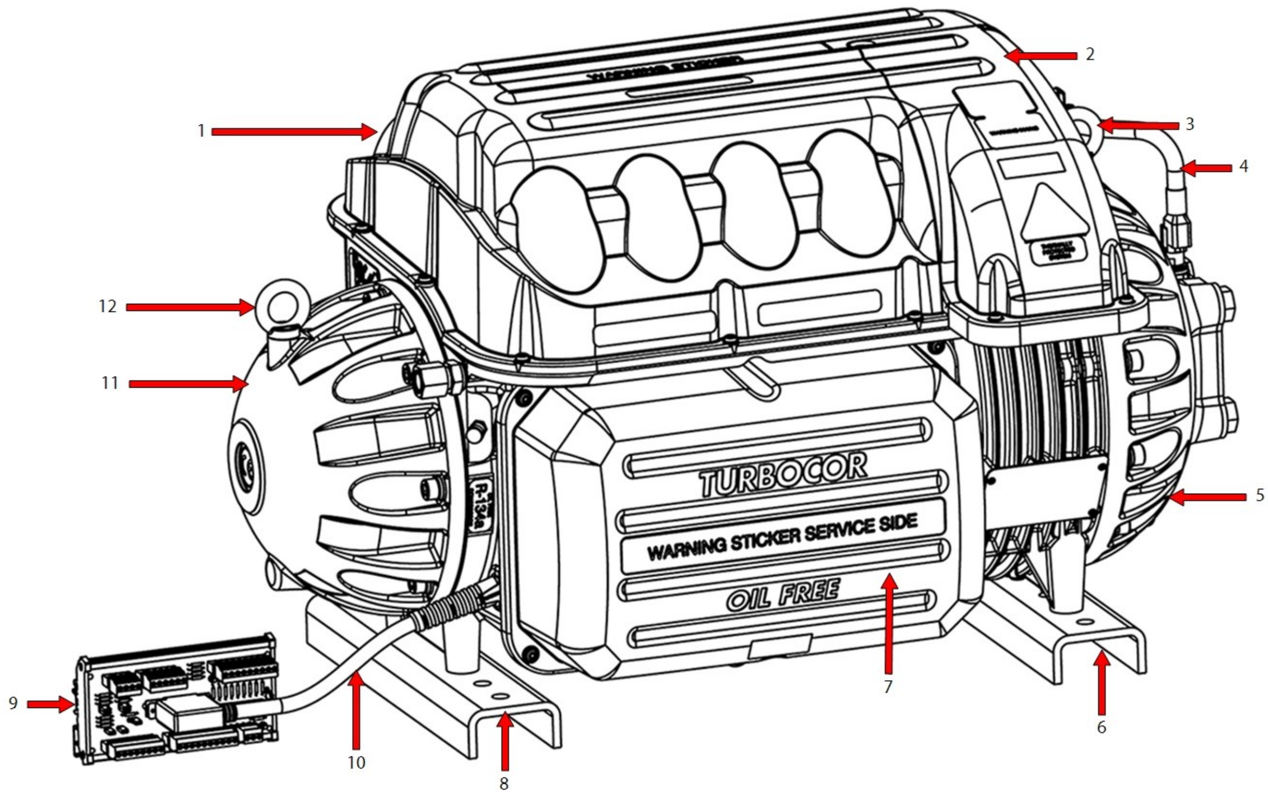


Table 4-1 Compressor Components (Covers On)

No.	Component	No.	Component
1	Top Cover	7	Service Side Cover
2	Mains Input Cover	8	Rear Support Base
3	Lift Anchor (Front)	9	Compressor I/O Board
4	Compressor Controller Cable Harness	10	Compressor I/O Cable
5	IGV Housing	11	End Cap
6	Front Support Base	12	Lift Anchor (Rear)

Figure 4-2 Compressor Component Identification (Excludes TTH/TGH Compressors)

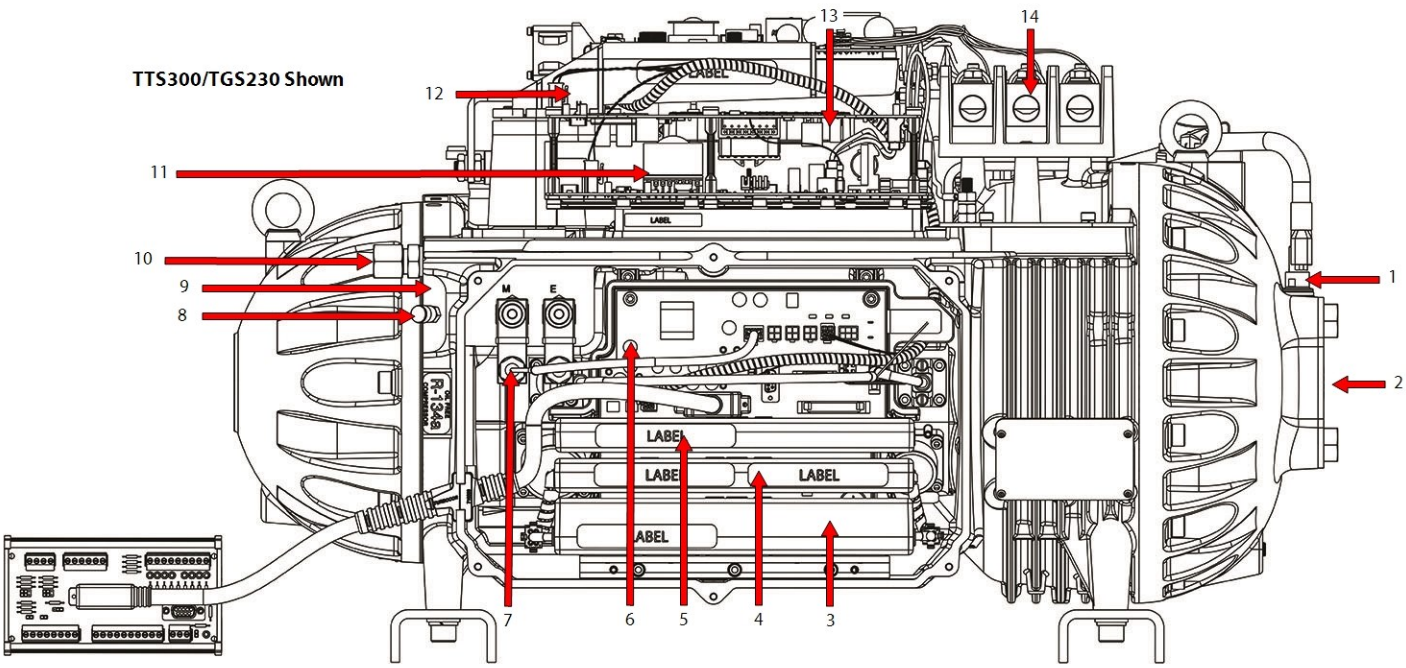


Table 4-2 Compressor Components(Excludes TTH/TGH Compressors)

No.	Component	No.	Component
1	Suction/Pressure/Temperature Sensor	8	Compressor Cooling Access Port Access Port #1 (**NOTE:** TTS300/TGS230 have only one access port)
2	IGV Suction Port	9	Compressor Cooling Access Port #2 (not available on TTS300/TGS230 compressors) **NOT SHOWN**
3	PWM Amplifier	10	Cooling Inlet Adapter
4	BMCC	11	DC-DC Converter
5	Serial Driver	12	Soft Start
6	Backplane	13	Inverter
7	Motor-Cooling Solenoids	14	Fast-Acting Fuses (TTS300/TGS230 only)

Figure 4-3 Compressor Component Identification (TTH/TGH Only)

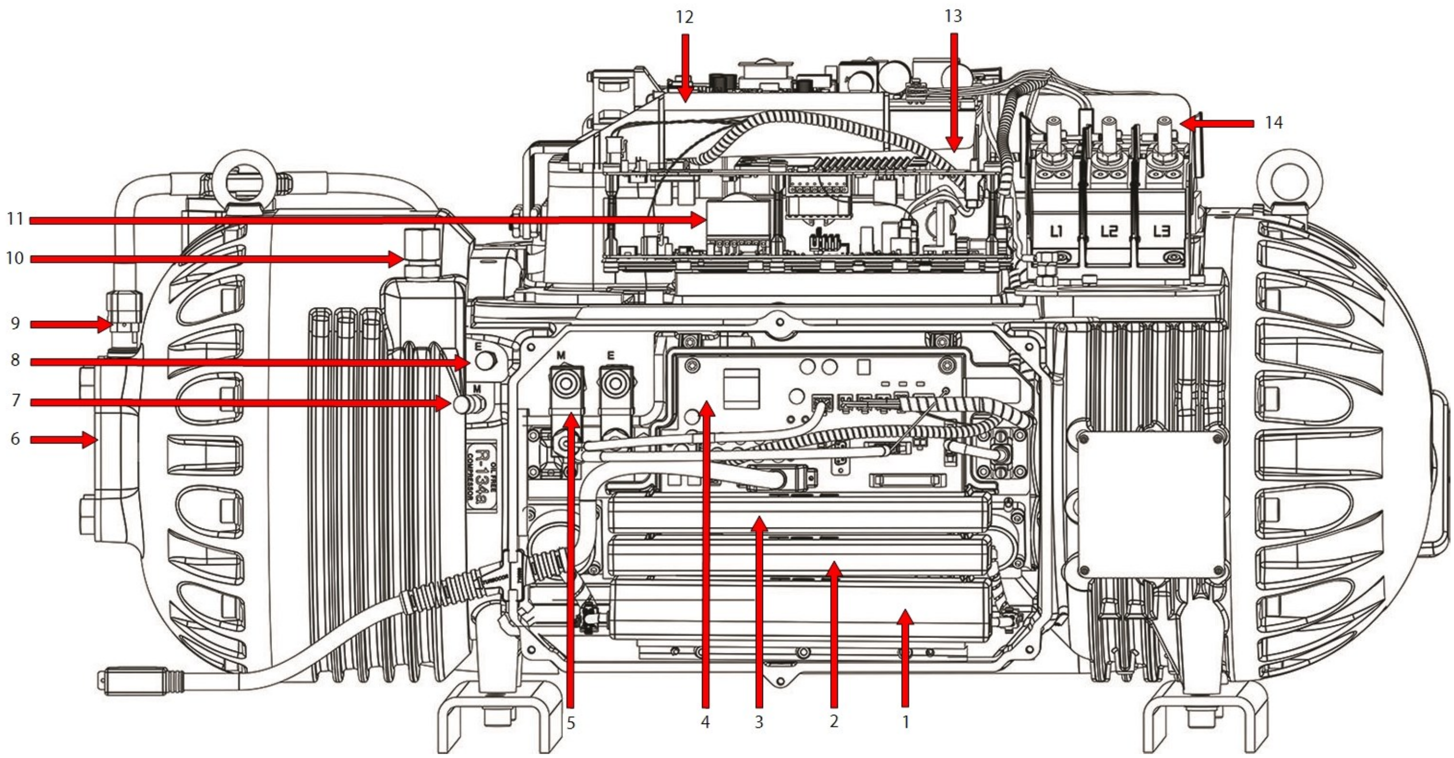


Table 4-3 Compressor Components Service Side (TTH/TGH Only)

No.	Component	No.	Component
1	PWM Amplifier	8	Compressor Cooling Access Port
2	BMCC	9	Suction Pressure/Temperature Sensor
3	Serial Driver	10	Cooling Inlet Adapter
4	Backplane	11	DC-DC Converter
5	Motor-Cooling Solenoids	12	Soft Start
6	IGV Suction Port	13	Inverter
7	Compressor Cooling Access Port	14	AC Mains Bus Bars

Figure 4-4 Compressor Component Identification - Capacitor Side (Excludes TTH/TGH)

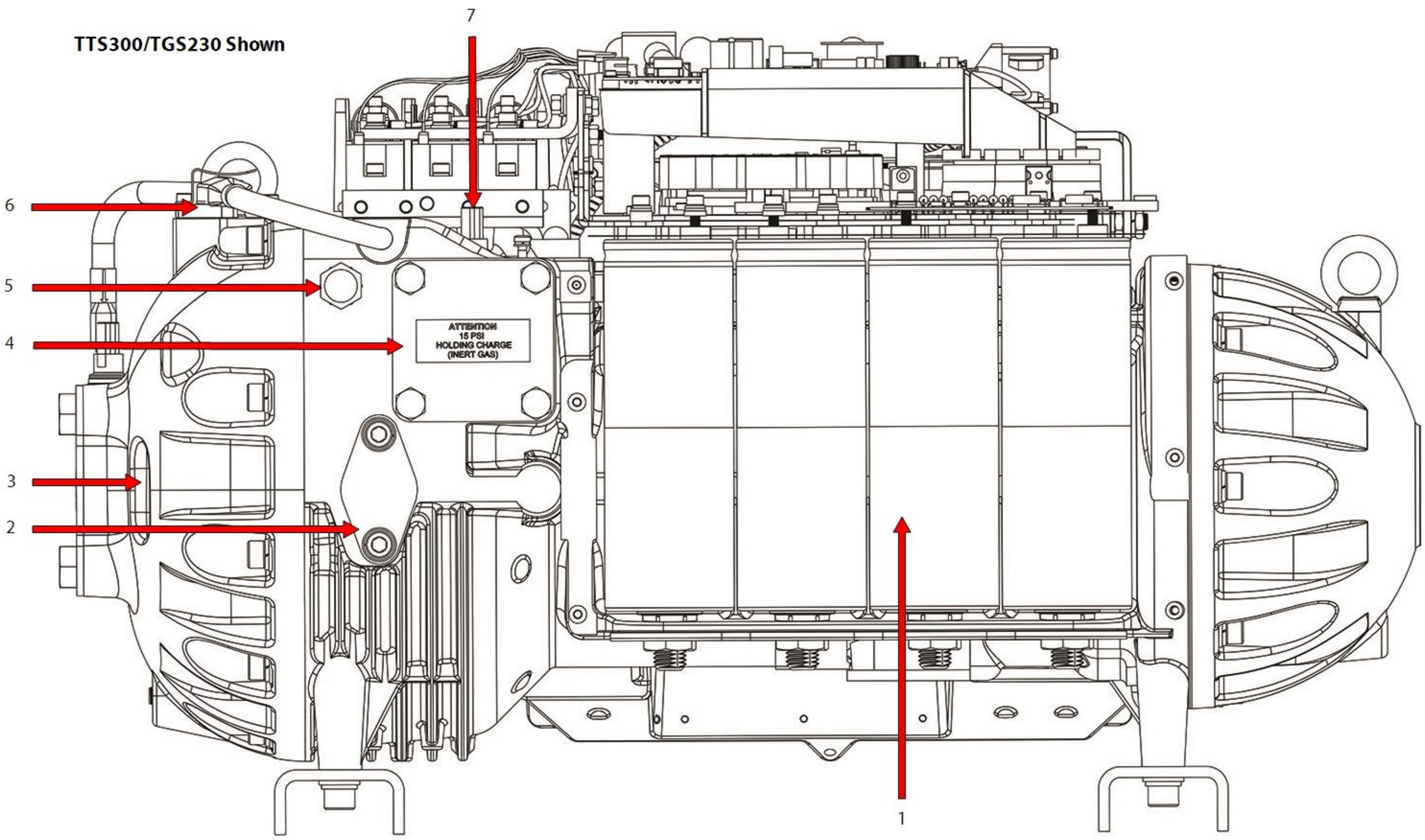


Table 4-4 Compressor Components Capacitor Side (Excludes TTH/TGH)

No.	Component	No.	Component
1	Capacitors	5	Optional (Medium-Temp application) Cooling Path Pressure Regulating Port
2	Economizer Port	6	IGV Motor Feedthrough
3	IGV Position Indicator	7	Discharge Temperature/Pressure Sensor
4	Discharge Port		

Figure 4-5 Compressor Component Identification - Capacitor Side (TTH/TGH Only)

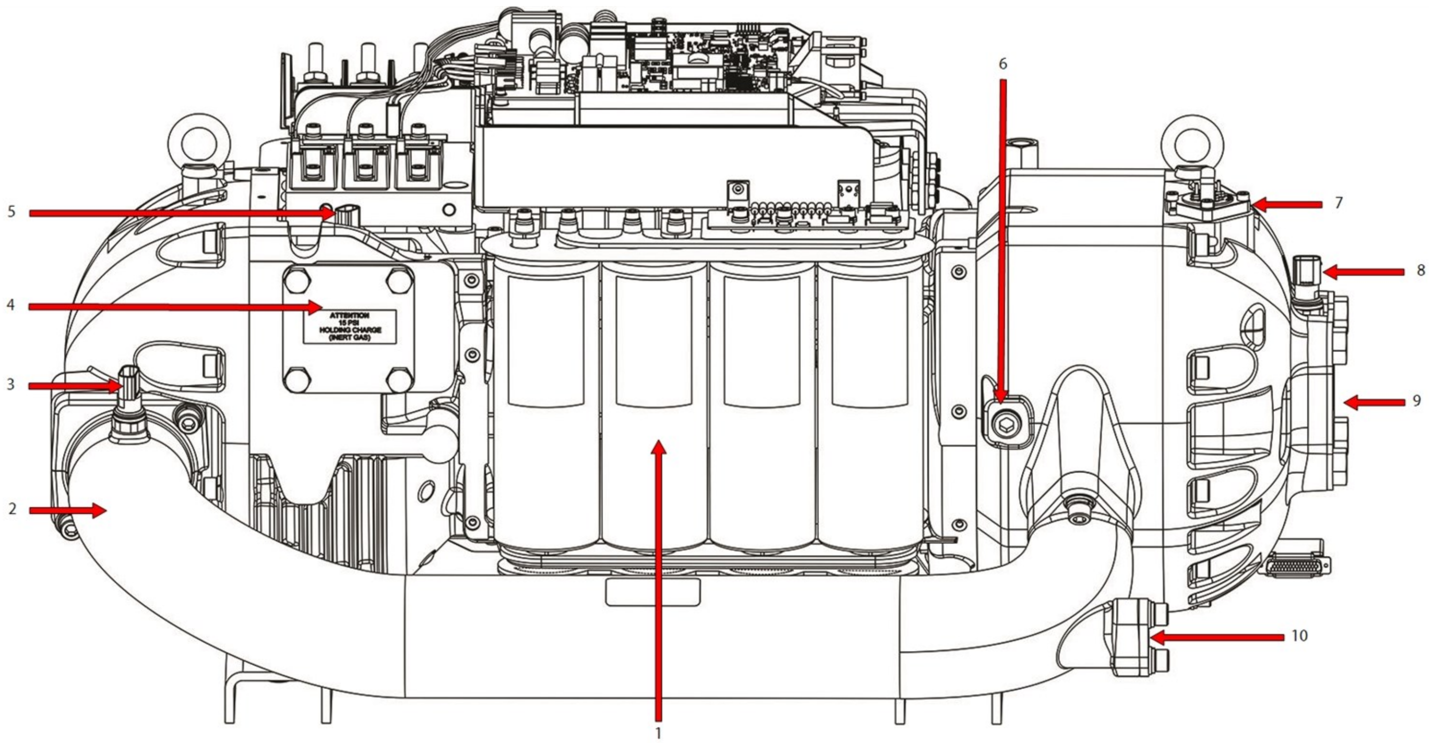


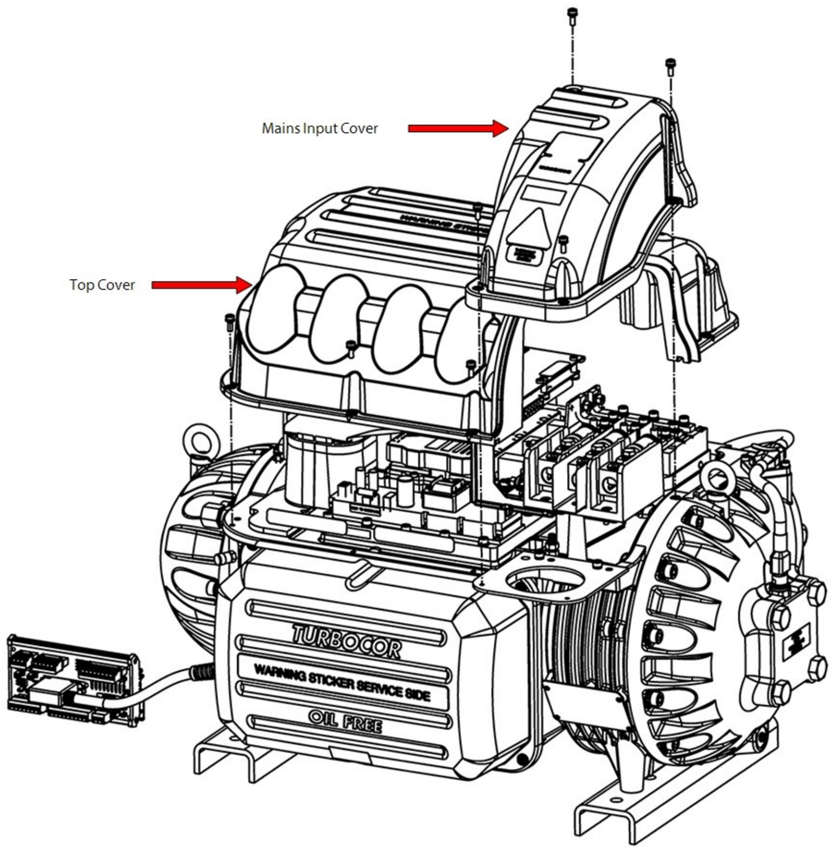
Table 4-5 Compressor Components Capacitor Side (TTH/TGH Only)

No.	Component	No.	Component
1	Capacitors	6	Optional (Medium-Temp application) Cooling Path Pressure Regulating Port
2	Interstage Pipe	7	IGV Motor Feedthrough
3	Interstage Temperature/Pressure Sensor	8	Suction Temperature/Pressure Sensor
4	Discharge Port	9	Suction Port
5	Discharge Temperature/Pressure Sensor	10	Economizer Port

4.1 Compressor Covers

The compressor covers provide protection to the internal components as well as protection for anyone that might be near the compressor while the mains power is applied and while the capacitors contain a dangerous electrical charge.

Figure 4-6 Top Covers Removal



• • • CAUTION • • •
Care must be taken in removal and installation of the covers to prevent the fasteners from falling in to the power electronic compartment. Dropping cover fasteners can cause a short circuit, cause energized components to fail catastrophically, and cause damage to the power electronic parts of the compressor. After properly positioning the covers, carefully install the fasteners to minimize the risk of them falling into the power electronic areas.

4.1.1 Mains Input Cover

4.1.1.1 Mains Input Cover Removal and Installation

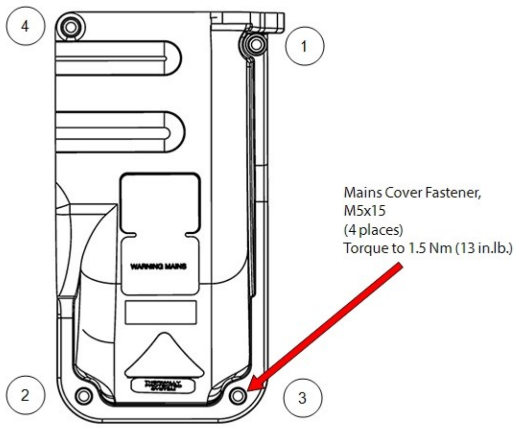
Mains Input Cover Removal

1. Isolate compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Remove the M5x15 fasteners that secure the Mains Input Cover.
3. Remove the cover.

Mains Input Cover Installation

1. Ensure that no residue remains on the contact surfaces of Mains Input Cover and Top Cover.
2. Place the Mains Input Cover and secure it with the M5x15 fasteners. Tighten according to the sequence shown in Figure 4-7 Mains Input Cover Torque Sequence.

Figure 4-7 Mains Input Cover Torque Sequence



3. Follow the sequence twice. The first time, only tighten the fasteners halfway down to allow for adjustment. Tighten the # 4 fastener only once and be sure to not overtighten. Torque to 13 in.lb. on the second pass.
4. Return the compressor to normal operation.

4.1.2 Top Cover

4.1.2.1 Top Cover Removal and Installation

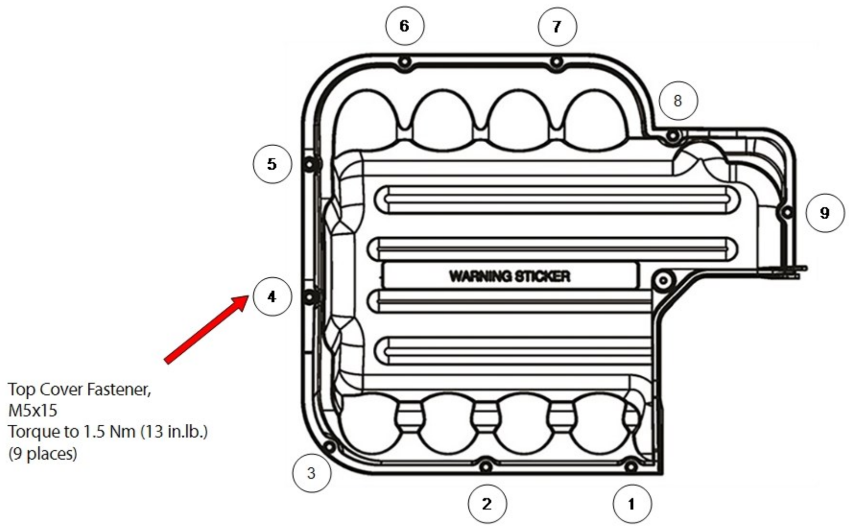
Top Cover Removal

1. Isolate compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Remove the Mains Input Cover by releasing the M5x15 fasteners.
3. Remove the Mains Input cover.
4. Remove the M5x15 fasteners that secure the Top Cover and remove the cover.

Top Cover Installation

1. Ensure that no residue remains on the contact surfaces of Top Cover and casting sides.
2. Place the Top Cover and secure it with the M5x15 fasteners according to the sequence shown in Figure 4-8 Top Cover Torque Sequence on page 54. Follow the sequence twice. The first time, only tighten the fasteners halfway down to allow for adjustments. Torque to 13 in.lb. on the second pass.

Figure 4-8 Top Cover Torque Sequence

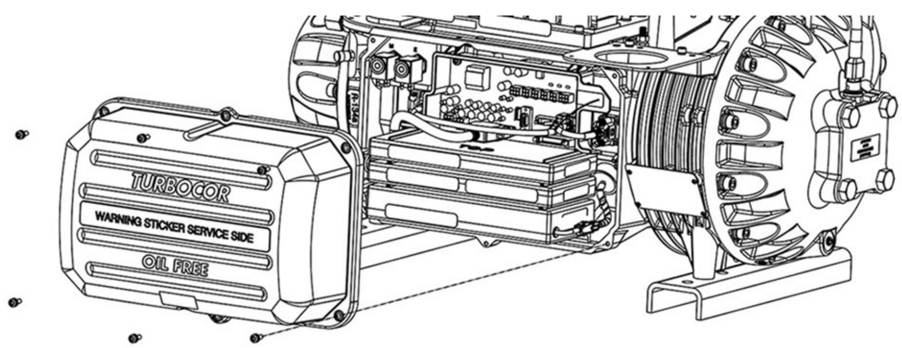


3. Ensure that no residue remains on the contact surfaces of the Mains Input Cover and casting sides.
4. Place the Mains Input Cover and secure it with the M5x15 fasteners. Tighten according to the sequence show in Figure 4-7 Mains Input Cover Torque Sequence on page 53.
5. Follow the sequence twice. The first time, only tighten the fasteners halfway down to allow for adjustment. Torque to 13 in.lb. on the second pass. Tighten the # 4 fastener only once and use caution as to not overtighten.
6. Return the compressor to normal operation.

4.1.3 Service Side Cover

The Service Side Cover provides protection for the Backplane, Serial Driver, BMCC, PWM, feedthroughs, and cabling.

Figure 4-9 Service Side Cover



4.1.3.1 Service Side Cover Removal and Installation

Service Side Cover Removal

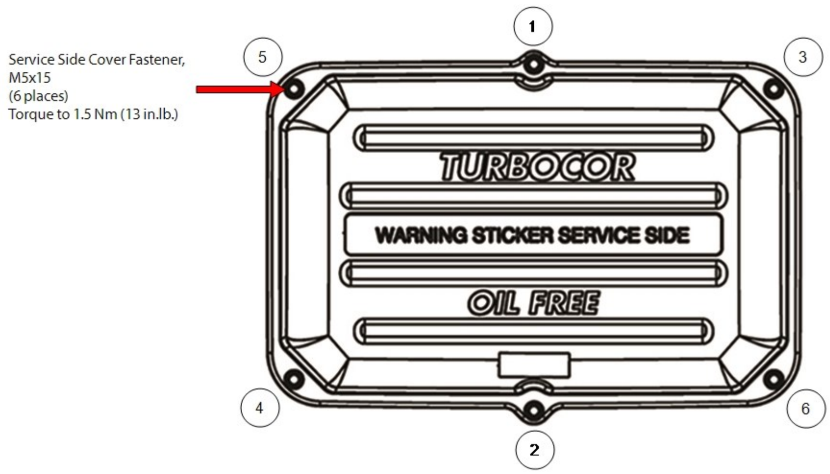
1. Remove the M5x15 fasteners that secure the Service Side Cover.
2. Remove the cover.

Service Side Cover Installation

1. Ensure that no residue remains on the contact surfaces of the Service Side Cover and compressor housing sides.

2. Place the Service Side Cover and secure it with the M5x15 fasteners according to the sequence shown in Figure 4-10 Service Side Cover Torque Sequence.
3. Follow the sequence twice. The first time, only tighten the fasteners halfway down to allow for adjustment. Torque to 13 in.lb. on the second pass.

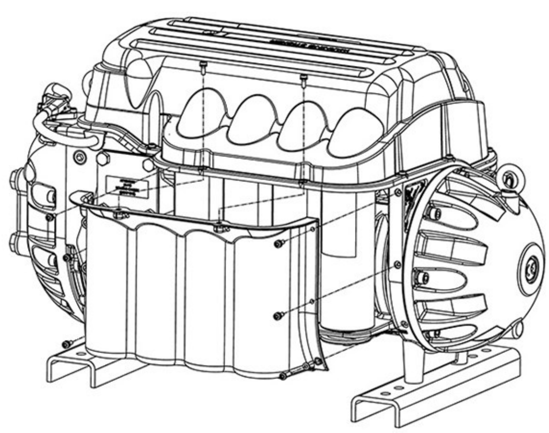
Figure 4-10 Service Side Cover Torque Sequence



4.1.4 Capacitor Cover

The Capacitor Cover provides protection for the capacitors.

Figure 4-11 Capacitor Cover



4.1.4.1 Capacitor Cover Removal and Installation

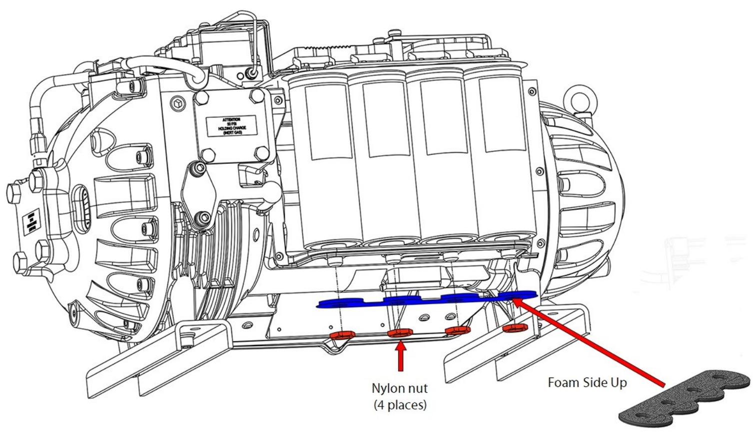
Capacitor Cover Removal

1. Isolate compressor power as describe in Section 1.8 Electrical Isolation on page 22.
2. Remove the fasteners that secure the Capacitor Cover.
3. Remove the cover.
4. Remove the nylon nuts under the capacitor assembly, then remove the capacitor relief membrane.

Capacitor Cover Installation

1. Install the capacitor relief membrane with the foam side up. Refer to Figure 4-12 Capacitor Nylon Nuts for this and the following step.
2. Install the nylon nuts to the base of the DC Capacitor Bus Bar Assembly, under the main compressor housing and torque to 7 Nm (62 in.lb.).

Figure 4-12 Capacitor Nylon Nuts



3. Place the Capacitor Cover and secure it with the M5x15 fasteners from the Top Cover.
4. Place the Capacitor Cover on the compressor and loosely secure it with the M5X15 fasteners. The bottom of the cover should rest just above the Relief Membrane. Refer to Figure 4-13 Relief Membrane Position. Additionally, the cover should line up and sit in the recessed holes in the compressor housing. Refer to Figure 4-14 Recessed Holes.

Figure 4-13 Relief Membrane Position

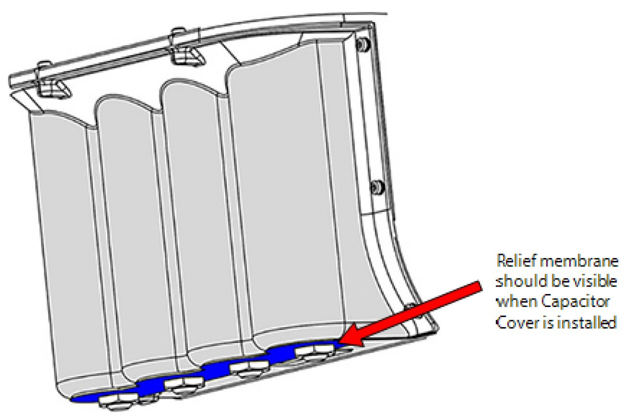
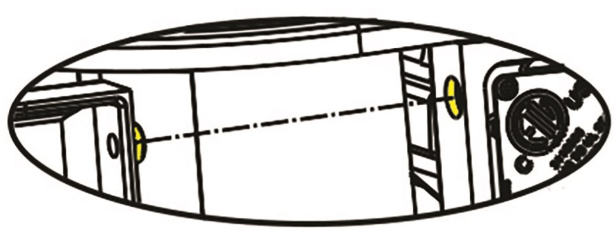
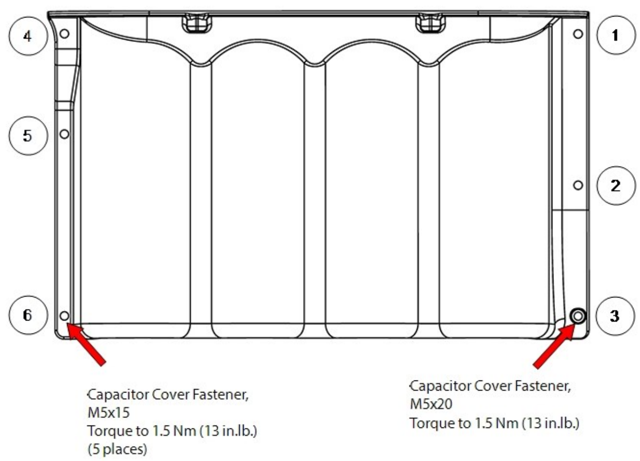


Figure 4-14 Recessed Holes



5. Place the long M5x20 fastener and flat washer in position number three (3) shown in Figure 4-15 Capacitor Cover Torque Sequence. Use the remaining M5x15 fasteners to secure the cover. Tighten all fasteners according to the sequence in Figure 4-15 Capacitor Cover Torque Sequence. Torque to 13 in.lb. on the second pass.
6. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
7. Return the compressor to normal operation.

Figure 4-15 Capacitor Cover Torque Sequence



4.1.5 Compressor Cover Torque Specifications

Table 4-6 Compressor Cover Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
Cover Fastener, M5x15	1.5	-	13
Cover Fastener, M5x20 (#3 on Capacitor Cover)	1.5	-	13

4.2 Cooling Adapter

To provide cooling for the motor and power electronics, a liquid feed line is connected to the compressor via the Cooling Adapter. This adapter contains a strainer to collect any debris that may be present.

• • • CAUTION • • •

A filter/drier must be used in conjunction with the Cooling Inlet Adapter strainer. The strainer is used as a backup to prevent damage to the solenoid orifices should any debris get past the filter/drier.

Figure 4-16 Cooling Adapter - Excludes TTH375/TGH285

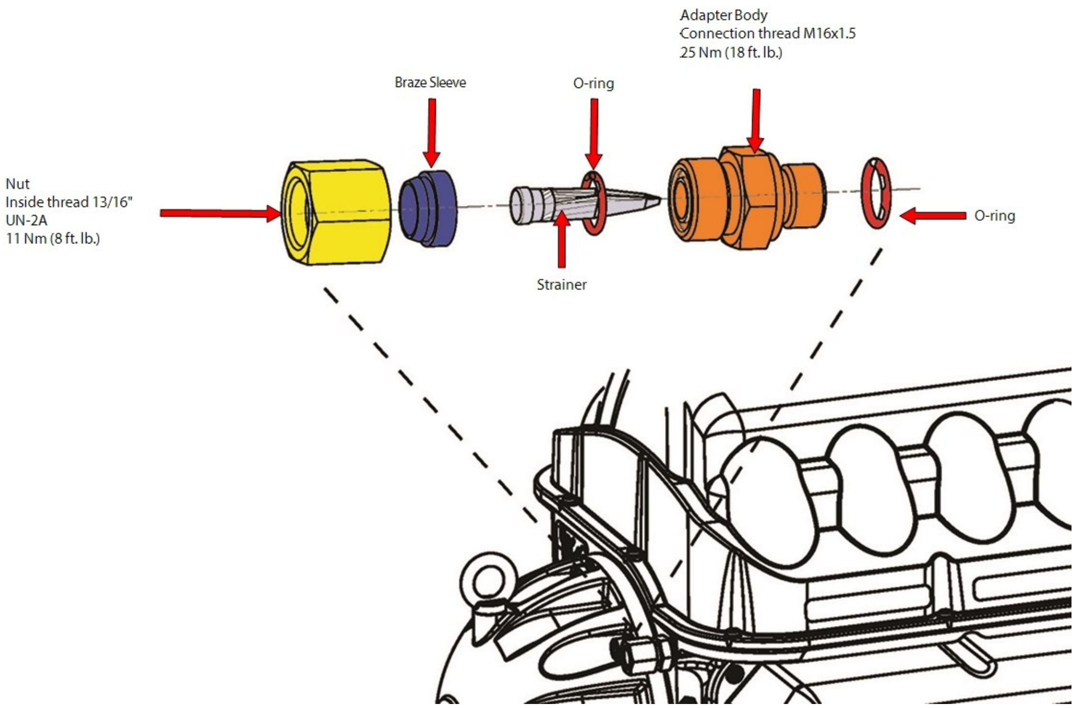
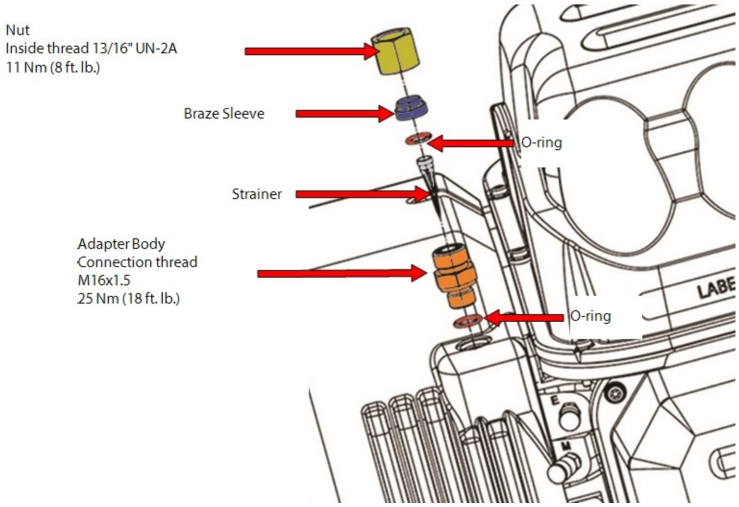


Figure 4-17 Cooling Adapter - TTH375/TGH285)



4.2.1 Cooling Adapter Removal and Installation

Cooling Adapter Removal

1. Isolate the compressor and recover the refrigerant according to industry standards. Refer to Section 3.1 Refrigerant Containment on page 41.
2. Hold the Adapter Body with a 15/16" line wrench while loosening the Connection Nut with another 15/16" line wrench.
3. Remove the line away from the Adapter Body.
4. Remove the Adapter Body with a 15/16" line wrench.
5. Remove O-ring from the compressor housing if it does not come out with the Adapter Body.

Cooling Adapter Installation

1. Verify the threads in the compressor housing are clean and free of debris (do not use compressed gas to clean the threads as this may blow the debris into the compressor).
2. Clean and lubricate the O-ring. Install onto the cooling adapter body.
3. Insert the cooling adapter body into the compressor and finger tighten.
4. Torque the cooling adapter body to the compressor housing to 25 Nm (18 ft.lb.).
5. Install the screen inside the cooling adapter.
6. Install the braze sleeve and nut minus the O-ring. Tighten the nut finger tight against the Cooling Adapter. This will allow for the measurement and fitting of the liquid line. Once the measuring and fitting of the liquid line has been completed, unscrew the nut from the cooling adapter body and complete the brazing of the liquid line to the braze sleeve.
7. Once the Cooling Adapter assembly has cooled, install the O-ring into the Cooling Adapter and the finger tighten the nut. Torque the nut to 11 Nm (8 ft.lb.).
8. Leak test and evacuate compressor in accordance with standard industry practices.

NOTE

A magnet may need to be placed on the motor cooling solenoids if evacuation cannot be performed directly to the liquid line.

9. Return the compressor to normal operation.

4.2.2 Cooling Adapter Torque Specifications

Table 4-7 Cooling Adapter Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
Adapter Body Connection	25	18	221
Nut	11	8	97

4.3 Compressor Interface Module

The Compressor Interface Module (CIM), also referred to as the Compressor I/O Board, allows the user to control and communicate with the compressor, and allows the compressor to return status and sensor information to the user. Refer to Figure 4-18 Compressor Interface Module Ports & Jumpers.

Figure 4-18 Compressor Interface Module Ports & Jumpers

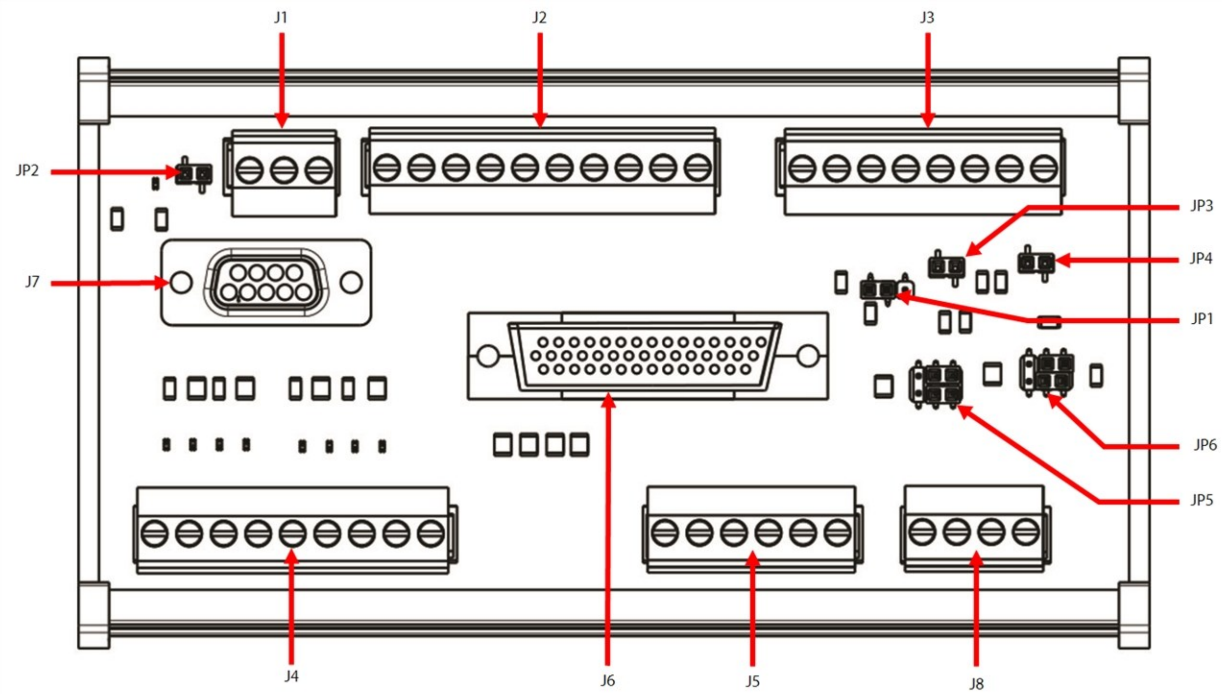


Table 4-8 CIM Ports and Jumpers

No.	Component	No.	Component
J1	RS-485 Communication Port	JP1	Analog Output Voltage
J2	Input/Output	JP2	MODBUS Terminator
J3	Input/Output	JP3	Entry
J4	EXV1 and EXV2 Control	JP4	Leave
J5	Liquid Level Input	JP5	LIQ LEV1
J6	Compressor Interface Cable Connection	JP6	LIQ LEV2
J7	RS-232 External Communication Port		
J8	External Sensor Inputs		

4.3.1 Compressor Interface Module Connection Descriptions

J1 – RS-485 external 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)

NOTE
SPEED output no longer available for compressors running BMCC firmware versions CC 3.0 and later.

- LIQT – Pin 9 & 10 – Liquid temperature sensor input
- Refer to the Applications and Installation 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 and Installation 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 and Installation Manual for thermistor specifications

J4 – EXV 1 & EXV 2 Control – 15V output (200mA maximum each)

- EXV1 – Pin 6 to 9
- EXV2 – Pin 1 to 4

J5 – Liquid Level input

- LIQ LEV 1 – Pin 4 to 6 – Liquid level sensor
- LIQ LEV 2 – Pin 1 to 3 – Liquid level sensor
- Provides Liquid Level feedback to drive EXV 1&2 in CC 3.1.4 only.
- Refer to the Applications and Installation 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 Compressor Interface Cable connection

- Communication port with Backplane

J7 – RS-232 external communication port

- 9-pin Serial Port

J8 – External sensor inputs

- Spare T: External temperature sensor input
  - Refer to the Applications and Installation Manual for thermistor specifications
- Spare P: External pressure sensor input
  - Refer to the Applications and Installation Manual for pressure sensor specifications
  - Refer to the OEM Programming Manual 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)

4.3.2 Compressor Interface Module Verification

4.3.2.1 Determining if the Compressor Interface Module is Draining Energy

1. Identify if the D9, green light-emitting diode (LED) is on.
2. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
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 Interface 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.

4.3.2.2 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 Service Monitor Tool (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.

4.3.2.3 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.
    - Refer to Section 5.5.3 Troubleshooting an Open Interlock on page 273 for further details.

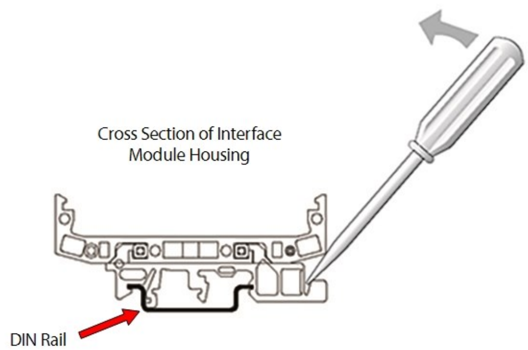
4.3.3 Compressor Interface Module Removal & Installation

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

4.3.3.1 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. Refer to Figure 4-19 Removing the Compressor Interface Module from the DIN Rail on page 64.
4. Repeat the procedure for the other mounting foot to disengage the CIM from the DIN rail.

Figure 4-19 Removing the Compressor Interface Module from the DIN Rail



4.3.3.2 Compressor I/O Board Installation

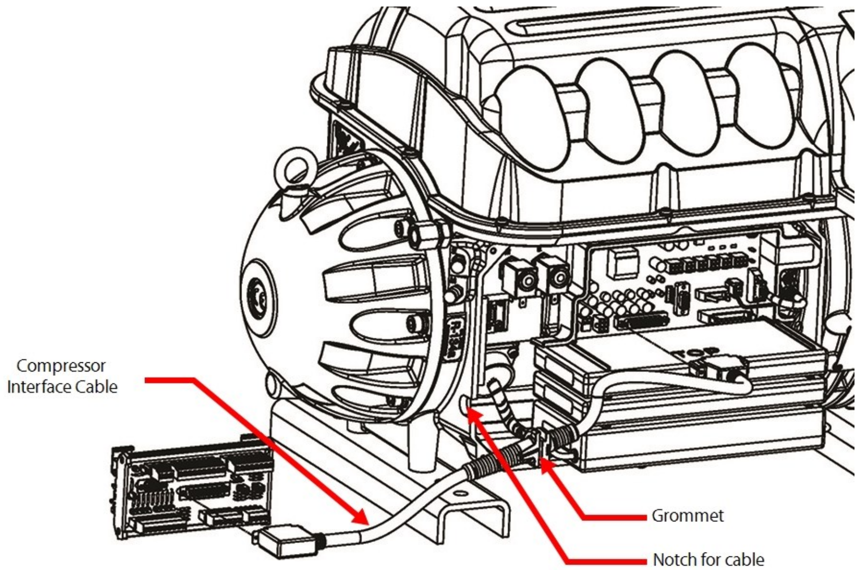
1. Install the left foot of the replacement board into the rail and press the right side of the board down until it engages the rail.
2. Reconnect all external connections and wiring on the CIM.
3. Return the compressor to normal operation.

4.4 Compressor Interface Cable

The Compressor Interface Cable connects the compressor to the CIM. Refer to Figure 4-20 Compressor Interface Cable.

NOTE
The other cables have been removed for clarity.

Figure 4-20 Compressor Interface Cable



4.4.1 Compressor Interface Cable Verification

If any communication problems exist, verify the integrity of the cable assembly. This can be accomplished by performing a continuity test at each corresponding pin.

4.4.2 Compressor Interface Cable Removal and Installation

4.4.2.1 Compressor Interface Cable Removal

1. Isolate compressor power.
2. Wait for the green light (D9) on the CIM to turn off.
3. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
4. Wait for the Backplane LEDs to turn off.
5. Use a flat-blade screwdriver to disengage the connector screws from the Backplane.
6. Disengage the connector thumbscrews from the CIM.
7. Remove the cable by grasping each connector (J6 on CIM and J7 on Backplane) and pulling away from the board connectors.

4.4.2.2 Compressor Interface Cable Installation

1. Install the cable into the J6 connector on the CIM and the J7 connector on the Backplane.
2. Tighten the connectors to secure the cable.

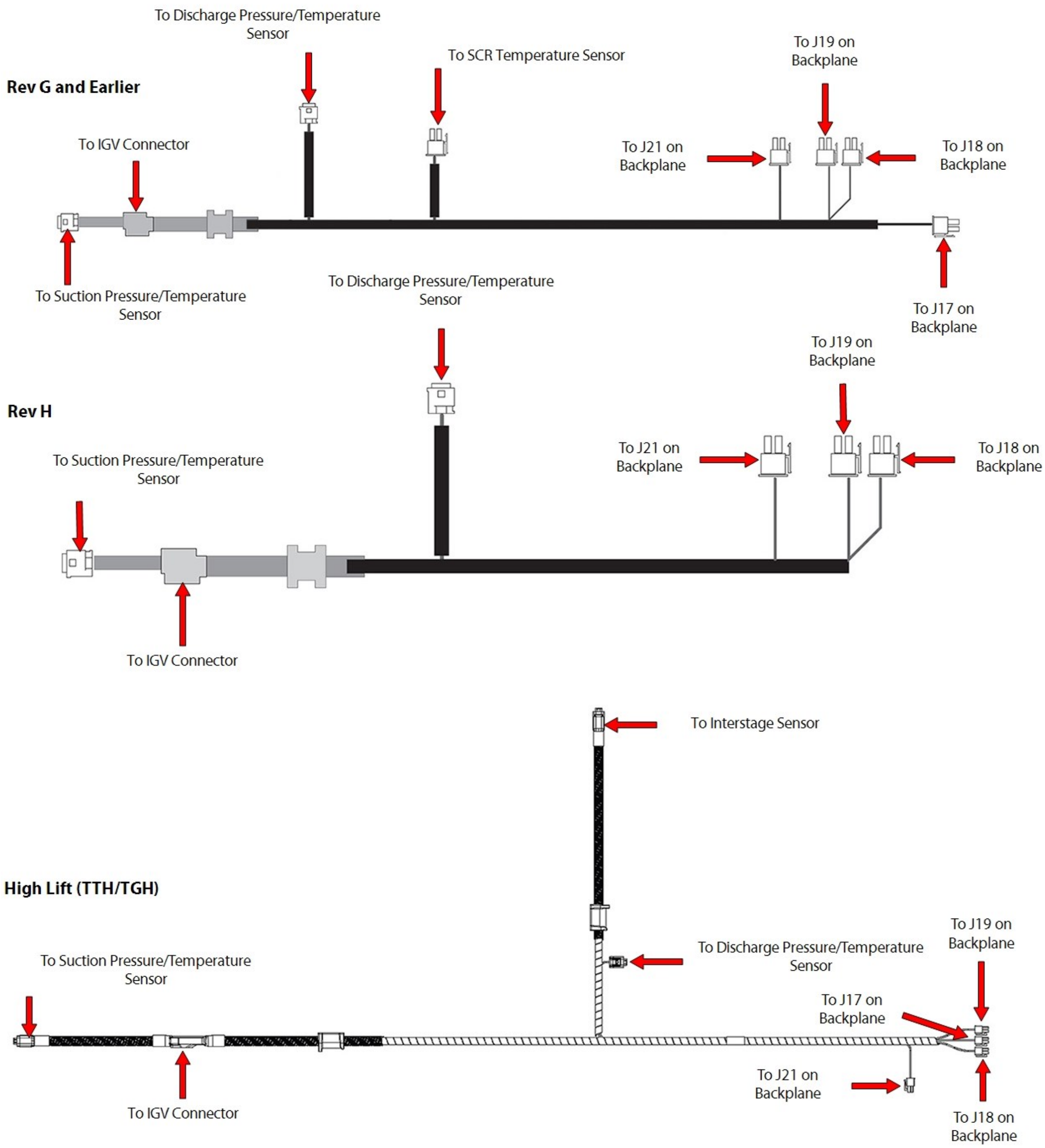
3. Ensure the cable is routed properly and that the grommet is properly positioned in the compressor housing notch.
4. Install the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
5. Return the compressor to normal operation.

4.5 Compressor Controller Cable Harness

The Compressor Controller Cable Harness passes signals from the sensors on the compressor to the Backplane. The following steps provide detail on how to replace the Compressor Controller Cable Harness. Prior to removal, note the location of the harness routing as this will minimize the installation time of the new harness.

4.5.1 Compressor Controller Cable Connections

Figure 4-21 Compressor Controller Cable Harness Variants

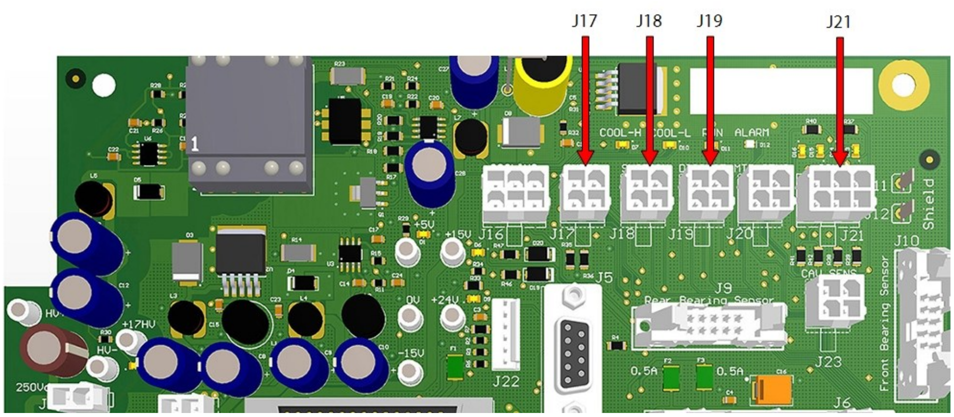


4.5.2 Compressor Controller Cable Harness Removal and Installation

Compressor Controller Cable Harness Removal

1. Isolate compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
3. Remove the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
4. Remove the Terminal Block Assembly (excluding TTS300/TGS230 compressors). Refer to Section 4.11.2 3-Phase Main Voltage Input Terminal Block Removal and Installation on page 102.
5. Remove the DC Bus Bar and Capacitor Assembly. Refer to Section 4.21.3 DC Capacitor Bus Bar Assembly Removal and Installation on page 168.
6. Refer to Figure 4-22 Backplane Connections and remove the following connectors from the Backplane:
   - Pressure/temperature sensor connectors (J17, J18, and J19)
   - IGV motor drive connector (J21)

Figure 4-22 Backplane Connections



7. Disconnect the cables from the suction and discharge pressure sensors. Refer to Figure 4-23 Pressure/Temperature and SCR Temperature Sensor Locations - TTS300/TGS230 on page 69, Figure 4-24 Pressure/Temp and SCR Temp Sensor Locations - TTS/TGS (Except TTS300/TGS230) on page 69, and Figure 4-25 Pressure/Temperature Sensor Locations - TTH375/TGH285 on page 69 for this and the following step.

NOTE

All TTH/TGH compressors and all TTS/TGS Major Rev H and later compressors do not contain an SCR Temperature Sensor.

Figure 4-23 Pressure/Temperature and SCR Temperature Sensor Locations - TTS300/TGS230

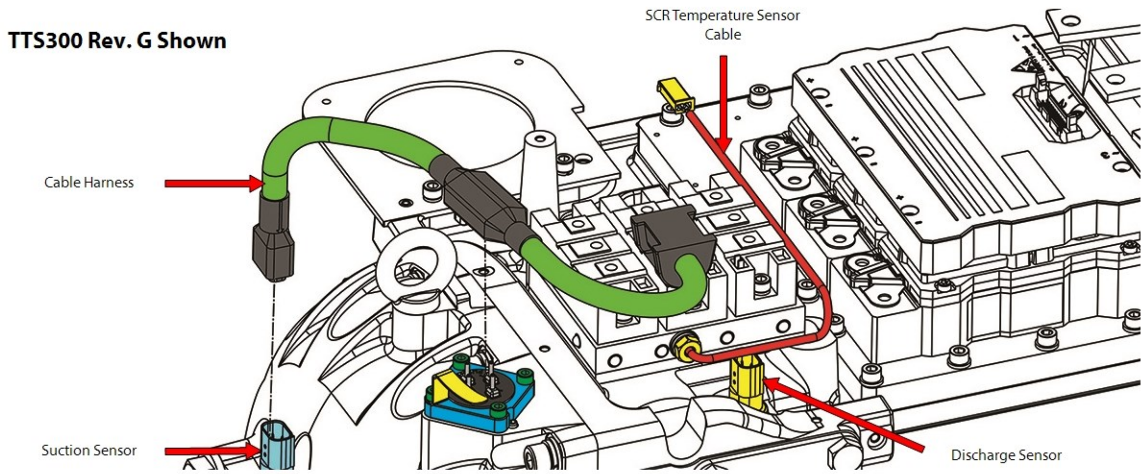


Figure 4-24 Pressure/Temp and SCR Temp Sensor Locations - TTS/TGS (Except TTS300/TGS230)

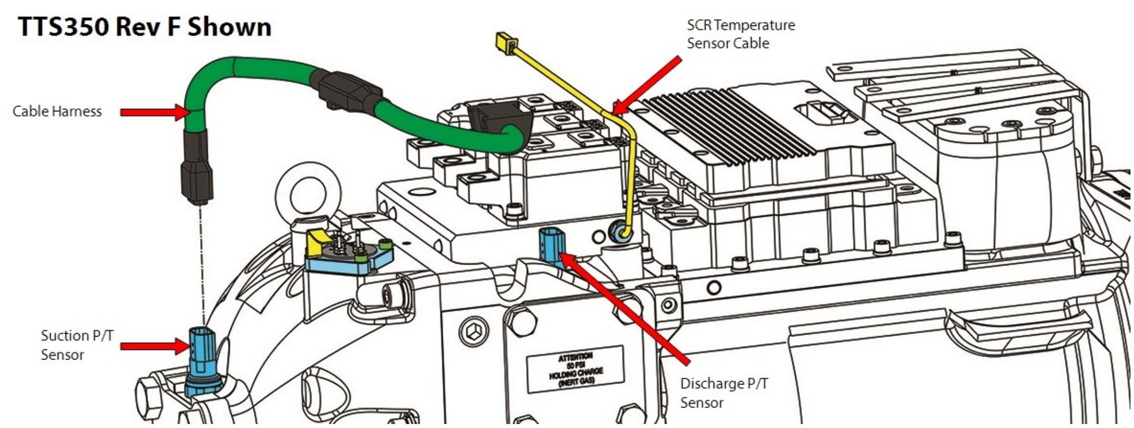
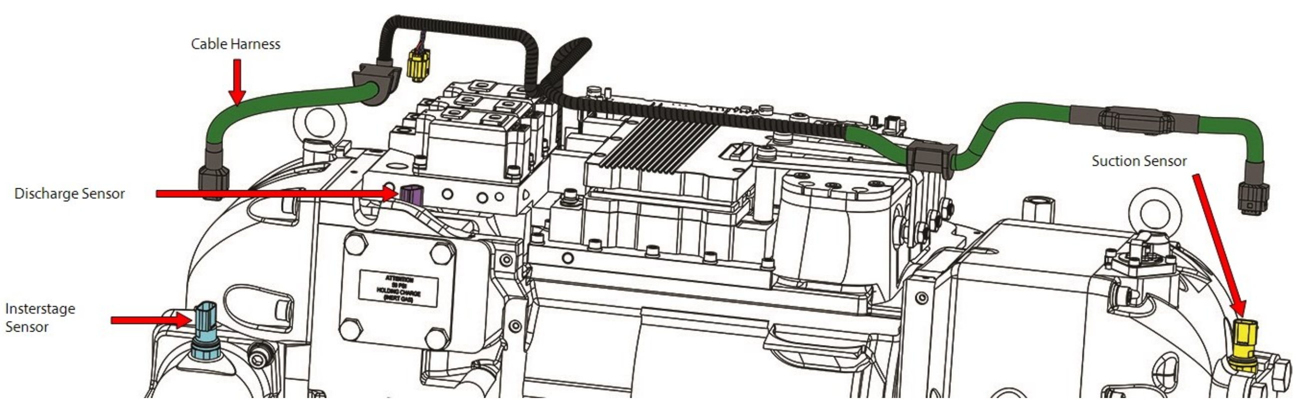
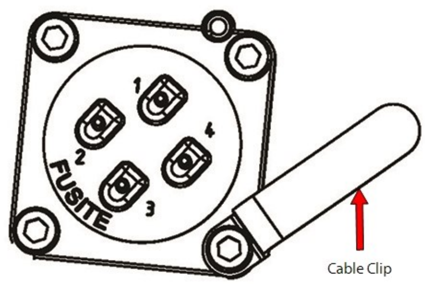


Figure 4-25 Pressure/Temperature Sensor Locations - TTH375/TGH285



8. Disconnect the SCR Manifold Sensor connector.
9. Loosen the M5x16 fastener securing the IGV Connector Clamp and rotate the clamp out of the way. Refer to Figure 4-26 IGV Connector Clamp.
10. Remove the harness connector from the IGV Feedthrough.

Figure 4-26 IGV Connector Clamp

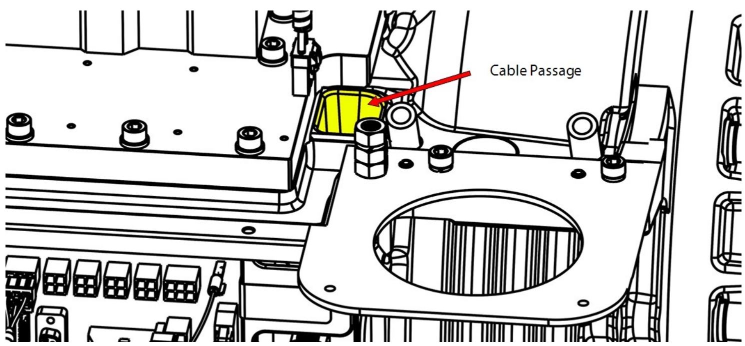


11. Remove the cable harness in stages so the same routing can be followed for the installation.

Compressor Controller Cable Harness Installation

1. Route the cable harness through the hole in the main compressor housing at the service side. Refer to Figure 4-27 Cable Passage.

Figure 4-27 Cable Passage



2. Route the cable harness between the DC-DC Converter and the Inverter. Lay the harness over the Inverter Plate.
3. Bend the cable harness under the Mains Terminal Block and route it toward the capacitor side of the compressor.
4. Install the harness onto the IGV Feedthrough.
5. Rotate the clamp over the IGV connector and torque the M5x16 fastener to 25 Nm (18 ft.lb.) Refer to Figure 4-26 IGV Connector Clamp.
6. Connect the SCR Manifold Sensor connector (if required). Refer to Figure 4-23 Pressure/Temperature and SCR Temperature Sensor Locations - TTS300/TGS230 on page 69 andFigure 4-25 Pressure/Temperature Sensor Locations - TTH375/TGH285 on page 69 for this and the following step.
7. Connect the cables to the suction and discharge pressure sensors.
8. Insert the molded rubber grommet in the notch in the main compressor housing.
9. Install the four (4) Backplane connectors (J17, J18, J19, and J21).
   - Pressure/temperature sensor connectors (J17, J18, and J19)
   - IGV motor drive connector (J21)

10. Install the DC Capacitor Bus Bar Assembly. Refer to Section 4.21.3 DC Capacitor Bus Bar Assembly Removal and Installation on page 168.
11. Install the Mains Terminal Block (if required).
12. Install the compressor covers. Refer to Section 4.1 Compressor Covers on page 52.
13. Return the compressor back to normal operation.

4.5.3 Compressor Controller Cable Harness Torque Specifications

Table 4-9 Compressor Controller Cable Harness Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
IGV Feedthrough Fastener, M5x16	25	18	221
Cover Fastener, M5x15	1.5	-	13
Cover Fastener, M5x20	1.5	-	13

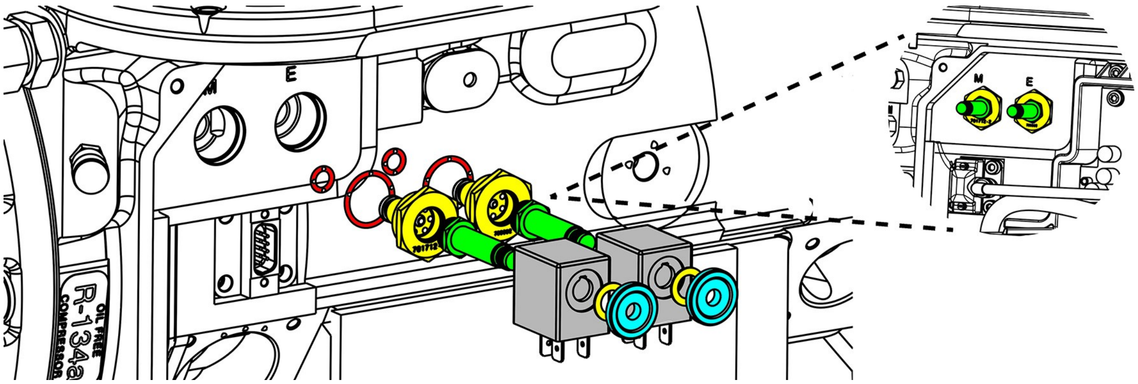
4.6 Solenoids and Coils

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

4.6.1 Solenoid and Coil Connections

Solenoids are secured to the service side of the compressor housing in the upper left. Refer to Figure 4-28 Cooling Valve Bodies.

Figure 4-28 Cooling Valve Bodies

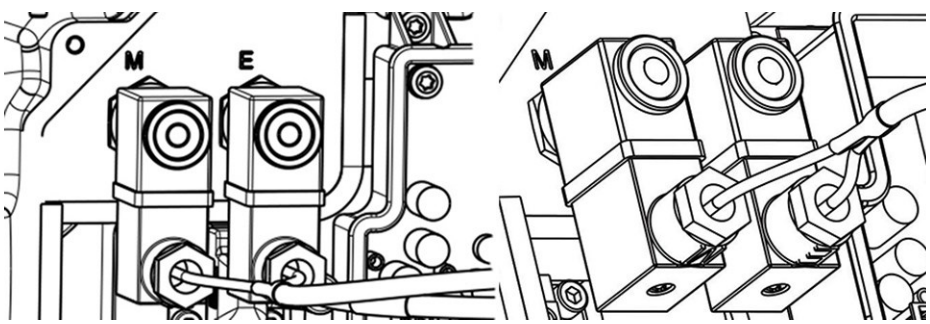


Solenoid orifice size will vary between compressor models. The size can be identified by reading the number engraved into the solenoid orifice body. For solenoid identification by model, reference the Spare Parts Selection Guide.

Solenoid actuator coils are secured to the solenoids by nuts tightened at the back of each actuator. Refer to Figure 4-29 Compressor Cooling Solenoid Coils.

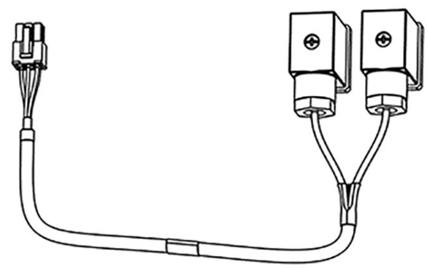
24VDC Power is supplied to the Coils through the Backplane from the Serial Driver and controlled by signals from the BMCC to the Serial Driver. The cable is connected to J16 on the Backplane. Refer to Figure 4-31 Backplane - J16 Connector on page 73.

Figure 4-29 Compressor Cooling Solenoid Coils



4.6.2 Solenoid Coil Harness

Figure 4-30 Solenoid Coil Harness



4.6.2.1 Solenoid Coil Harness Removal and Installation

For details, refer to Section 4.6.4 Solenoid and Coil Removal and Installation on page 75.

4.6.3 Solenoid Verification

> **• • • 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.

4.6.3.1 Resistance Measurement of Cooling Solenoid Coils

1. Isolate compressor power.
2. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
3. Disconnect the Compressor-Cooling Solenoid Coil Connector (J16) from the Backplane.
4. Set the multimeter for resistance measurement. Refer to Table 4-10 Solenoid Coil Resistance Ranges on page 74 to find the expected resistance for the left and right Compressor-Cooling Coils.
5. To measure the resistance across the left Compressor-Cooling Solenoid Coil, place the meter probes at Pins 1 and 3 of the cable connector. Refer to Figure 4-32 Compressor Cooling Solenoid Coil Cable Connector on page 74.
6. To measure the resistance across the right Compressor-Cooling Coil, place the meter probes at Pins 5 and 6 of the cable connector. Refer to Figure 4-32 Compressor Cooling Solenoid Coil Cable Connector on page 74.

Figure 4-31 Backplane - J16 Connector

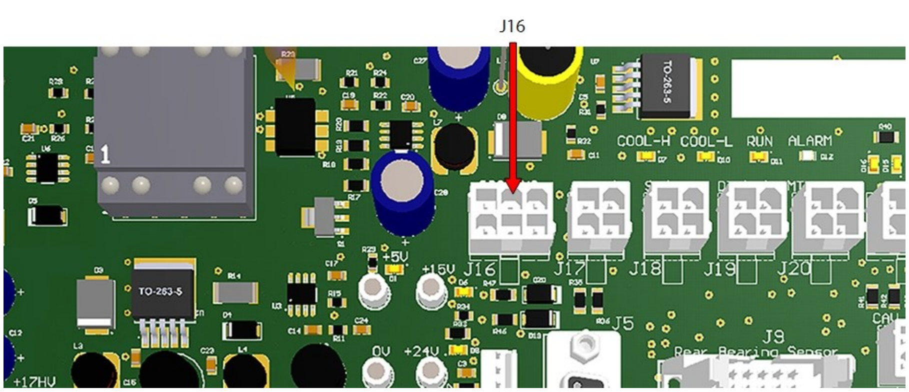
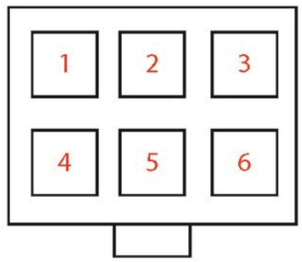


Table 4-10 Solenoid Coil Resistance Ranges

Voltage	Power	Resistance
24V	9.3W	56.25Ω – 68.75Ω

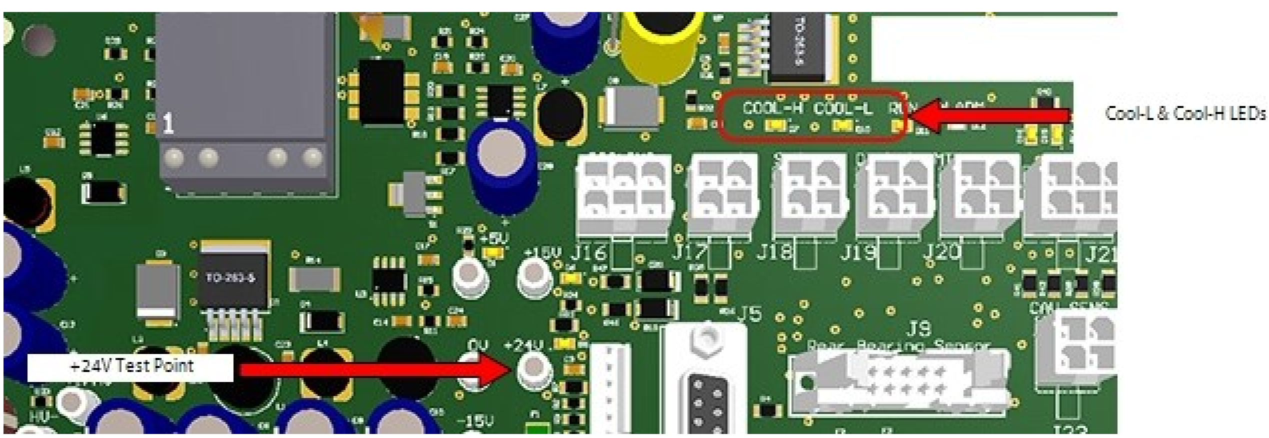
Figure 4-32 Compressor Cooling Solenoid Coil Cable Connector



4.6.3.2 Output Voltage to Solenoid Coils

1. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
2. The compressor must be running and make a call to enable the cooling solenoid coils for the LEDs to turn on. The SMT Cooling Mode will indicate "inverter," "motor," or "motor and inverter" when the software is sending the signal to the coils.
3. To ensure the Serial Driver is providing power to the solenoids, look for the Cool-L and Cool-H LEDs on the Backplane. Refer to Figure 4-33 Backplane - Cool LEDs and +24V Test Points.
4. To determine if 24VDC is present at one or both solenoid coils, use a multimeter to test the back sides of pins 1 & 3 and pins 5 & 6 of the cooling solenoid coils WHILE they are energized. Refer to Figure 4-32 Compressor Cooling Solenoid Coil Cable Connector.

Figure 4-33 Backplane - Cool LEDs and +24V Test Points

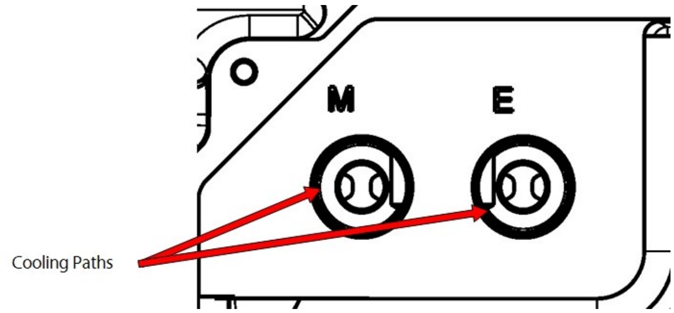


4.6.3.3 Cooling Path Blockage Inspection

1. Isolate compressor power.
2. Isolate the compressor and recover the refrigerant according to industry standards. Refer to Section 3.1 Refrigerant Containment on page 41.
3. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
4. Remove the actuators, solenoids, and orifices.

5. Remove the Liquid Line connection from the compressor and inspect the strainer.
6. Ensure that the cooling paths are clean, as shown in Figure 4-34 Solenoid Cooling Path - TTS300/TGS230.

Figure 4-34 Solenoid Cooling Path - TTS300/TGS230



4.6.4 Solenoid and Coil Removal and Installation

NOTE
On certain compressor 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. Refer to Figure 4-29 Compressor Cooling Solenoid Coils on page 72.

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

4.6.4.1 Solenoid and Coil Removal

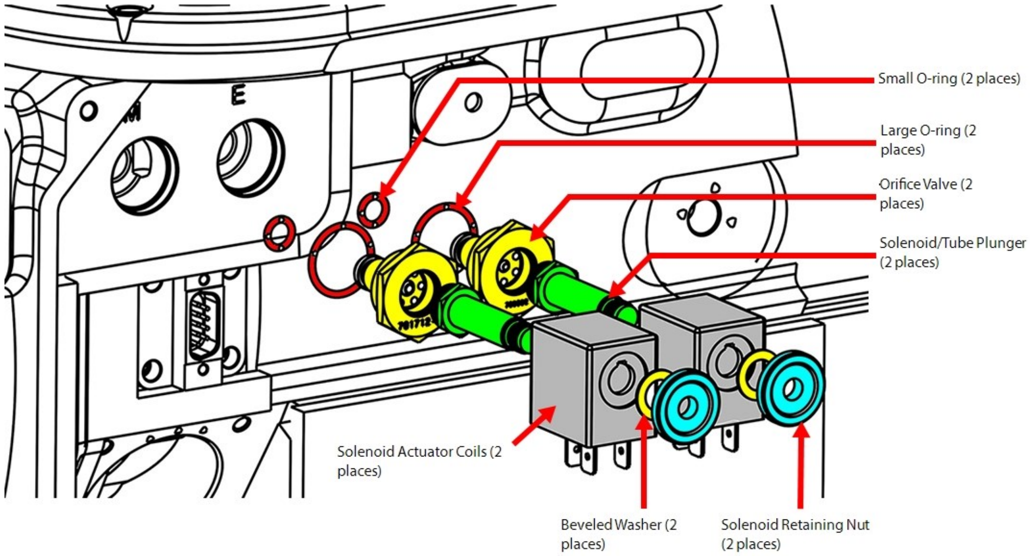
1. Isolate compressor power.
2. Isolate the compressor and recover the refrigerant according to industry standards. Refer to Section 3.1 Refrigerant Containment on page 41.

NOTE
There is no need to recover the refrigerant if only the solenoid coils are being removed.

3. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
4. Disconnect the Solenoid Coil J16 connector from the Backplane. Refer to Figure 4-31 Backplane - J16 Connector on page 73.
5. Remove the solenoid retaining nuts and the beveled washers.
6. Note and mark the position of each coil (left and right) as they need to be installed in the same orientation once the repair has been completed.
7. Remove the Solenoid Coils. Refer to Figure 4-35 Solenoid Component Removal on page 76 for this and the following four (4) steps.
8. Before removing either cooling valve assembly from the compressor body, identify which cooling valve assembly goes to the left and to the right passage as there may be different orifice sizes. You can use the engraving on each orifice body to determine which goes left and right. You should also verify that the new cooling valve assemblies are the same as the ones being removed.
9. Remove the Solenoid/Tube Plungers using a six-point 13mm deep socket.

10. Remove the Orifice Cooling Valves from the compressor housing using a 15/16" socket.
11. Discard the old O-rings.

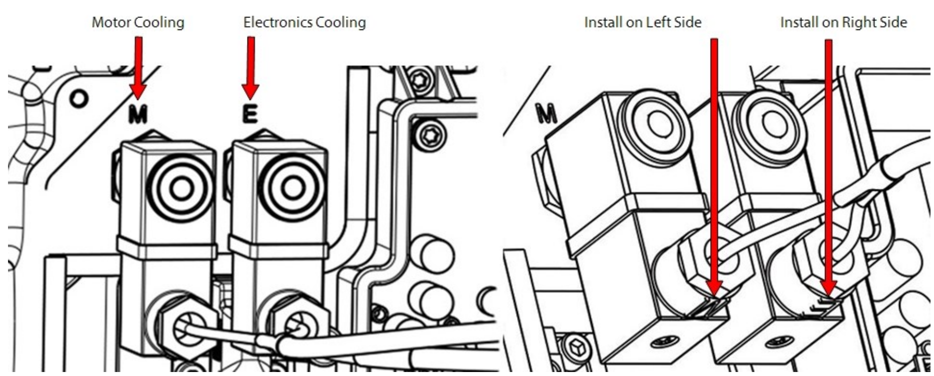
Figure 4-35 Solenoid Component Removal



4.6.4.2 Solenoid and Actuator Installation

1. Ensure that all components and threads are clear, clean, and oil free.
2. Lubricate the small and large new O-rings with O-ring lubricant and install them on the Cooling Valve Assemblies.
3. Install the new Orifice Bodies into the correct cooling passage based on the information obtained in the removal instructions.
4. Tighten the Orifice Bodies with a 15/16" socket and torque to 7 Nm (62 in.lb.).
5. Apply O-ring lubricant to the o-rings on the plunger assemblies.
6. Check that the plunger moves freely by exercising action of spring by hand ~10 cycles.
7. Insert the Plunger Assemblies into the Orifice Bodies and engage the first few threads by hand.
8. Tighten the Plunger Assemblies using a six-point 13mm deep socket and torque to 4 Nm (35 in.lb.).
9. Leak test and evacuate compressor in accordance with standard industry practices.
10. Install the solenoid coils onto the plunger assemblies in the correct orientation as previously noted in the Removal instructions. Refer to Figure 4-36 Solenoid Actuator Coil Position.

Figure 4-36 Solenoid Actuator Coil Position



11. Install the beveled washers and solenoid retaining nuts to secure the Solenoid Actuator Coils.

• • • CAUTION • • •

Only hand tighten the solenoid retaining nuts. Do not over-tighten or use pliers to install.

12. Reconnect the Solenoid Coils to J16 on the Backplane.
13. Install the Service Side Cover. Refer to Section 4.1 Compressor Covers on page 52.
14. Return the compressor to normal operation.

4.6.4.3 Solenoid Torque Specifications

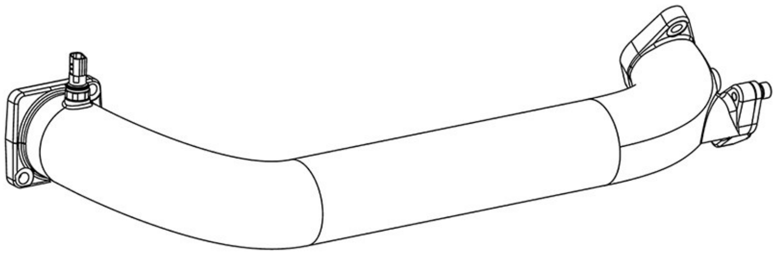
Table 4-11 Solenoid Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
Solenoid Tube/Plunger	4	-	35
Orifice Valve	7	-	62
Cover Fastener, M515	1.5	-	13

4.7 Interstage Pipe - TTH/TGH

The Interstage Pipe connects the first-stage impeller output to the second-stage impeller input of the High Lift compressor. It is also the connection point for the economizer port.

Figure 4-37 Interstage Pipe

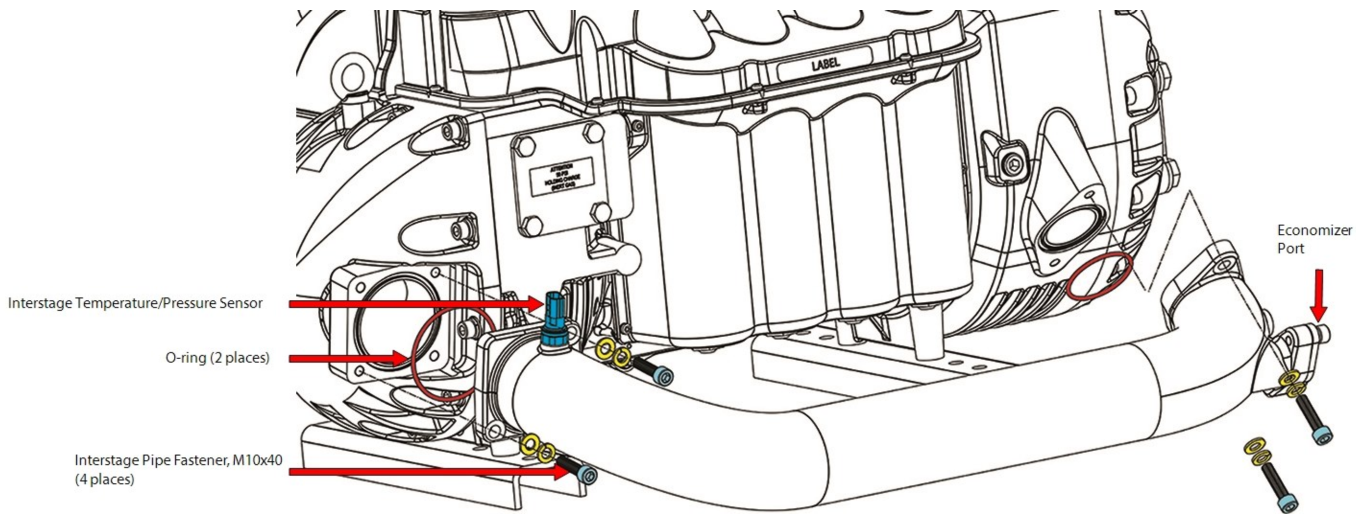


4.7.1 Interstage Pipe Removal and Installation

4.7.1.1 Interstage Pipe Removal

1. Isolate compressor power.
2. Isolate the compressor and recover the refrigerant according to industry standards. Refer to Section 3.1 Refrigerant Containment on page 41.
3. Disconnect the Interstage Pressure/Temperature (P/T) Sensor harness. Refer to Figure 4-38 Interstage Pipe Removal for this and the following steps.
4. Disconnect the pipe connected to the Economizer port.
5. Remove the four (4) M10x40 fasteners (2 per side) and remove the Interstage Pipe.
6. Remove the O-rings from the flanges.

Figure 4-38 Interstage Pipe Removal



4.7.1.2 Interstage Pipe Installation

1. Clean all mating surfaces.
2. Obtain two (2) new O-rings for the Interstage Pipe and lubricate them with O-lube.
3. Install the new O-rings into the grooves of the Housing Extension and the Second-Stage Suction Housing. Refer to Figure 4-38 Interstage Pipe Removal for this and the following steps.

4. Carefully line up the Interstage Pipe and insert a fastener into each flange.
5. Install the remaining two (2) fasteners finger tight.
6. Torque all four (4) M10x40 fasteners evenly to 32 Nm (24 ft.lb.).
7. Obtain a new O-ring for the economizer port and lubricate with O-lube.
8. Install the O-ring to the economizer port.
9. Connect the Economizer flange and torque the M10x30 fasteners to 32 Nm (24 ft.lb.).
10. Lubricate the P/T Sensor O-ring and install into the Interstage Pipe. Torque to 10 Nm (7ft.lb.).
11. Connect the Sensor Harness.
12. Leak test and evacuate compressor in accordance with standard industry practices.

NOTE

A magnet may need to be placed on the motor cooling solenoids if evacuation cannot be performed directly to the liquid line.

13. Return the compressor to normal operation.

4.7.2 Interstage Pipe Torque Specifications

Table 4-12 Interstage Pipe Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
Interstage Pipe Fastener, M10x40	32	24	283
Economizer Flange Fastener, M10x30	32	24	283
P/T Sensor	10	7	89

4.8 Compressor Housing End Cap

The Compressor Housing End Cap may be removed if it is damaged or if there is a refrigerant leak between the mating surfaces.

There are no field-serviceable components inside of the Compressor Housing End Cap. After the assembly of the compressor, its function is to prevent refrigerant from escaping. It also contains an eyebolt to allow for installation and removal of the compressor.

Figure 4-39 Compressor Housing End Cap - TTS/TGS

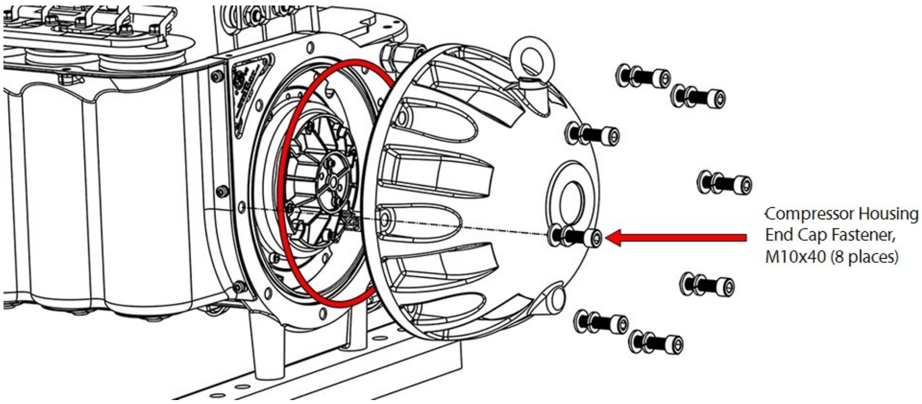
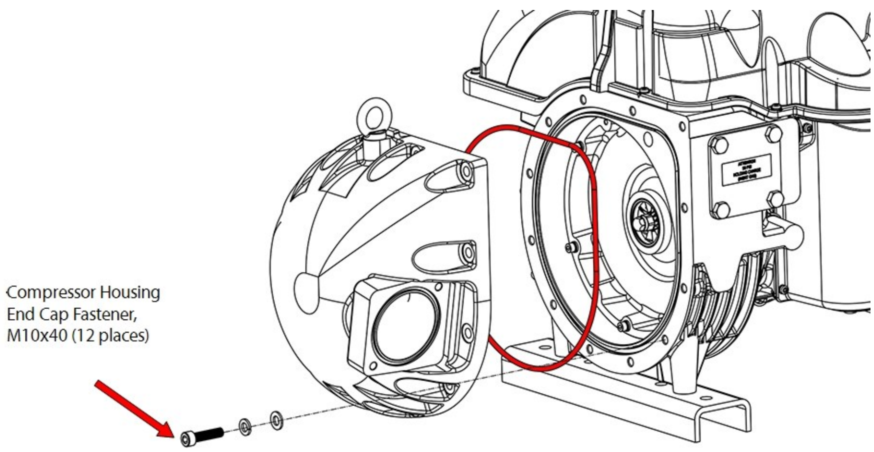


Figure 4-40 Compressor Housing End Cap - TTH/TGH



4.8.1 Compressor Housing End Cap Removal and Installation

4.8.1.1 Compressor Housing End Cap Removal

1. Isolate compressor power.
2. Isolate the compressor and recover the refrigerant according to industry standards. Refer to Section 3.1 Refrigerant Containment on page 41.
3. Remove the Interstage Pipe (TTH/TGH compressors only). Refer to Section 4.7.1.1 Interstage Pipe Removal on page 78.
4. Remove the End Cap.
    a. For TTS/TGS compressors remove the eight (8) M10x40 fasteners that secure the Compressor Housing End Cap to the compressor housing and remove the End Cap. Refer to Figure 4-39 Compressor Housing End Cap - TTS/TGS.

b. For TTH/TGH compressors, remove the 10 M10x40 fasteners that secure the Compressor Housing End Cap to the compressor housing and remove the End Cap. Refer to Figure 4-40 Compressor Housing End Cap - TTH/TGH on page 80.

5. Remove and discard the O-ring.

4.8.1.2 Compressor Housing End Cap Installation

1. Ensure that all components and threads are clear, clean, and oil free.
2. Clean, lubricate, and install the O-ring into the groove in the compressor housing.
3. Carefully line up the Compressor Housing End Cap and loosely install several of the M10x40 fasteners to hold the end cap in place. Refer to Figure 4-39 Compressor Housing End Cap - TTS/TGS on page 80 and Figure 4-40 Compressor Housing End Cap - TTH/TGH on page 80.
4. Install the remaining fasteners and torque fasteners in a crisscross pattern to 32 Nm (24 ft.lb.).
5. Install the Interstage Pipe (TTH/TGH compressors only). Refer toSection 4.7.1.2 Interstage Pipe Installation on page 78.
6. Leak test and evacuate compressor in accordance with standard industry practices.
7. Return the compressor back to normal operation.

4.8.1.3 Compressor Housing End Cap Torque Specifications

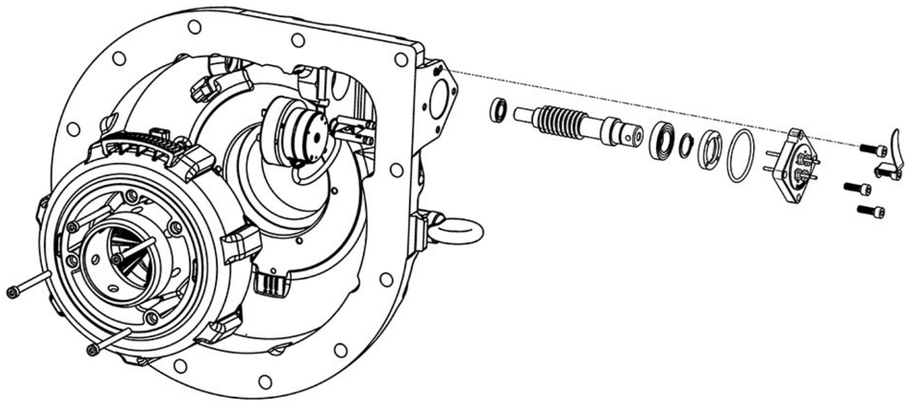
Table 4-13 Compressor Housing End Cap Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
Compressor Housing End Cap Fastener, M10x40	32	24	283
Interstage Pipe Fastener, M10x40	32	24	283
Economizer Flange Fastener, M10x30	32	24	283

4.9 IGV

The IGV assembly consists of movable vanes and a motor. The IGV assembly is a variable-angle guiding device that is used to control capacity at low-load conditions. The IGV position can vary between 0 degrees (closed/perpendicular to flow) and 90 degrees (open/parallel to flow). The vane angle is determined by the BMCC and controlled by the Serial Driver. The Serial Driver uses +15VDC to control the IGV stepper motor.

Figure 4-41 IGV Assembly



4.9.1 IGV Connections

Refer to Figure 4-42 IGV Connections for the location of the IGV connections.

Figure 4-42 IGV Connections

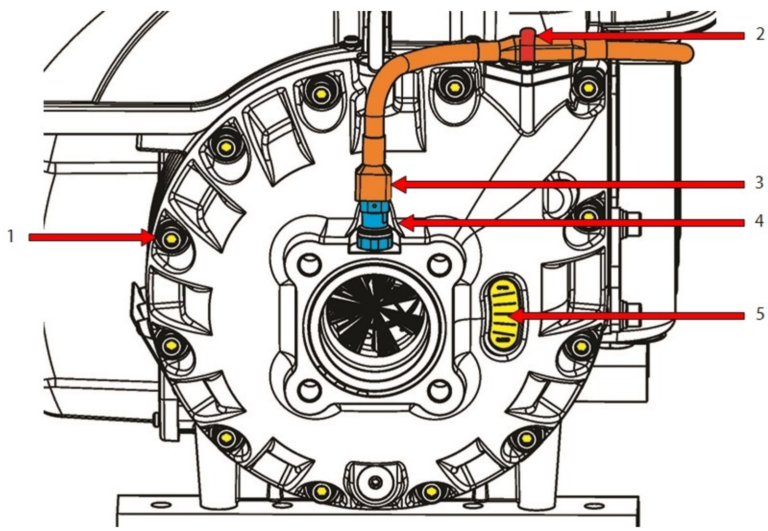


Table 4-14 IGV Components

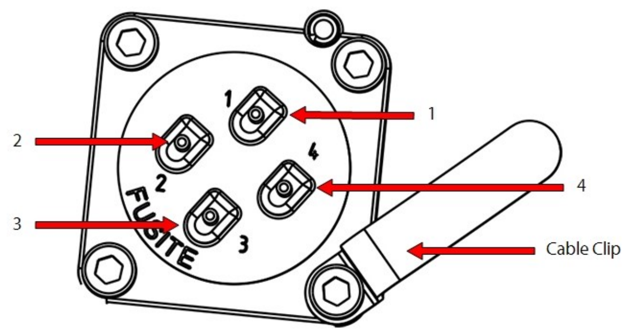
No.	Component
1	The IGV assembly is bolted to the compressor housing.
2	The compressor controller cable is held to the IGV Motor feedthrough by the cable clip.
3	The compressor controller cable continues on to the suction pressure/temperature sensor.
4	The suction pressure/temperature sensor is connected to the IGV Housing.
5	IGV Position Indicator.

4.9.2 IGV Verification

4.9.2.1 IGV Stepper Motor Verification

1. Isolate compressor power.
2. Disconnect the IGV Motor Cable from the suction pressure/temperature sensor and the IGV Motor power feedthrough. Refer to Figure 4-43 IGV Motor Feedthrough for this and the following step.
3. Measure the resistance between terminals 1-2, and 3-4 of the IGV Motor feedthrough. The measured value should be between 46Ω and 59Ω.
4. Measure the resistance between the IGV Motor feedthrough terminals and the IGV Housing. The measured value should be open or infinity.

Figure 4-43 IGV Motor Feedthrough



4.9.2.2 IGV Operation Verification

Some of the steps contained within this section require the use of the SMT. Refer to the Service Monitoring Tool Manual regarding the proper usage of the SMT.

1. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
2. Open the SMT installed on your computer and connect to the compressor. Refer to Figure 4-44 SMT Icon.

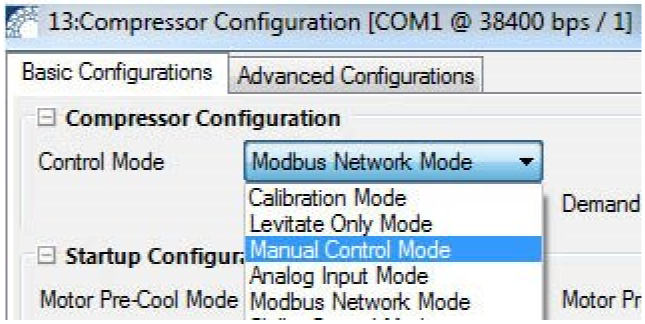
Figure 4-44 SMT Icon

3. Open the **Compressor Configuration** tool. Refer to Figure 4-45 Compressor Configuration Tool.

Figure 4-45 Compressor Configuration Tool

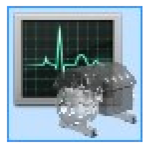
4. Set the Compressor Control Mode to **Manual Control** by selecting **Manual Control** from the Compressor Control Mode drop-down list. Refer to Figure 4-46 Control Mode on page 84.

Figure 4-46 Control Mode



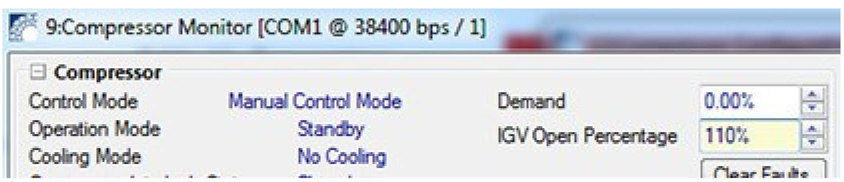
5. Open the **Compressor Monitor** tool. Refer to Figure 4-47 Compressor Monitor Tool.

Figure 4-47 Compressor Monitor Tool



6. In the IGV Open Percentage parameter box, **input 110%(assuming the IGV Open Percentage = 0%) and press "enter" on the keyboard**. Refer to Figure 4-48 IGV Open Percentage - 110%.

Figure 4-48 IGV Open Percentage - 110%



7. On the Backplane, there are four (4) LEDs that should blink when the IGV Motor is being driven. Refer to Figure 4-50 Backplane IGV LEDs on page 85.
   - Check that all four (4) LEDs are blinking (D13, D14, D15, and D16) and that the IGV position indicator ball moves toward open. Refer to Figure 4-42 IGV Connections on page 82 for the location of the IGV Position Indicator.

NOTE

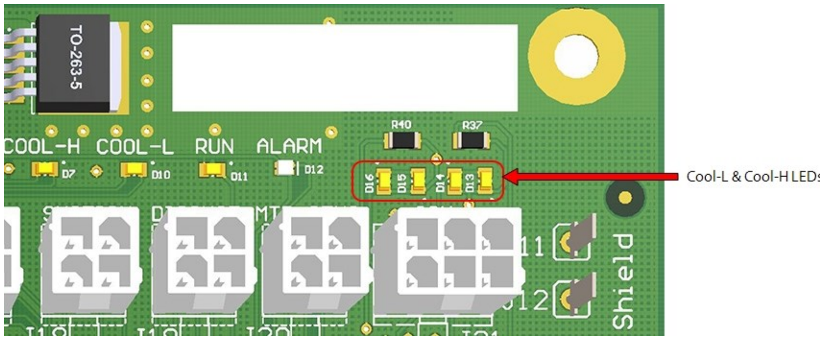
The LEDs will not remain illuminated once the requested position has been achieved..

8. In the IGV Open Percentage parameter box, **input 0%**. Refer to Figure 4-49 IGV Open Percentage - 0%.

Figure 4-49 IGV Open Percentage - 0%

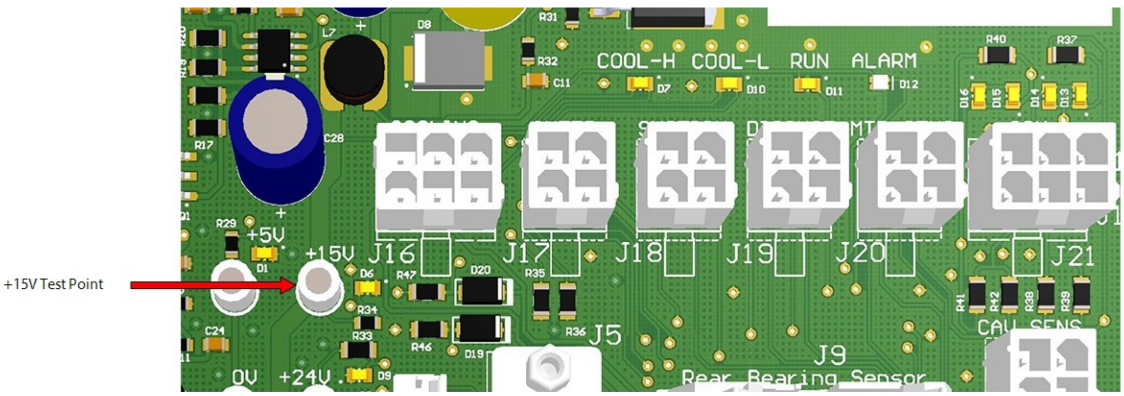
9. Check that all four (4) LEDs are blinking. Refer to Figure 4-50 Backplane IGV LEDs on page 85.

Figure 4-50 Backplane IGV LEDs



10. Verify the IGV position indicator moves toward closed.
11. Measure the +15V test point on the Backplane to verify voltage is supplied to the Serial Driver for the IGV. Refer to Figure 4-51 Backplane +15V Test Point.

Figure 4-51 Backplane +15V Test Point



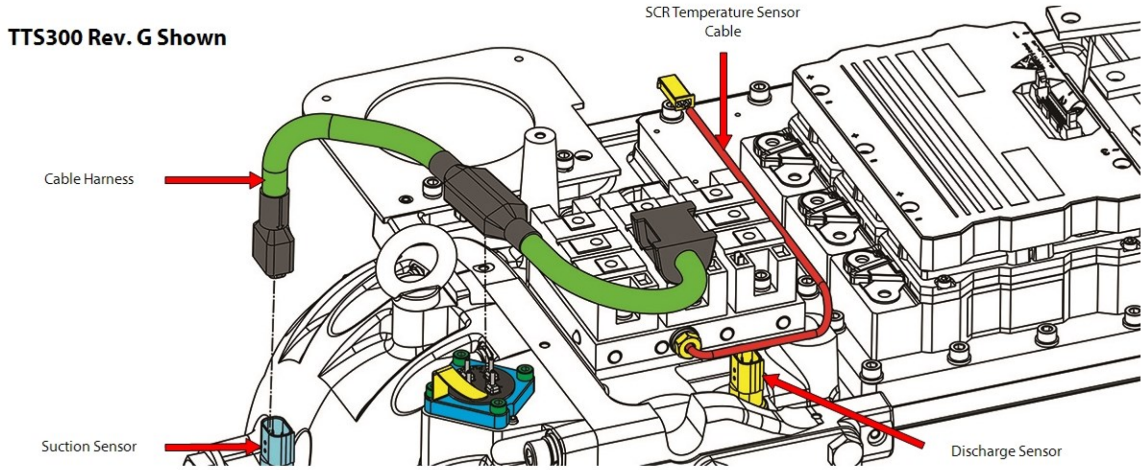
4.9.3 IGV Housing Removal and Installation

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

4.9.3.1 IGV Housing Assembly Removal

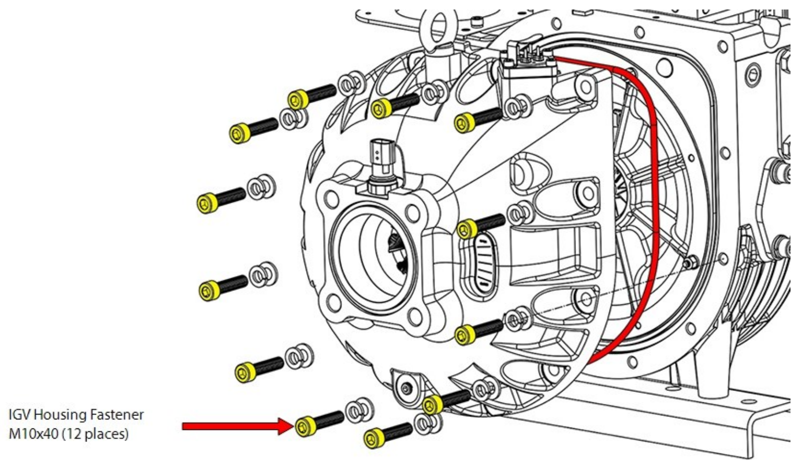
1. Isolate compressor power.
2. Remove the clamp securing the IGV Connector. Refer to Figure 4-52 IGV Harness Removal on page 86. for this and the following step.
3. Disconnect the IGV Motor Cable and Suction Sensor connector.

Figure 4-52 IGV Harness Removal



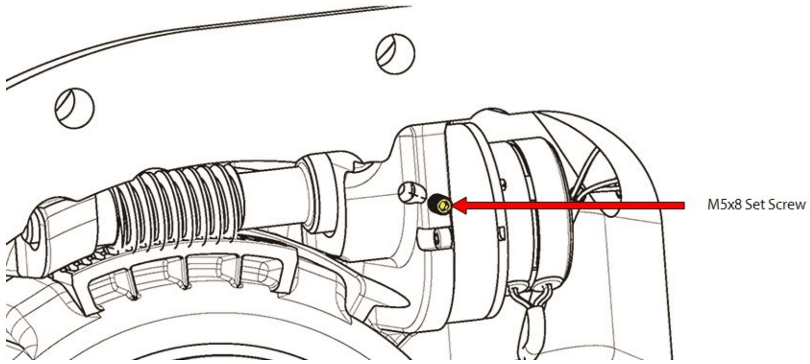
4. Isolate the compressor and recover the refrigerant according to industry standards. Refer to Section 3.1 Refrigerant Containment on page 41.
5. Remove the 12 M10x40 fasteners that secure the IGV Housing Assembly to the compressor housing and pull the housing away from the compressor. Refer to Figure 4-53 IGV Housing Removal.

Figure 4-53 IGV Housing Removal



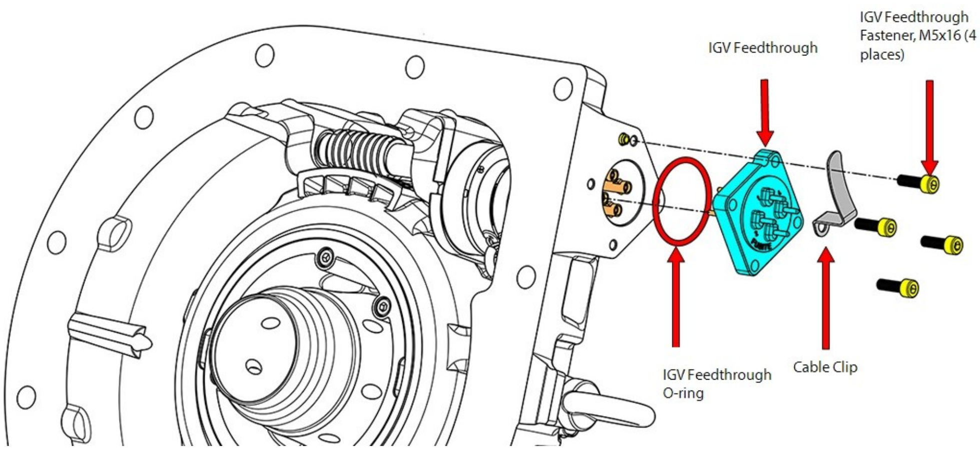
4.9.3.2 IGV Assembly Removal

Figure 4-54 Set Screw Removal



1. Remove the IGV Housing Assembly.
2. Remove the four (4) M5x16 fasteners and separate the four-pin Feedthrough from the IGV Housing. Refer to Figure 4-55 IGV Feedthrough Removal.

Figure 4-55 IGV Feedthrough Removal



3. Disconnect the four (4) wires from the four-pin Feedthrough. Note and record position of wire colors to their corresponding pins. Expected: 1 = Red, 2 = Gray, 3 = Yellow, and 4 = Black. Refer to Table 4-15 IGV Feedthrough Wiring Order on page 92.

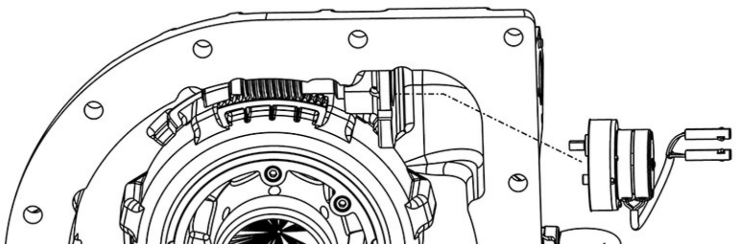
NOTE
The colors associated with each pin could vary, so be sure to identify those on the respective compressor.

4. Remove the IGV Motor assembly by pulling away from worm shaft. Refer to Figure 4-56 IGV Motor Assembly Removal on page 88. Support the bottom of the IGV Motor to prevent damage to the motor shaft. A light tap on the motor locating screw with a tool may help release the motor shaft from the worm gear.
5. If necessary, using a Stepper Motor Driver, turn the worm gear and Vane Drive assembly to position the motor shaft so that locking set screw is aligned with the hole shown in Figure 4-54 Set Screw Removal. Use needle-nose pliers or similar tool to turn the worm gear if a Stepper Motor Driver is not available.
6. Remove the set screw completely using a 2.5 mm hex bit to release the motor from the worm gear.

NOTE

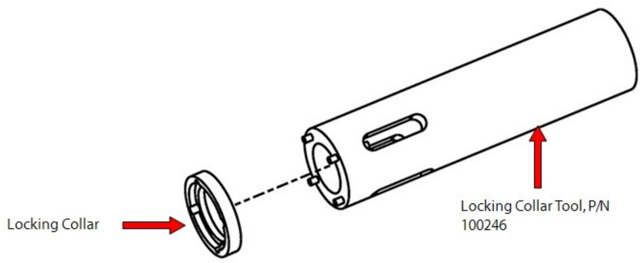
The set screw may be difficult to release as it will have threadlocker applied. For proper engagement into the set screw, do not use a ball-end hex wrench.

Figure 4-56 IGV Motor Assembly Removal



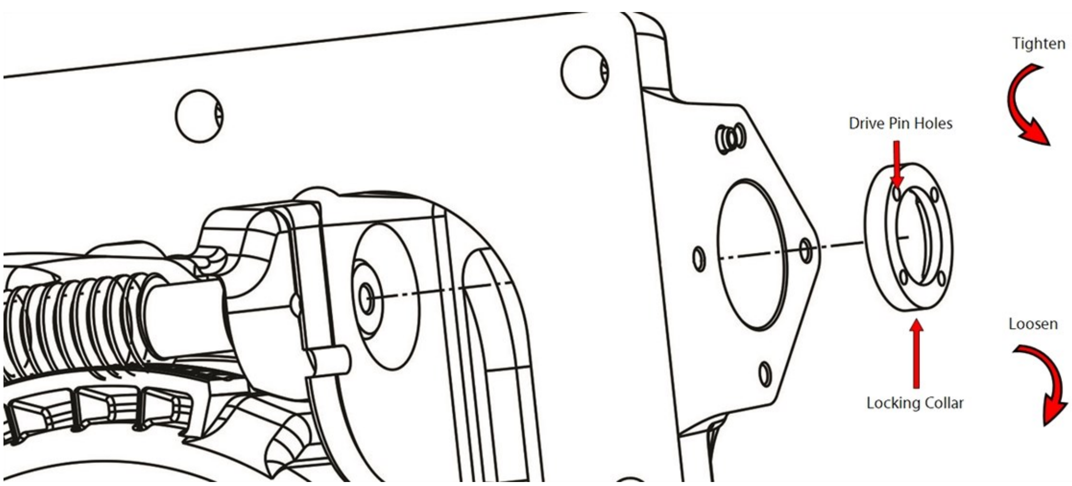
7. Slide the Locking Collar Tool (P/N 100246) into the housing and over the worm shaft. Ensure the drive pins are engaged in the Locking Collar. Refer to Figure 4-57 Locking Collar Tool.

Figure 4-57 Locking Collar Tool



8. Turn the Locking Collar clockwise to remove. Refer to Figure 4-58 Locking Collar .

Figure 4-58 Locking Collar

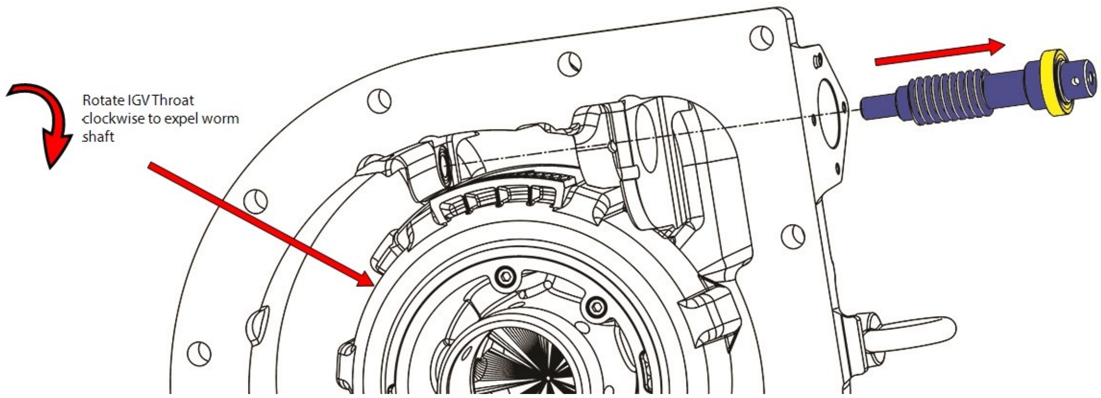


NOTE

The Locking Collar contains a left-hand thread. To remove, turn clockwise when viewing from the motor end.

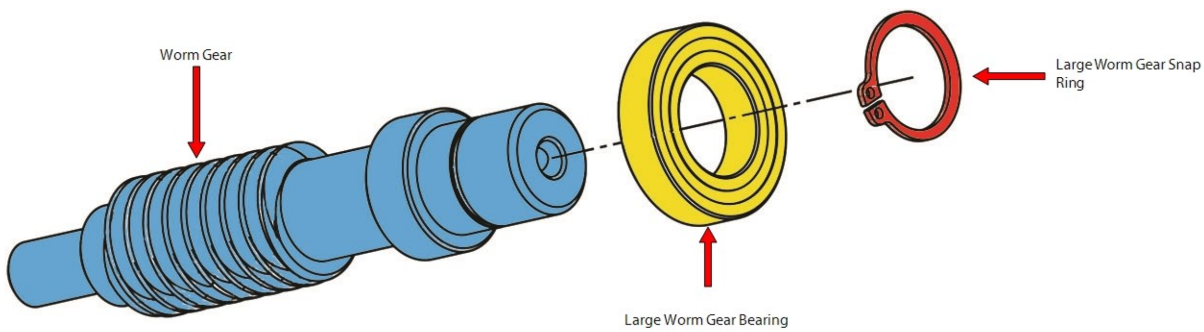
9. Remove the worm gear by rotating the IGV Throat clockwise by hand or rotate the worm shaft by hand. Refer to Figure 4-59 Worm Gear Removal on page 89.

Figure 4-59 Worm Gear Removal



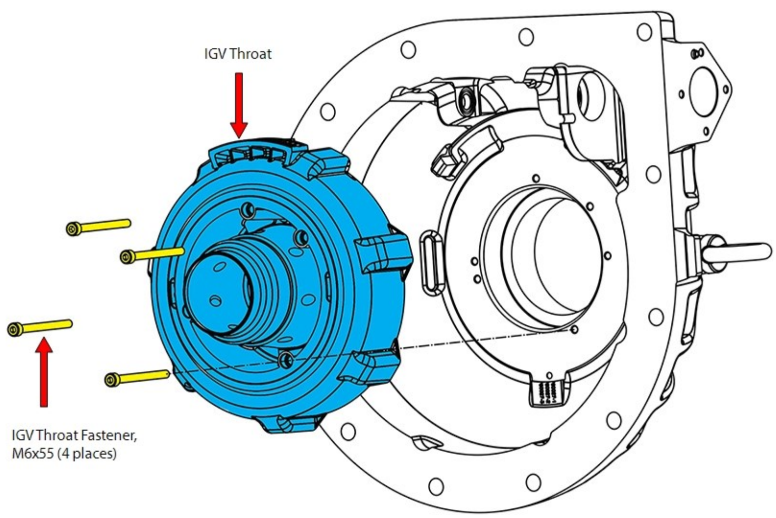
10. Remove the snap ring from the worm gear shaft. Refer to Figure 4-60 Large Worm Gear Bearing for this and the following step.
11. Remove the upper (large) bearing from the worm gear.

Figure 4-60 Large Worm Gear Bearing



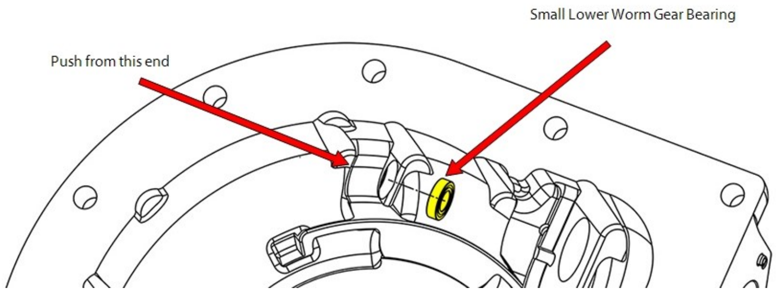
12. Remove the four (4) M6x55 fasteners that retain the IGV Throat assembly and lift the entire assembly from the IGV Housing. Refer to Figure 4-61 IGV Throat Removal.

Figure 4-61 IGV Throat Removal



13. Inspect the IGV Housing assembly for residue/contamination or foreign objects.
14. Remove the small lower worm gear bearing from the housing. Perform this step by pushing the bearing out from the port below the bearing. Refer to Figure 4-62 Small Worm Gear Bearing.

Figure 4-62 Small Worm Gear Bearing

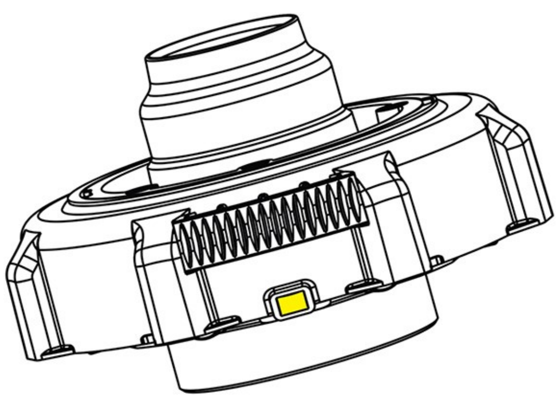


4.9.3.3 IGV Assembly Installation

• • • CAUTION • • •
Fitting incorrect IGV components for the specific compressor model will result in physical damage to the compressor.

1. Ensure that all components and threads are clear, clean, and oil free.
2. Install the lower (small) worm gear bearing into the housing. This may require a very light tap with a hammer. Ensure the lower worm gear bearing is fully seated into the housing. Refer to Figure 4-62 Small Worm Gear Bearing.
3. Ensure the IGV position indicator magnet is in place in the IGV Throat assembly. Refer to Figure 4-63 IGV Position Indicator Magnet.

Figure 4-63 IGV Position Indicator Magnet



4. Place the IGV Throat assembly into the IGV Housing orientating the IGV Throat threads directly below the IGV Motor Mount.
5. Add one (1) drop of threadlocker (Loctite 243 blue or equivalent) to the IGV Throat fastener threads and install. Torque to 5 Nm (44 in.lb.).
6. Rotate the outer ring of the drive assembly and ensure that the guide vanes move freely. The assembly must rotate over a span where the vanes are open (perpendicular to gas flow) and fully closed.
7. Fit the upper (large) bearing to the worm gear and install the snap ring. Refer to Figure 4-60 Large Worm Gear Bearing on page 89.

8. Install the worm gear into the housing by "screwing" the worm gear along the IGV Throat Gear. Locate the worm gear shaft into the bottom (small) bearing.
9. Place the threaded Locking Collar on the four (4) pins of the Collar tool and install into the housing.

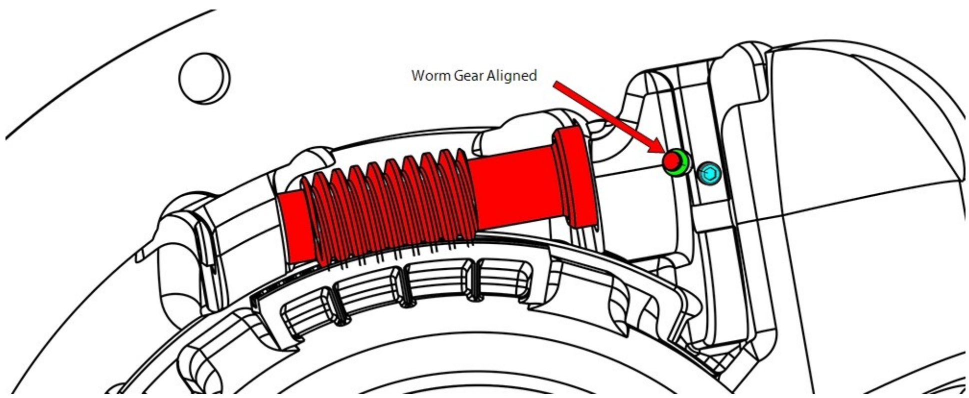
NOTE
Ensure the flat side of the collar is against the tool.

10. Turn the Locking Collar counter clockwise and torque to 5 Nm (44 in.lb.). Refer to Figure 4-58 Locking Collar on page 88.

NOTE
Locking collar is a left-hand thread. Turn counter-clockwise when viewed from motor end to tighten (do not use threadlocker on collar).

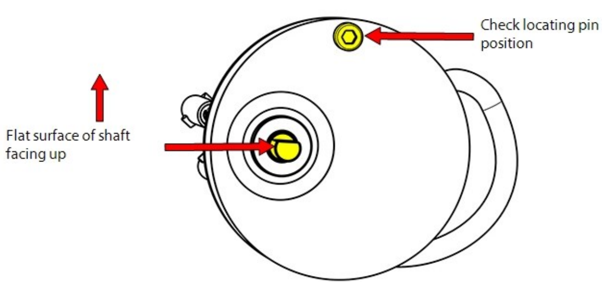
11. Rotate the worm gear by hand until the set screw hole in the worm gear is visible through the access hole in the casting. Verify that the worm gear turns freely. Do not install the set screw at this time. Refer to Figure 4-64 IGV Worm Gear Alignment.

Figure 4-64 IGV Worm Gear Alignment



12. Insert the IGV Motor wires through the Feedthrough hole.
13. Check the position of the flat surface of the shaft relative to the locating pin. The flat surface should be oriented facing up, ready to receive the set screw; adjust if necessary. Refer to Figure 4-65 Shaft Position.

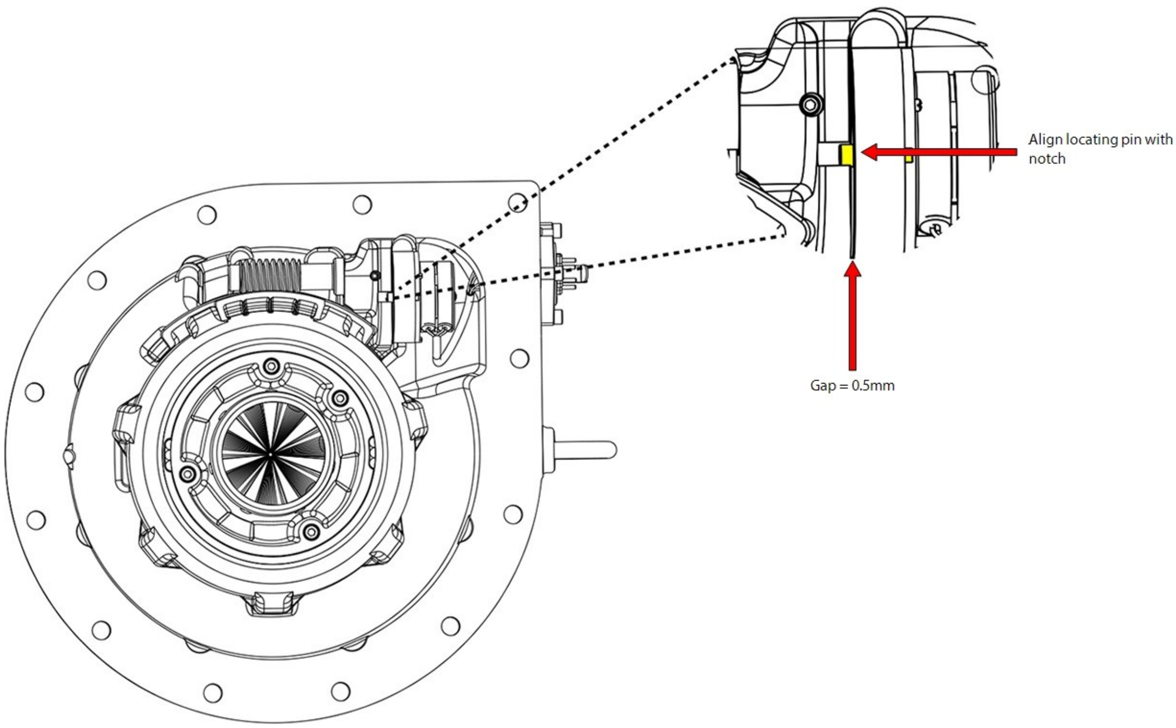
Figure 4-65 Shaft Position



14. Install the motor into the housing and align the motor shaft flat surface with worm gear shaft .
15. Ensure the motor locating pin is aligned with the notch in the housing flange. Refer to Figure 4-66 IGV Motor Alignment on page 92.

• • • CAUTION • • •
Check that wiring is clear of housing and edges of motor.

Figure 4-66 IGV Motor Alignment



16. Put one (1) drop of threadlocker (Loctite 243 blue or equivalent) on the threads of the small set screw. While pushing in, on the backside of the motor, secure the worm gear set screw to the flat surface of the motor shaft using a 2.5 mm hex bit. Rock the motor backwards and forwards while tightening to ensure full and correct engagement of the screw to the flat of the motor shaft. Torque the set screw to 5Nm (44 in.lb.). Refer to Figure 4-64 IGV Worm Gear Alignment on page 91.
17. Clean, lubricate, and install the O-ring on the Feedthrough before connecting the wires.
18. Insert the motor wires onto the Feedthrough pins in accordance with Table 4-15 IGV Feedthrough Wiring Order. Also reference your notes from removal.

NOTE
The colors associated with each pin could vary, so be sure to refer to notes taken during removal.

Table 4-15 IGV Feedthrough Wiring Order

Color	Pin #
Red	1
Gray	2
Yellow	3
Black	4

19. Position the wires as shown inFigure 4-67 Motor Wire Position and Figure 4-68 IGV Motor Wires Connected.

Figure 4-67 Motor Wire Position

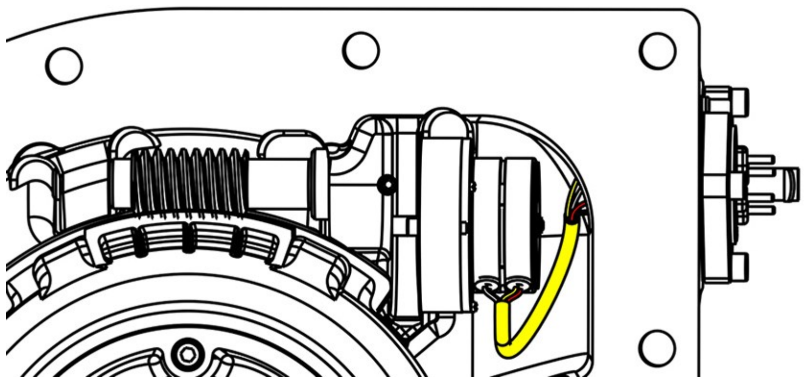
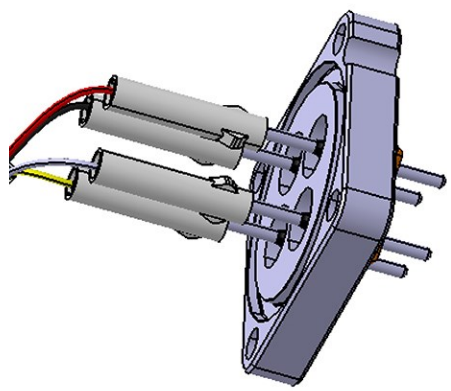
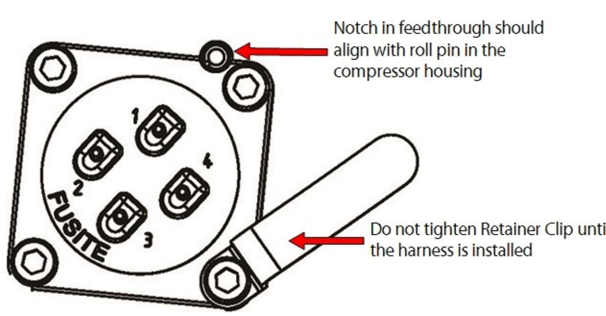


Figure 4-68 IGV Motor Wires Connected



20. Install the Feedthrough using the four (4) M5x16 fasteners and install the IGV Motor Cable Retainer Clip under one of the fasteners. Tighten only three (3) of the fasteners to 5Nm (44 in.lb.) while leaving the fourth fastener with the retainer clip slightly loose. Refer to Figure 4-69 Feedthrough Orientation.

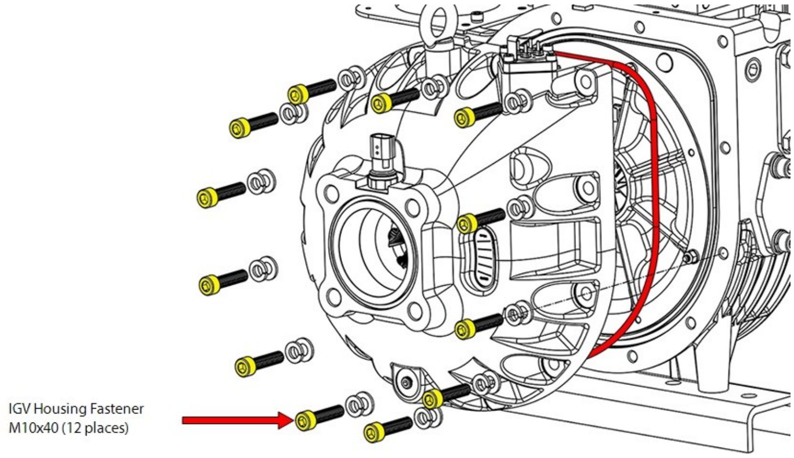
Figure 4-69 Feedthrough Orientation



21. If available, test the motor operation with a stepper motor driver. Operation of the IGV can also be tested using the SMT driving the IGV manually (once the IGV has been mounted on the compressor).
22. Clean the mating surfaces of both the compressor and IGV.
23. Clean, lubricate, and install the IGV Housing O-ring.

24. Re-install the IGV on the compressor and finger-tighten the fasteners.
25. Tighten the fasteners in a crisscross pattern to 22 Nm (16 ft.lb.).

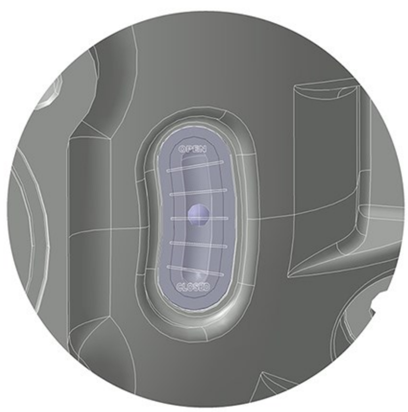
Figure 4-70 IGV Housing Installation



26. Leak test and evacuate compressor in accordance with standard industry practices.
27. Plug in the Feedthrough and Suction Pressure Temperature Sensor Harness.
28. Torque the remaining Feedthrough fastener (the one securing the Motor Harness Retainer Clip) to 5 Nm (44 in.lb.).
29. Return the compressor back to normal operation.
30. Test run the compressor to verify proper operation and movement of the IGV assembly. Refer to Figure 4-71 IGV Position Indicator to verify the position of the IGV.

NOTE
All IGV assemblies are fully open when the Position Indicator Ball is at the OPEN position.

Figure 4-71 IGV Position Indicator



4.9.4 IGV Torque Specifications

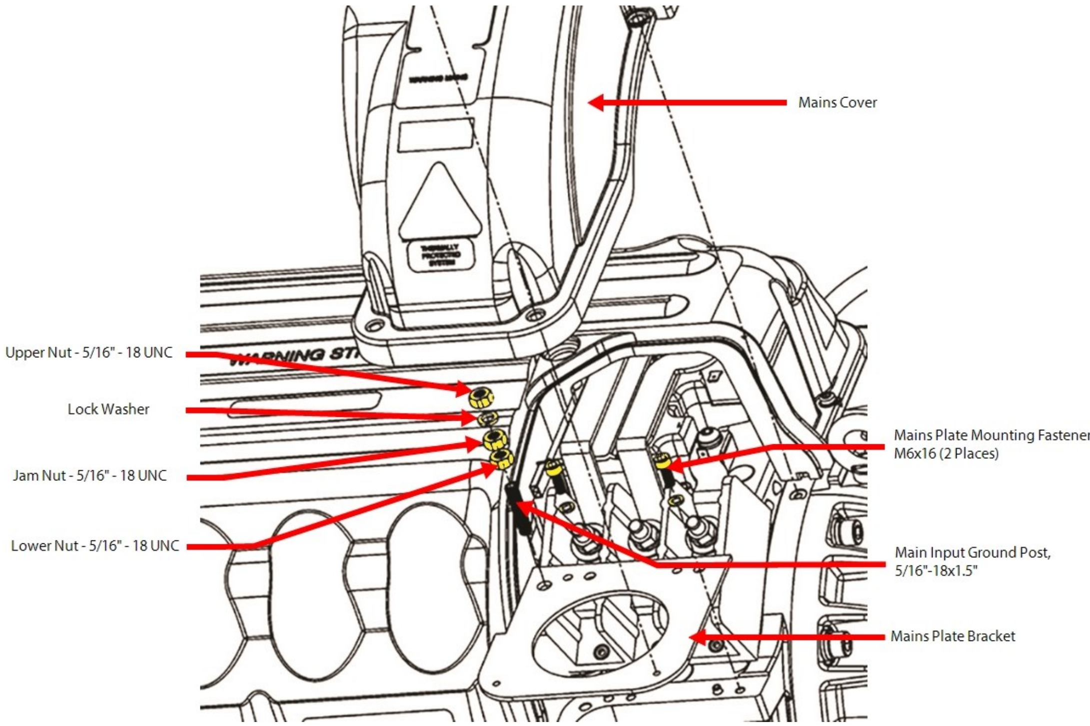
Table 4-16 IGV Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
IGV Housing Fastener, M10x40	22	16	195
IGV Feedthrough Fastener, M5x16	5	-	44
IGV Motor Setscrew, M5x8	5	-	44
IGV Throat Fastener, M6x55	5	-	44
Locking Collar	5	-	44

4.10 Mains Plate Bracket

The Mains Plate is used to secure the mains cable conduit to the compressor. The Mains Plate may have different size openings, but the installation is identical across all models of the compressors. The illustrations in this section are of the TTS350 and all removal and installation steps of the various TTS/TTH/TGS/TGH compressors are the same.

Figure 4-72 Mains Plate Bracket



4.10.1 Mains Plate Bracket Removal and Installation

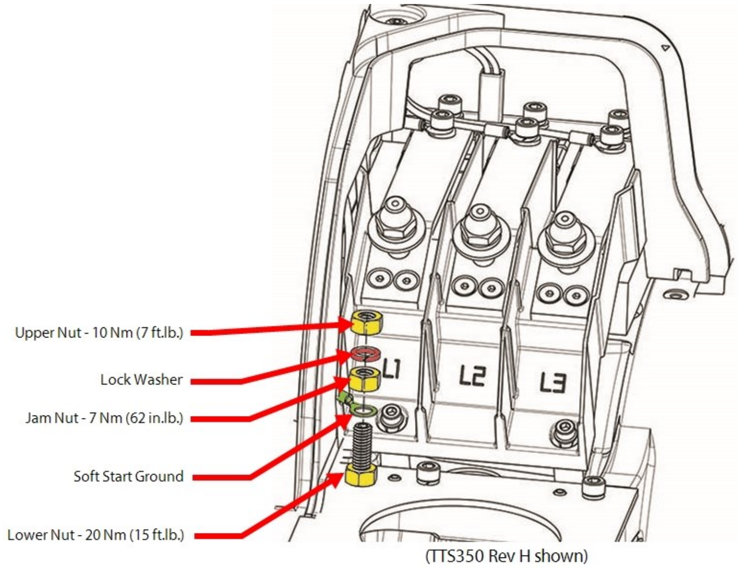
4.10.1.1 Mains Plate Bracket Removal

1. Isolate compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Disconnect the mains input cables from the Terminal Block.
3. Disconnect the main input ground cable and Soft Start ground wire from the ground post.
4. Remove the lower nut from the ground post.
5. Remove the cable gland that secures the mains input cable conduit to the Mains Plate.
6. Remove the two (2) M6x16 fasteners that secure the Mains Plate. Refer to Figure 4-72 Mains Plate Bracket.
7. Remove the Mains Plate.

4.10.1.2 Mains Plate Bracket Installation

1. Install the Mains Plate using the M6x16 fasteners and torque to 7 Nm (62 in.lb.).
2. Install the cable gland.
3. Install the lower nut to the ground post and torque to 20 Nm (15 ft.lb.).
4. Install the Soft Start ground wire on top of the lower nut and torque the jam nut to 7 Nm (62 in.lb).
5. Install the ground cable for the mains on top of the jam nut with the lock washer and torque the upper nut to 10 Nm (7 ft.lb.) Refer to Figure 4-73 Ground Post Nuts on page 97.

Figure 4-73 Ground Post Nuts



6. Install the mains input cables to the Terminal Block and torque to 20 Nm (15 ft.lb.) for TTS300/TGS230 compressors and torque all others to 21 Nm (15 ft.lb.). Refer to Figure 4-74 Mains Input Installation - TTS300/TGS230 Compressors and Figure 4-75 Mains Input Nut Installation - TTS/TGS/TTH/TGH (Except TTS300/TGS230).

Figure 4-74 Mains Input Installation - TTS300/TGS230 Compressors

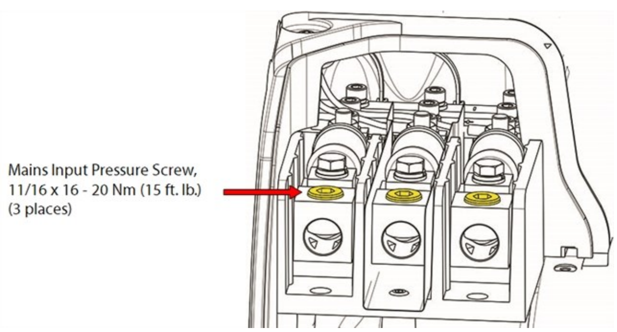
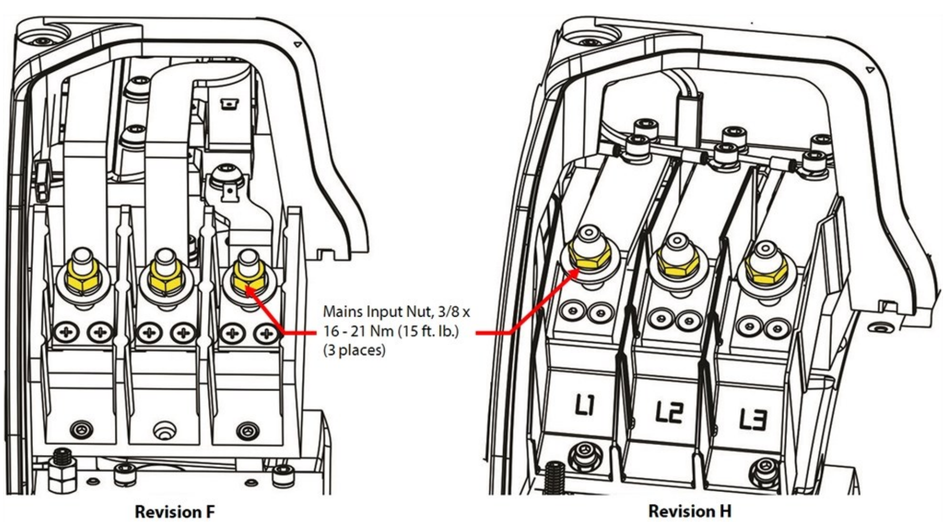


Figure 4-75 Mains Input Nut Installation - TTS/TGS/TTH/TGH (Except TTS300/TGS230)



NOTE

The TTS300/TGS230 series compressors do not utilize cable lugs. Because of this, torque specifications will vary depending on the type of cabling. It is recommended to contact the manufacturer of the cabling used for the appropriate torque specification.

7. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
8. Return the compressor to normal operation.

4.10.1.3 Mains Plate Torque Specifications

Table 4-17 Mains Plate Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
Mains Plate Mounting Screw, M6x16	7	-	62
Cover Fastener, M5x15	1.5	-	13
Upper Nut, 5/16" - 18 UNC	10	7	89
Jam Nut, 5/16" - 18 UNC	7	-	62
Lower Nut, 5/16" - 18 UNC	20	15	177
Mains Input Nut, 3/8" - 16 UNC (excludes TT300/TG230 compressors)	21	15	186
Mains Input Pressure Screw, 11/16" - 16 UNC (TTS300/TGS230 compressors only)	20	15	177

4.11 3-Phase Main Voltage Input Terminal Block

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. The compressor does NOT directly measure 3-phase power values. All 3-phase power 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.

There are three (3) different configurations of the Terminal Blocks:

- For TTS300/TGS230 compressors, Refer to Figure 4-76 Input Terminal Block - TTS300/TGS230
- For all compressors that are Revision F and earlier, Except TTS300/TGS230, refer to Figure 4-78 Input Terminal Block - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230) on page 100
- For all compressors that are Revision H, Except TTS300/TGS230, refer to Figure 4-77 Input Terminal Block - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230) on page 100

Figure 4-76 Input Terminal Block - TTS300/TGS230

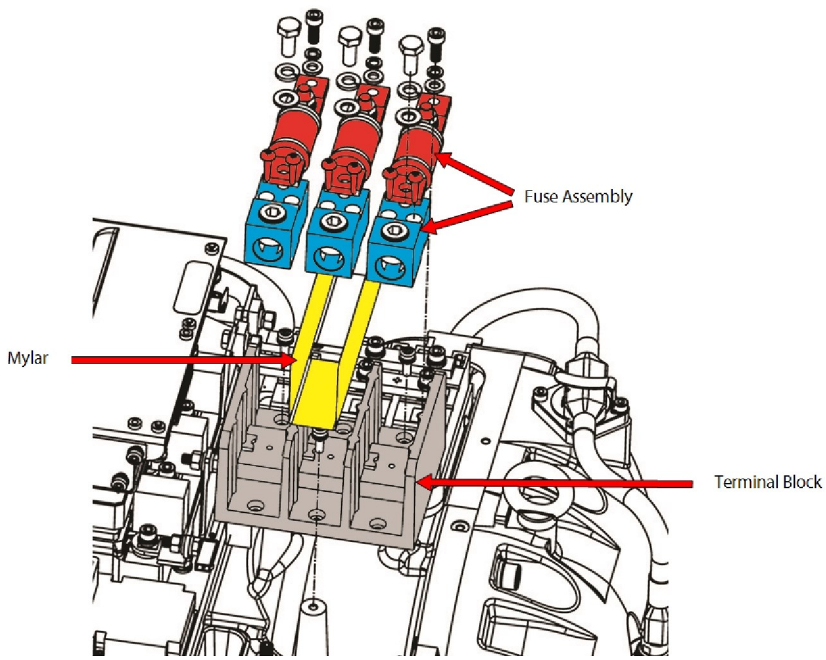


Figure 4-77 Input Terminal Block - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230)

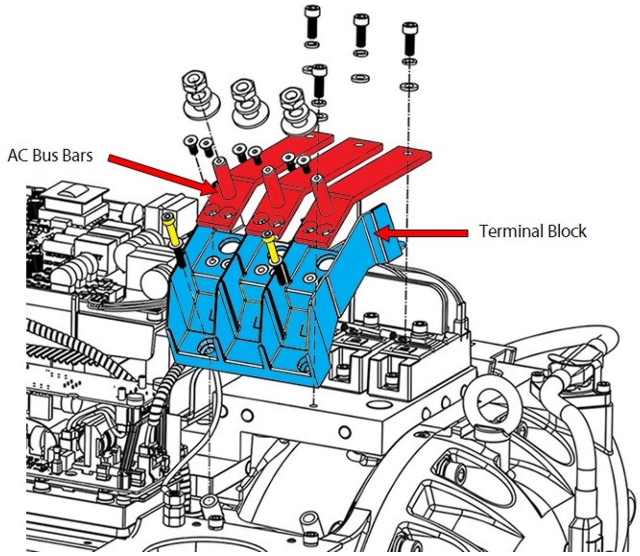
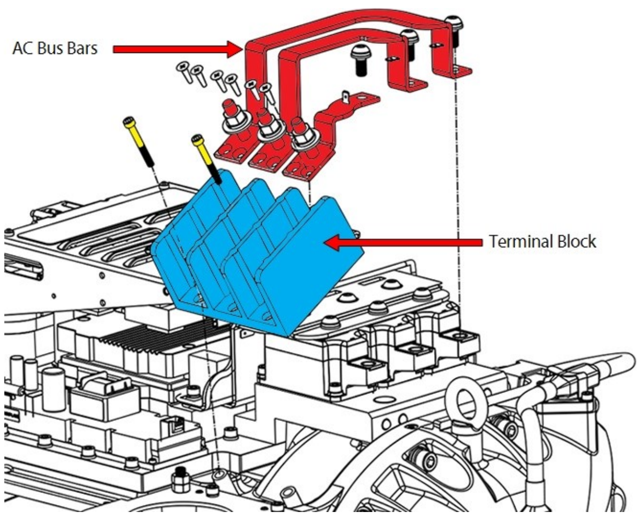


Figure 4-78 Input Terminal Block - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230)



4.11.1 3-Phase Main Voltage Input Terminal Block Verification

4.11.1.1 3-Phase AC input Verification

The compressor requires a 3-phase power source with UL-approved or CE-approved components in the 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.
- Always wear safety glasses when working around components energized by high voltage. Faulty components can explode and cause serious eye injuries.

4.11.1.2 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.

4.11.1.3 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 4-79 Measuring the 3-Phase AC Input Voltage on the AC Input Terminals - TTS300/TGS230 and Figure 4-80 Measuring 3-Phase AC Input Voltage on AC Input Terminals (TTS/TGS/TTH/TGH (Except TTS300/TGS230). Repeat for all AC input terminals. Repeat on load side of the fuses (TT300/TG230 only).

Figure 4-79 Measuring the 3-Phase AC Input Voltage on the AC Input Terminals - TTS300/TGS230

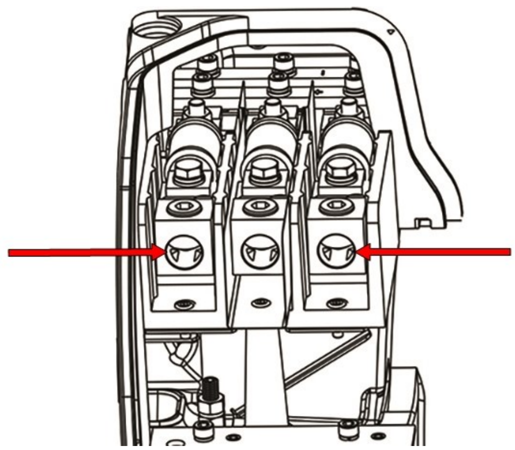
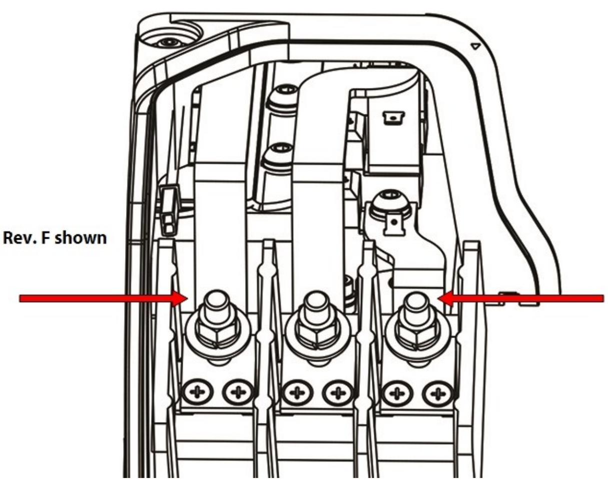


Figure 4-80 Measuring 3-Phase AC Input Voltage on AC Input Terminals (TTS/TGS/TTH/TGH (Except TTS300/TGS230)



4. Verify that the meter shows the expected AC measurement within the range as indicated in Table 4-18 Expected AC Voltage Range on page 102. The acceptable AC input voltage range is +/-10% of the nameplate AC input voltage.
5. If the meter does not show any reading, it is possible 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, 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 okay.

Table 4-18 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

4.11.2 3-Phase Main Voltage Input Terminal Block Removal and Installation

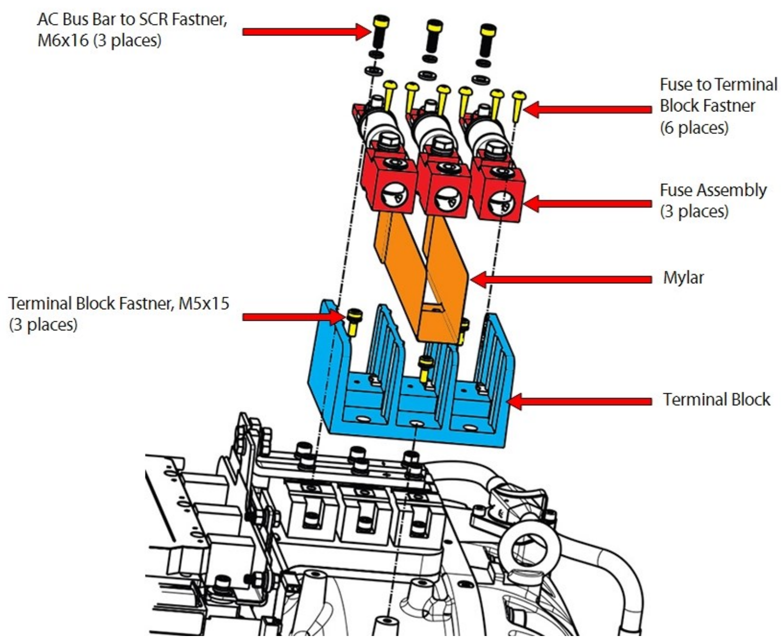
4.11.2.1 General 3-Phase Main Voltage Input Terminal Block Removal

1. Isolate compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Disconnect the mains input cables from the Terminal Block.
3. For TT300/TG230 compressors, continue to Section 4.11.2.2 Specific 3-Phase Main Voltage Input Terminal Block Removal - TTS300/TGS230; for all others, continue to Section 4.11.2.3 3-Phase Main Voltage Input Terminal Block Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230) on page 103.

4.11.2.2 Specific 3-Phase Main Voltage Input Terminal Block Removal - TTS300/TGS230

1. Remove the three (3) M6x16 fasteners that connect the Fast Acting Fuses and Soft Start AC Ring terminals L1, L2, L3, to the SCRs. Refer to Figure 4-81 Terminal Block Removal - TTS300/TGS230 for this and the following four (4) steps.
2. Remove the six (6) Fuse to Terminal Block fasteners that secure the fuses to the Terminal Block Adapter.
3. Remove the fuses.
4. Remove the insulating Mylar.
5. Remove the Terminal Block fasteners that secure the Terminal Block to the compressor housing and remove the Terminal Block.

Figure 4-81 Terminal Block Removal - TTS300/TGS230



6. Continue to Section 4.11.2.4 3-Phase Main Voltage Input Terminal Block Installation - TTS300/TGS230 on page 104.

4.11.2.3 3-Phase Main Voltage Input Terminal Block Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230)

1. Disconnect the three (3) connectors of the Soft Start AC/DC harness from the bus bars.
2. Remove the three (3) fasteners that secure the AC Bus Bars to the SCRs. For Revision F and earlier compressors, refer to Figure 4-82 Input Terminal Block Removal - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230) and for Revision H compressors, refer to Figure 4-83 Input Terminal Block Removal - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230) on page 104 for this and the following three (3) steps.
3. Remove the six (6) fasteners that secure the three (3) AC Bus Bars to the Terminal Block.
4. Remove the AC Bus Bars.

NOTE

If the terminal block is being removed to access other components, it is not necessary to remove the AC Bus Bars from the terminal block on Rev F and earlier compressors - the terminal block and bus bars can be removed as an assembly. On Rev H compressors, the center AC Bus Bar must be removed to access a mounting fastener for the terminal block but the two (2) outer bus bars can remain attached.

5. Remove the fasteners that secure the Terminal Block to the casting and remove the Terminal Block.
   a. Rev F and earlier compressors use two (2) M5x45 fasteners that attach the Terminal Block to the compressor housing.
   b. Rev H compressors use three (3) fasteners; it uses the same two (2) as listed above and there is an additional M6x16 fastener that is located at the back center of the Terminal Block (under the center AC Bus Bar). This fastener secures the Terminal Block to the SCR Cooling Manifold.
6. Remove the two (2) spacers if the Terminal Block is to be replaced with a new one.
7. Continue to Section 4.11.2.5 3-Phase Main Input Terminal Block Installation - TTH/TGH/TTH/TGH (Except TTS300/TGS230) on page 105.

Figure 4-82 Input Terminal Block Removal - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230)

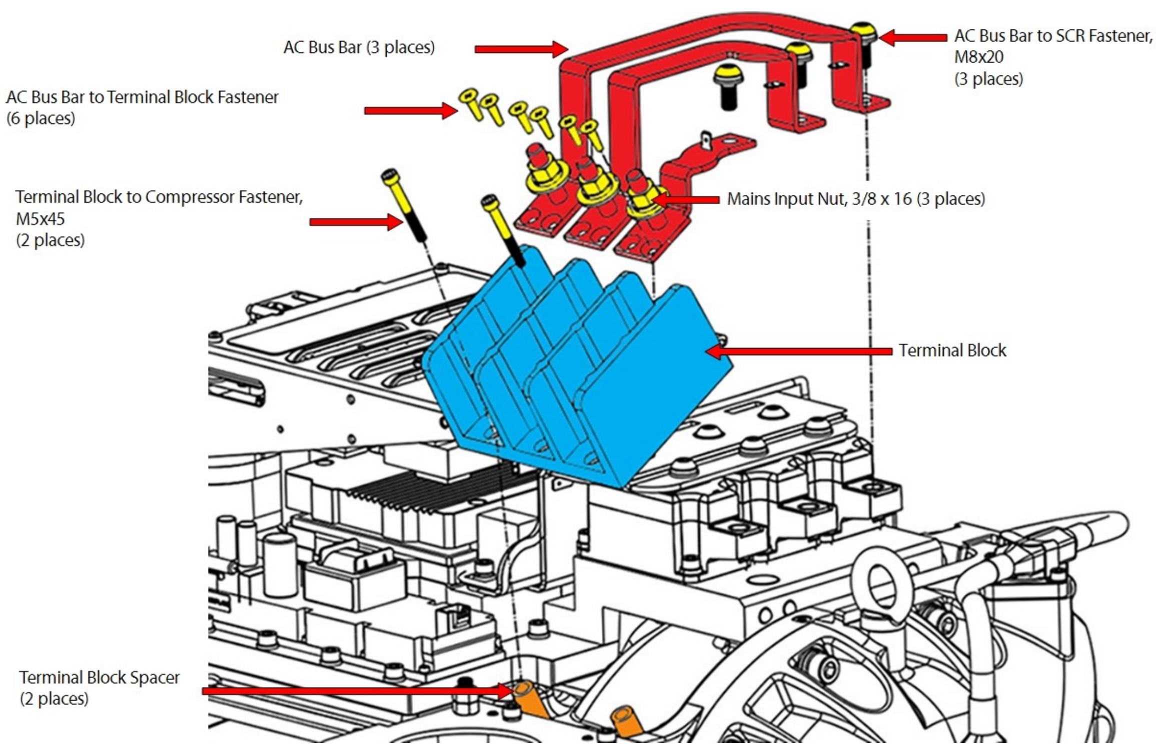
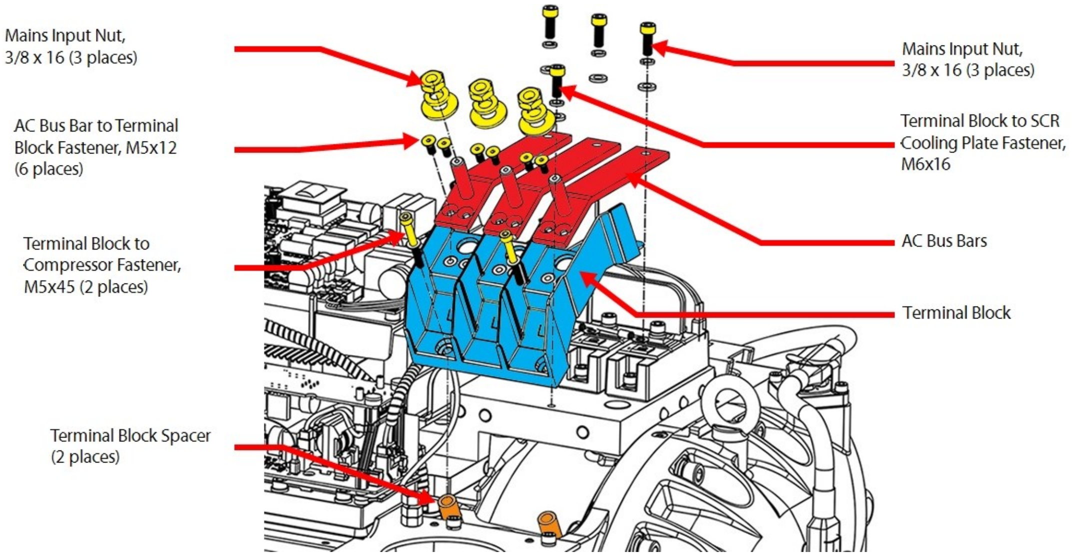


Figure 4-83 Input Terminal Block Removal - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230)



4.11.2.4 3-Phase Main Voltage Input Terminal Block Installation - TTS300/TGS230

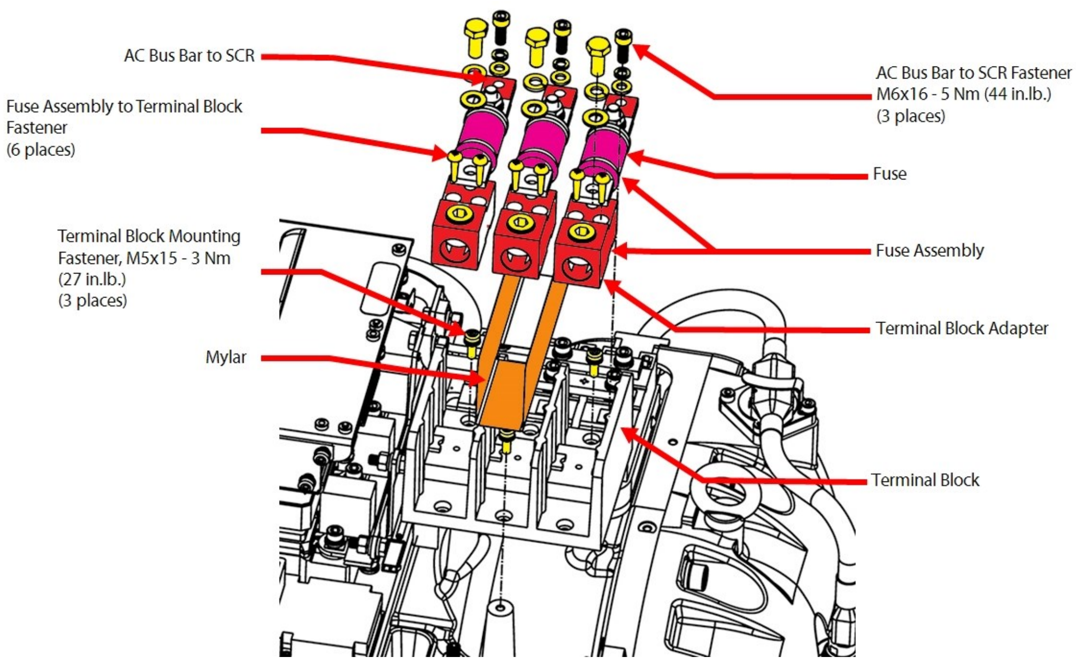
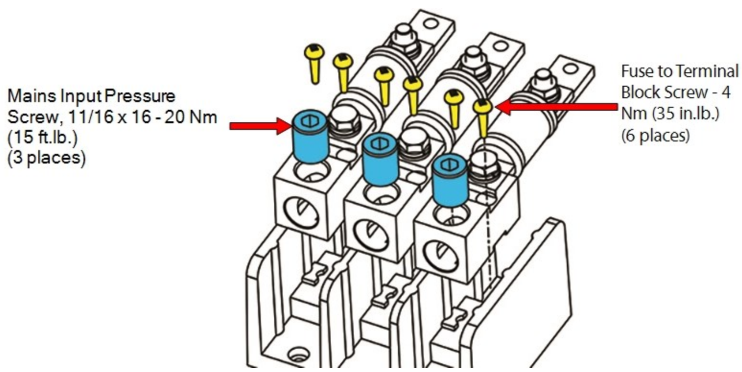


Figure 4-84 Input Terminal Block Installation - TTS300/TGS230

1. Place the Terminal Block on the compressor housing, secure with the M5x15 fasteners, and torque to 3 Nm (27 in.lb.).
2. Place the Mylar insulator in the center section of Terminal Block.
3. Including the Soft Start AC Ring terminals L1, L2, L3, Secure the three (3) Fuse Assemblies (Bus Bar side) to the SCRs using the M6x16 fasteners. Only finger tighten at this point.
4. Install the three (3) Fuse Assemblies to the Terminal Block with the six (6) fasteners and torque to 4 Nm (35 in.lb.).
5. Torque the M6x16 fastener for the Bus Bar side of the three (3) Fuse Assemblies to the SCRs to 4 Nm (35 in.lb.).

6. Install the mains input cables to the Terminal Block and torque to 20 Nm (15 ft.lb.). Refer to Figure 4-85 Terminal Block - Input Pressure Screws - TTS300/TGS230.

Figure 4-85 Terminal Block - Input Pressure Screws - TTS300/TGS230



7. Continue to Section 4.11.2.6 General 3-Phase Main Voltage Input Terminal Block Installation on page 106.

4.11.2.5 3-Phase Main Input Terminal Block Installation - TTH/TGH/TTH/TGH (Except TTS300/TGS230)

Figure 4-86 Input Terminal Block Installation - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230)

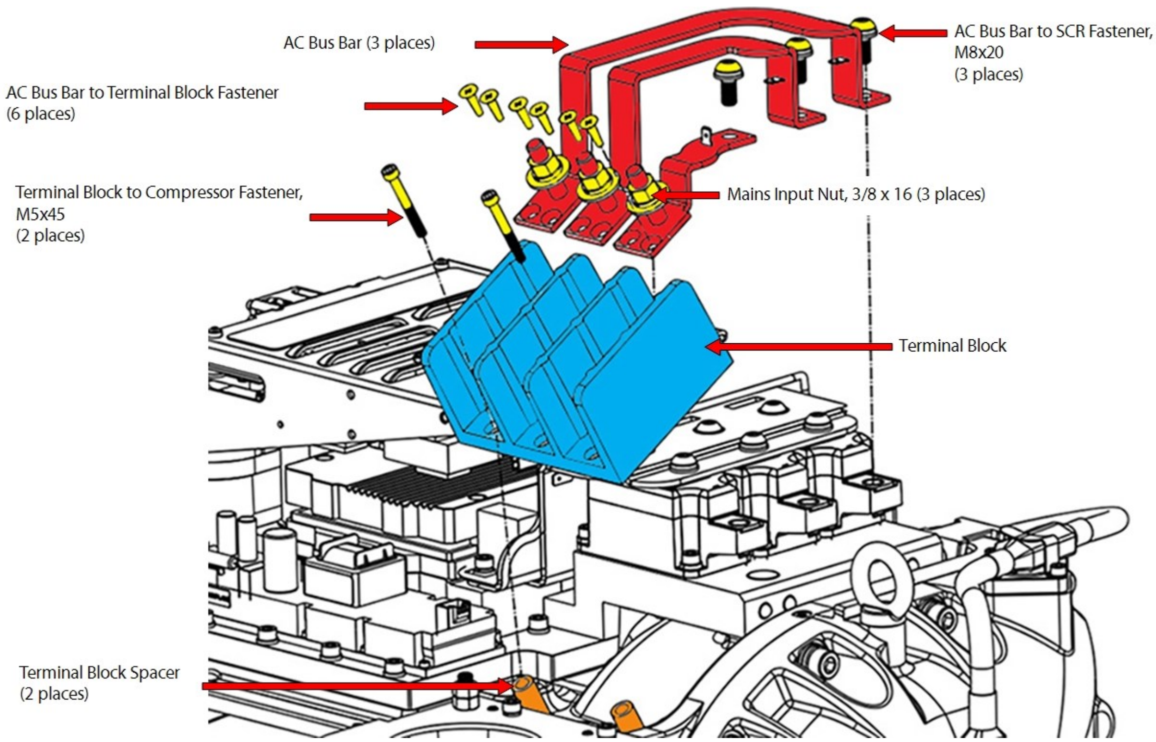
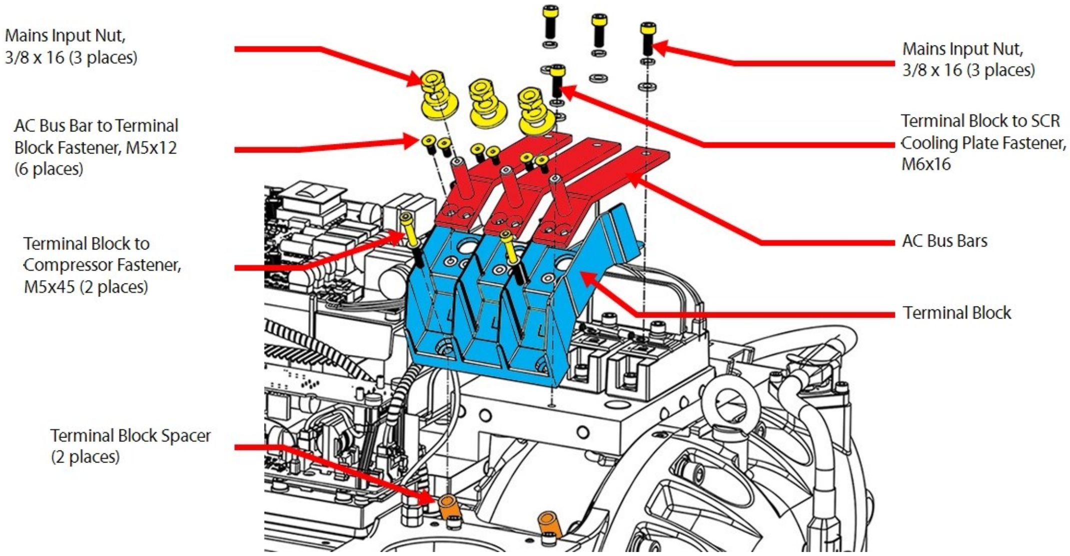


Figure 4-87 Input Terminal Block Installation - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230)



1. Install the two (2) spacers if previously removed.
2. Place the Terminal Block on the compressor housing.
   a. For Rev F and earlier compressors, use two (2) M5x45 fasteners to attach the Terminal Block to the compressor housing and and torque to 4 Nm (35 in.lb.).
   b. For Rev H compressors, loosely install the three (3) fasteners. Then torque the two (2) M5x45 fasteners to 4 Nm (35 in.lb.) and torque the rear M6x16 fastener to 5 Nm (44 in.lb).
3. Place the three (3) AC Bus Bars onto the Terminal Block and finger tighten all fasteners. Secure them with the six (6) Terminal Block fasteners. Torque the fasteners to 4 Nm (35 in.lb.).
   a. For Rev F and earlier compressors, torque the six (6) fasteners to 3 Nm (27 in.lb.) and the three (3) M8x20 AC Bus Bar Fasteners to 9 Nm (80 in.lb.).
   b. For Rev H compressors, torque the six (6) M5x12 fasteners to 2Nm (17 in.lb.) and the three (3) M6x16 AC Bus Bars to SCR fasteners to 5 Nm (44 in.lb.).
4. Reconnect the three (3) terminals of the Soft Start cable harness to the AC Bus Bars.
5. Install the mains input cables to the Terminal Block and torque to 21 Nm (15 ft.lb.).
6. Continue to Section 4.11.2.6 General 3-Phase Main Voltage Input Terminal Block Installation.

4.11.2.6 General 3-Phase Main Voltage Input Terminal Block Installation

1. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
2. Return the compressor to normal operation.

4.11.2.7 Terminal Block Torque Specifications

Table 4-19 Terminal Block Torque Specifications

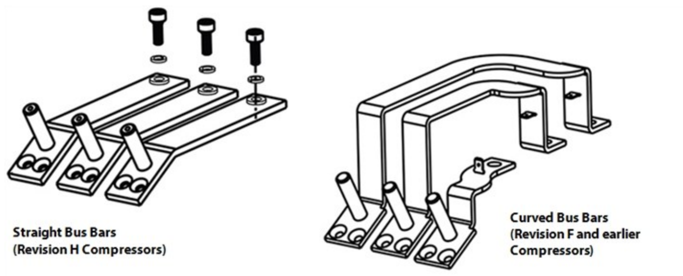
Description	Nm	Ft.Lb.	In.Lb.
TTS300/TGS230 AC Bus Bar to SCR fastener, M6x16	5	-	44
TTS300/TGS230 Terminal Block Mounting fastener, M5x15	3	-	27
TTS300/TGS230 Fuse Assembly to Terminal Block fastener	4	-	35
AC Bus Bar to Terminal Block fastener - Rev F and earlier (excludes TTS300/TGS230 compressors)	3	-	27
AC Bus Bar to Terminal Block fastener - Rev H (excludes TTS300/TGS230 compressors)	2	-	17
Terminal Block to Compressor fastener, M5x45 (excludes TTS300/TGS230 compressors)	4	-	35

Description	Nm	Ft.Lb.	In.Lb.
Terminal Block to SCR Cooling Manifold fastener, M6x16, Rev H (excludes TTS300/TGS230 compressors)	5	-	44
AC Bus Bar to SCR fastener, M8x20 (excludes TTS300/TGS230 compressors)	9	-	80
Mains Input Pressure Screw, 11/16" - 16 UNC (TTS300/TGS230 compressors only)	20	15	177
Cover Fastener, M5x15	1.5	-	13
Upper Nut, 5/16" - 18 UNC	10	7	89
Jam Nut, 5/16" - 18 UNC	7	-	62
Lower Nut, 5/16" - 18 UNC	20	15	177
Mains Input Nut, 3/8" - 16 UNC (excludes TT300/TG230 compressors)	21	15	186

4.12 Input Mains Bus Bars

This section applies to all compressors with the exception of TTS300 and TGS230 models.

Figure 4-88 Input Mains Bus Bar Examples



4.12.1 Input Mains Bus Bar Removal

4.12.1.1 General Mains Bus Bar Removal

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Disconnect the mains input cables from the Terminal Block.
3. For Revision F and earlier compressors, refer to Figure 4-89 AC/DC Bus Bar Connectors - TTS/TGS/TTH/TGS Rev. F and earlier (Except TTS300/TGH230) on page 109 and do the following:
   a. Remove the connectors of the Soft Start AC/DC Harness from the bus bars and lift away the Soft Start AC/DC Harness.
   b. Remove the three (3) M8x20 fasteners that secure the AC Bus Bars to the SCRs.
   c. Remove the six (6) fasteners that secure the three (3) AC Bus Bars to the Terminal Block.
   d. Remove the AC Bus Bars.
4. For Revision H compressors, refer to Figure 4-90 AC/DC Bus Bar Connectors - TTS/TGS/TTH/TGS Rev. H (Except TTS300/TGH230) on page 109:
   a. Remove the three (3) M6x16 fasteners that secure the AC Bus Bars to the SCRs.
   b. Remove the three (3) ring terminals and lift away the Soft Start AC/DC Harness.
   c. Remove the six (6) fasteners that secure the three (3) AC Bus Bars to the Terminal Block.
   d. Remove the AC Bus Bars.

Figure 4-89 AC/DC Bus Bar Connectors - TTS/TGS/TTH/TGS Rev. F and earlier (Except TTS300/TGH230)

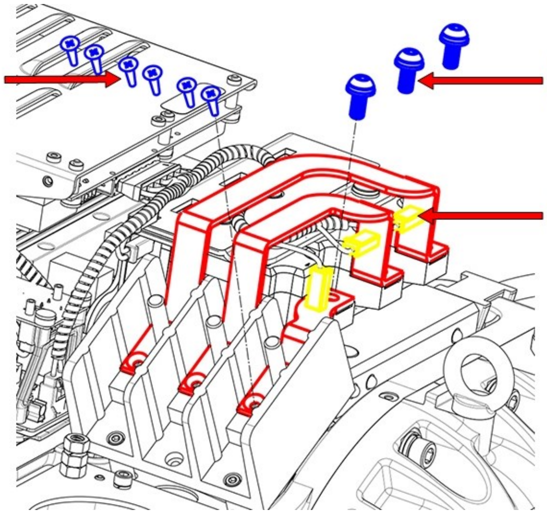
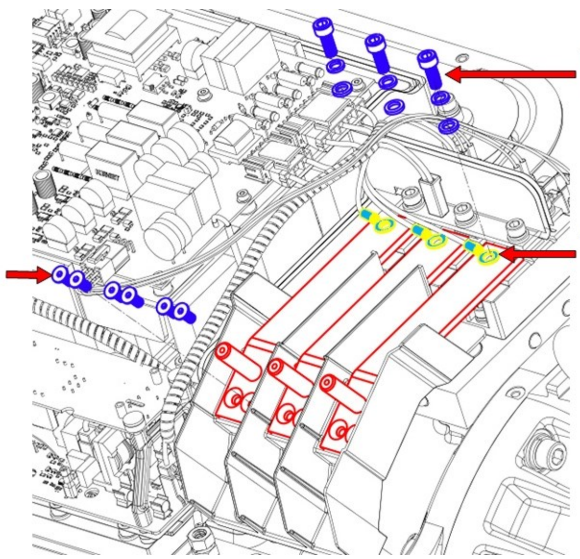


Figure 4-90 AC/DC Bus Bar Connectors - TTS/TGS/TTH/TGS Rev. H (Except TTS300/TGH230)



4.12.2 Input Mains Bus Bar Installation

1. For Revision F and earlier compressors, refer to Figure 4-89 AC/DC Bus Bar Connectors - TTS/TGS/TTH/TGS Rev. F and earlier (Except TTS300/TGH230) and do the following:
   a. Place the AC Bus Bars into position.
   b. Loosely install the six (6) fasteners that secure the three (3) AC Bus Bars to the Terminal Block.
   c. Loosely install the three (3) M8x20 fasteners that secure the AC Bus Bars to the SCRs.
   d. Torque the six (6) fasteners to 3 Nm (27 In.lb).
   e. Torque the three (3) M8x20 fasteners to 9 Nm (80 in.lb.).
   f. Route the Soft Start AC/DC harness under the AC bus bars.
   g. Install the connectors of the Soft Start AC/DC Harness to the bus bars.
2. For Revision H compressors, refer to Figure 4-90 AC/DC Bus Bar Connectors - TTS/TGS/TTH/TGS Rev. H (Except TTS300/TGH230) and do the following:

a. Place the AC Bus Bars into position.

b. Loosely install the six (6) fasteners that secure the three (3) AC Bus Bars to the Terminal Block.

c. Place the three (3) AC/DC Bus Bar ring terminals in position and loosely install the three (3) M6x16 fasteners that secure the AC Bus Bars to the SCRs.

d. Torque the six (6) M5x12 fasteners to 2 Nm (17 In.lb).

e. Torque the three (3) M6x16 fasteners to 5 Nm (44 in.lb.).

4.12.2.1 General Mains Bus Bar Installation

3. Install the mains input cables to the Terminal Block and torque to 21 Nm (15 ft.lb.).
4. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
5. Return the compressor to normal operation.

4.12.3 AC Bus Bar Torque Specifications

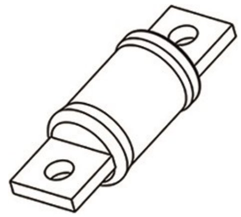
Table 4-20 AC Bus Bar Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
AC Bus Bar to Terminal Block fastener - Rev F and earlier (excludes TTS300/TGS230 compressors)	3	-	27
AC Bus Bar to Terminal Block fastener - Rev H (excludes TTS300/TGS230 compressors)	2	-	17
Terminal Block to SCR Cooling Manifold fastener, M6x16, Rev H (excludes TTS300/TGS230 compressors)	5	-	44
AC Bus Bar to SCR fastener, M8x20 (excludes TTS300/TGS230 compressors)	9	-	80
Mains Input Nut, 3/8" - 16 UNC (excludes TT300/TG230 compressors)	21	15	186
Cover Fastener, M5x15	1.5	-	13

4.13 Terminal Block Fuse Replacement

TTS300/TGS230 compressors have class T fast-acting fuses installed in the Terminal Block.

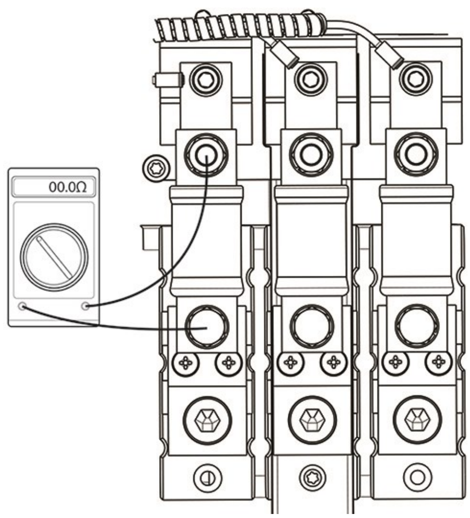
Figure 4-91 Terminal Block Fuse



4.13.1 Verification of Terminal Block Fuse

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Set the multimeter for resistance measurement.
3. Place one (1) meter probe the line side of the fuse and the other probe on the load side. Refer to Figure 4-92 Terminal Block Fuse Test. The resistance should be no greater than 2Ω.

Figure 4-92 Terminal Block Fuse Test



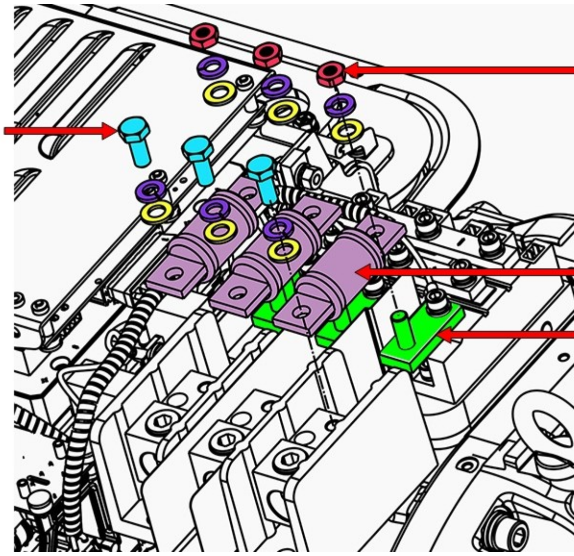
4. Continue for the remaining two (2) fuses.
5. Replace any fuses that read open or have a resistance greater than 2Ω.

4.13.2 Terminal Block Fuse Removal and Installation

4.13.2.1 Terminal Block Fuse Removal

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Remove the 5/16 - 18 fastener on the line side of the fuse.
3. Remove the 5/16 - 18 nut from the load side of the fuse.
4. Remove the fuse.

Figure 4-93 Terminal Block Fuse Removal



4.13.2.2 Terminal Block Fuse Installation

1. Place the fuse on the Terminal Block and over the threads on the short bus bar.
2. Install the 5/16 - 18 nut on the load side of the fuse and torque to 20 Nm (15 ft.lb.).
3. Install the 5/16 - 18 fastener on the line side of the fuse and torque to 20 Nm (15 ft.lb.).
4. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
5. Return the compressor to normal operation.

Table 4-21 Terminal Block Fuse Torque Specifications

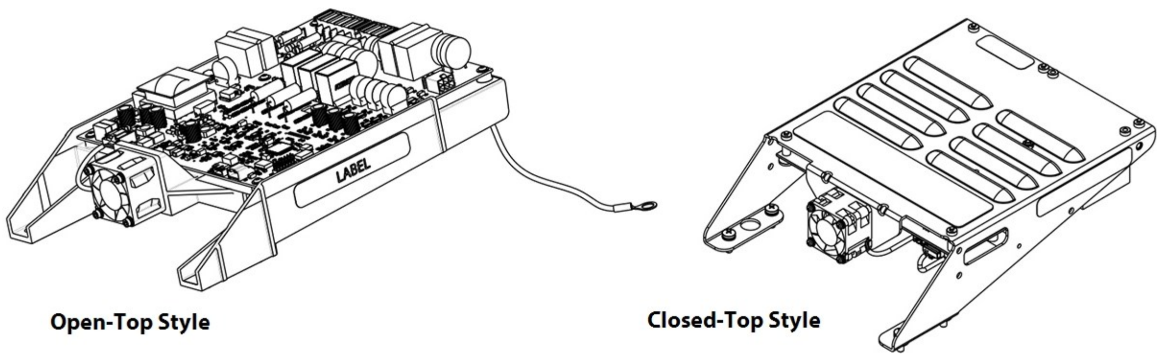
Description	Nm	Ft.Lb.	In.Lb.
TTS300/TGS230 Fuse Retaining fastener, 5/16 - 18	20	15	177
TTS300/TGS230 Fuse Retaining nut, 5/16 - 18	20	15	177
Cover Fastener, M5x15	1.5	-	13

4.14 Soft Start

There are two (2) different variants of compressor Soft Starts. All Revision G and earlier compressors had a factory installed Closed-Top Soft Start. Beginning with Revision H compressors, the Open-Top Soft Start was introduced. There is a significant visual difference between the two (2) variants, refer to Figure 4-94 Soft Start Variants for the visual differences.

The Open-Top Soft Start can handle all input voltages, whereas there are distinct versions of the Closed-Top Soft Starts to handle specific voltages. If a Closed-Top Soft Start must be replaced, Danfoss LLC offers conversion kits to allow the use of the Open-Top Soft Start. Refer to the Spare Part Selection Guide for TTS/TGS compressors for kit details.

Figure 4-94 Soft Start Variants



The Soft Start 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.

For Closed-Top Soft Starts, the 3-phase AC voltage is passed through 1/4A fast-acting fuses to two (2) onboard transformers that reduce the primary voltage to a secondary 15VAC. Both transformers pass the secondary voltage through separate Nano fuses. These transformers power the Soft Start and provide the trigger signal voltage to the Potted DC-DC when DC bus voltage levels reach the minimum level.

The Closed-Top Soft Start also uses a 2A 1000VDC fuse to pass high-voltage DC to the DC-DC Converter.

For Open-Top Soft Starts, the Mains AC voltage is passed through resettable fuses to an on-board isolated DC-DC converter during the initial startup stage. After DC bus voltage reaches minimum level, the Open-Frame DC-DC converter begins providing voltage to the service side without assistance from the Soft Start.

In addition to monitoring AC mains voltage and the HV DC bus, the Open-Top Soft Start also provides an on-board temperature sensor, varistors, and EMI filters for system protection.

All DC voltages from the Soft Start are with respect to the positive DC bus, not the compressor ground. Refer to Figure 4-95 Closed-Top Soft Start Connections on page 114. and Table 4-22 Closed-Top Soft Start Connection Identification on page 114. for the Soft Start connector locations and identifications.

4.14.1 Soft Start Connections

Figure 4-95 Closed-Top Soft Start Connections

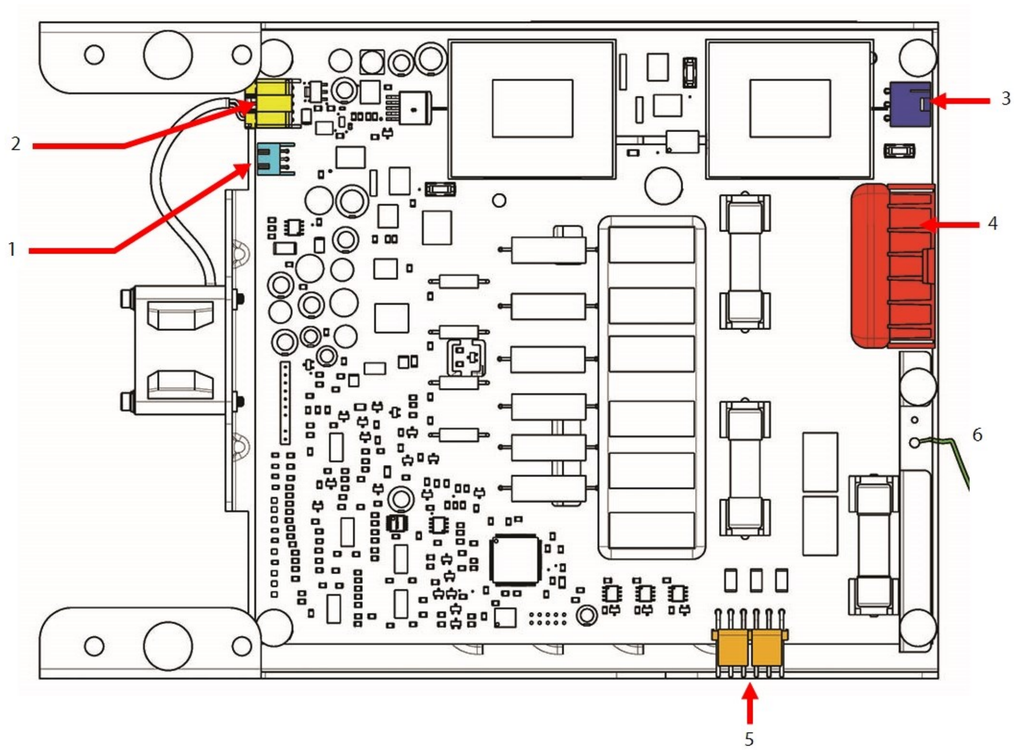


Table 4-22 Closed-Top Soft Start Connection Identification

No.	Component
1	J9: Soft Start Temperature Sensor connector
2	J5: Thermostatic Fan Control connector
3	J7: DC-DC Trigger Signal connector
4	J1: High Voltage AC/DC connector
5	J8: SCR Gate Signal connector
6	Ground

Figure 4-96 Open-Top Soft Start Connections

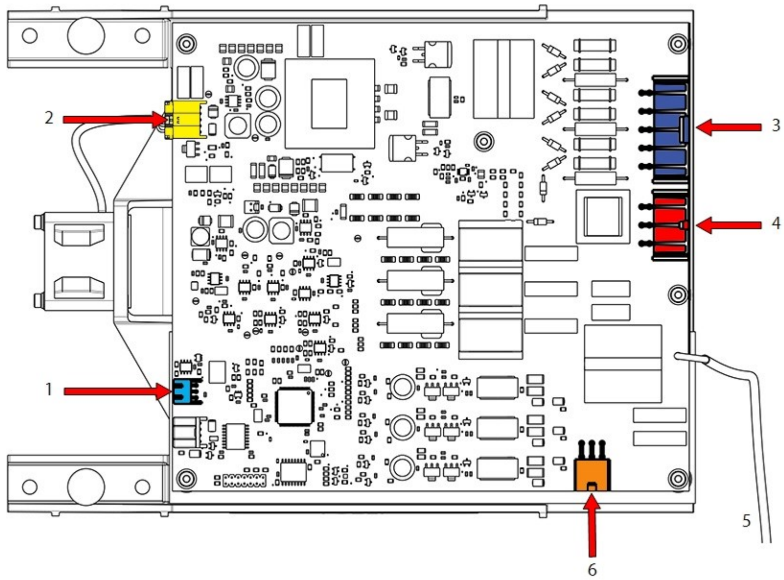


Table 4-23 Open-Top Soft Start Connection Identification

No.	Component
1	J7: Soft Start Temperature Sensor connector
2	J3: Thermostatic Fan Control connector
3	J1: AC Inputs
4	J8: DC Link
5	Ground
6	J2: SCR Gate Signal connector

4.14.2 Soft Start Verification

4.14.2.1 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 (refer to Section 1.10 DC Bus Test Harness Installation and Removal on page 25.) with power applied to the compressor, verify that the expected DC bus voltage is present for the application. Refer to Table 1-2 Expected DC Bus Voltage on page 29.
   - No DC voltage may indicate that the Soft Start is not controlling the SCRs, or an open fuse on Closed-Top Soft Starts
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. (Closed-Top Soft Starts only)
   - No 15VAC may indicate an open fuse on Closed-Top Soft Starts
   - If the 15VAC supply is not present at start-up, the Potted DC-DC converter will not function

4.14.2.2 Verifying Soft Start Fuses

The instructions in this section cover the revision "S" and "T" Closed-Top Soft Starts.

NOTE
There are no serviceable fuses on Open-Top Soft Starts.

The Soft Start part numbers and revisions are identified by a label on the side of the Soft Start mounting bracket. The Soft Start revision follows immediately after the 6-digit part number. Refer to Figure 4-97 Soft Start Label Location for details on the location of the label and the revision indicator.

Figure 4-97 Soft Start Label Location

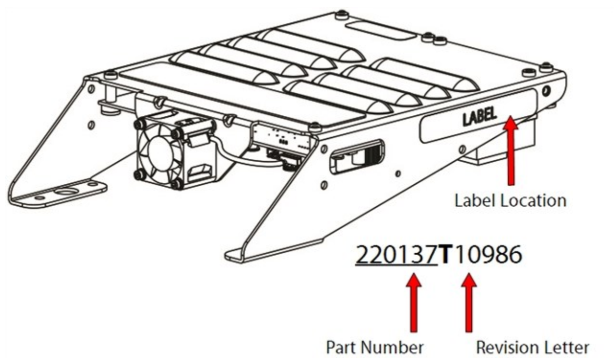
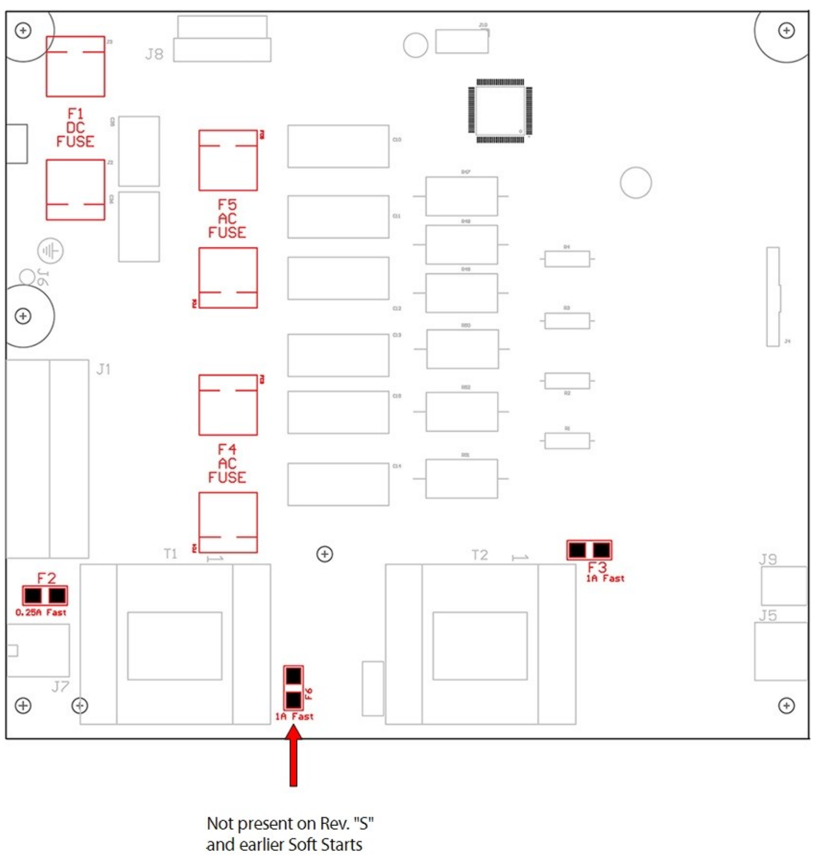


Figure 4-98 Soft Start Fuse Locations



1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Remove the Soft Start. Refer to Section 4.14.4 Soft Start Removal (Closed-Top).
3. Flip the Soft Start to access the fuses. Refer to Figure 4-98 Soft Start Fuse Locations on page 116 for detail on the fuse locations. Refer to Table 4-24 Soft Start Fuse Details for fuse detail.
4. Using a multimeter set for resistance measurements, place the leads on the ends of the F1 fuse. The reading should be less than 1Ω.
   - An open F1 fuse may indicate a problem with the Potted 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 less than 1Ω.
   - An open F2 fuse may indicate a problem with the Potted 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 less than 1Ω.
   - An open F3 fuse may indicate a problem with the Closed-Top Soft Start Circuit Board
7. Using a multimeter set for resistance measurements, place the leads on the ends of the F6 Nano fuse. The reading should be less than 1Ω.
   - An open F6 fuse may indicate a problem with the Closed-Top Soft Start Circuit Board
8. Using a multimeter set for resistance measurements, place the leads on the ends of the F4 or F5 fuses. The reading should be around 30-38Ω for either fuse.
   - An open F4 or F5 fuse may indicate a problem with the Closed-Top Soft Start transformers, circuit board, or fan

Table 4-24 Soft Start Fuse Details

Fuse	Amperage	Resistance (Ω)	Circuit	Class	Comments
F1	2A	Less than 1Ω	HV DC to DC	-	Fast Acting
F2	0.25A	Less than 1Ω	Transformer Secondary -15V AC to DC-DC	-	Fast Acting, Nano
F3	1A	Less than 1Ω	Transformer Secondary - Soft Start Board	-	Fast Acting, Nano
F4	0.25A	30-38Ω	HV AC to Transformer	Class CC	Slow Blow
F5	0.25A	30-38Ω	HV AC to Transformer	Class CC	Slow Blow
F6	1A	Less than 1Ω	Transformer Secondary - Soft Start Board	-	Fast Acting, Nano

9. Troubleshoot to determine the cause of the blown fuse, if necessary replace any fuse that is found to be defective. Some of the fuses may require the use of needle-nose pliers or forceps to replace them. Refer to 5.5.2.6 Determining the Cause of Blown Soft Start Fuses (Closed-Top Soft Start Only) on page 272.
10. Install the Soft Start. Refer to Section 4.14.6 Soft Start Installation (Closed-Top) on page 121.
11. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
12. Return the compressor back to normal operation.

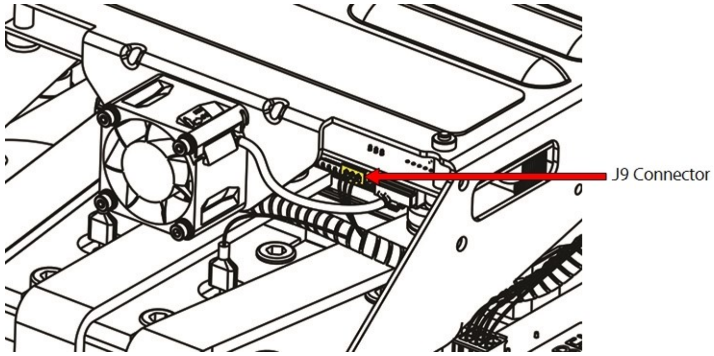
4.14.3 Soft Start Removal and Installation

This section covers the direct replacement of a Soft Start (i.e., Open-Top Soft Start to Open-Top Soft Start or Closed-Top Soft Start to Closed Top Soft Start). If you are upgrading to an Open-Top Soft Start from a Closed-Top Soft Start, be sure to review the spare part instructions that are included in the upgrade kit.

4.14.4 Soft Start Removal (Closed-Top)

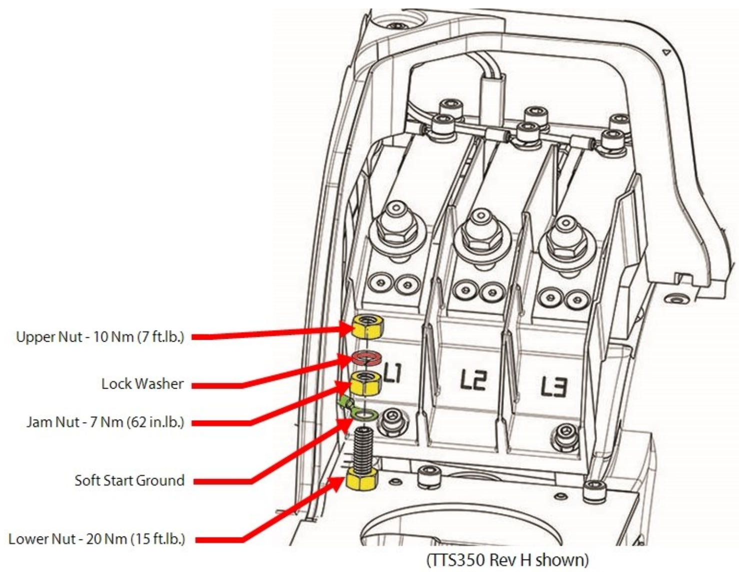
1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Remove the Soft Start Temperature Harness. Refer to Figure 4-99 Closed-Top Soft Start J9 Connector on page 118.

Figure 4-99 Closed-Top Soft Start J9 Connector



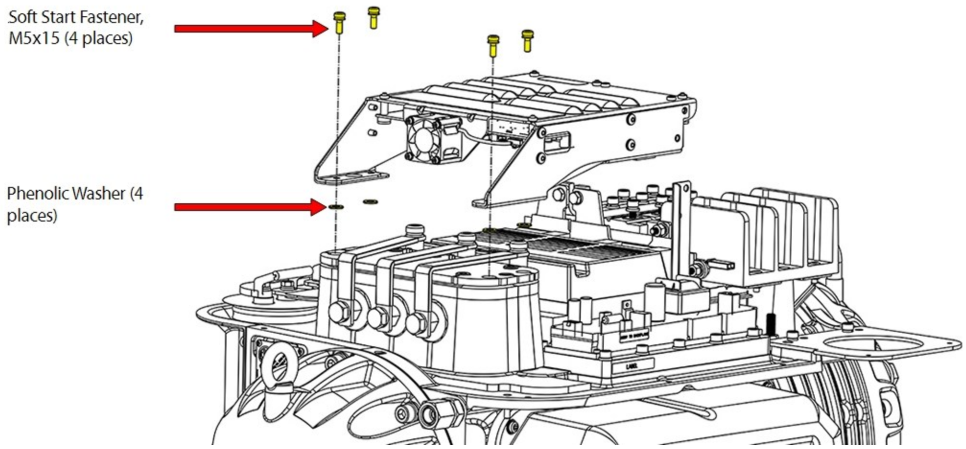
3. Disconnect the Soft Start ground wire by removing the nut and mains input ground wire from the ground post on the compressor housing at the 3 - phase connection point. Refer to Figure 4-100 Ground Location.

Figure 4-100 Ground Location



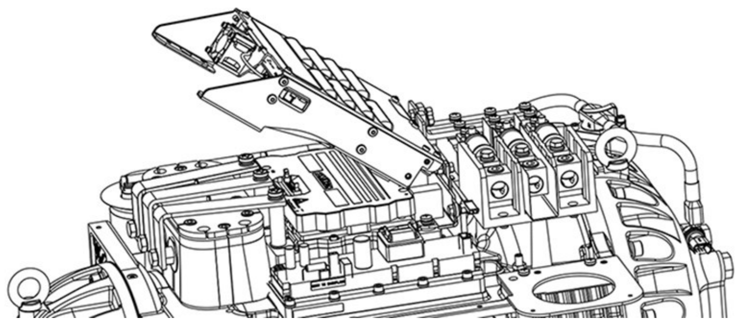
4. Remove the M5x15 fasteners that secure the Soft Start mounting bracket to the compressor. Refer to Figure 4-101 Closed-Top Soft Start on page 119.

Figure 4-101 Closed-Top Soft Start



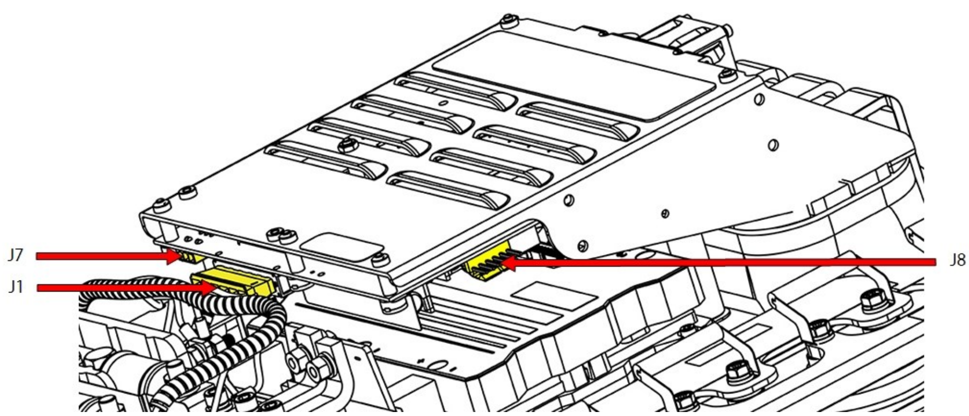
5. Lift the Soft Start and turn it over, placing it board-side up on the AC Bus Bars. Refer to Figure 4-102 Soft Start Lift.

Figure 4-102 Soft Start Lift



6. Unplug cable connectors J1, J7, and J8 from the Soft Start. Refer to Figure 4-103 Closed-Top Soft Start Connector Removal.

Figure 4-103 Closed-Top Soft Start Connector Removal

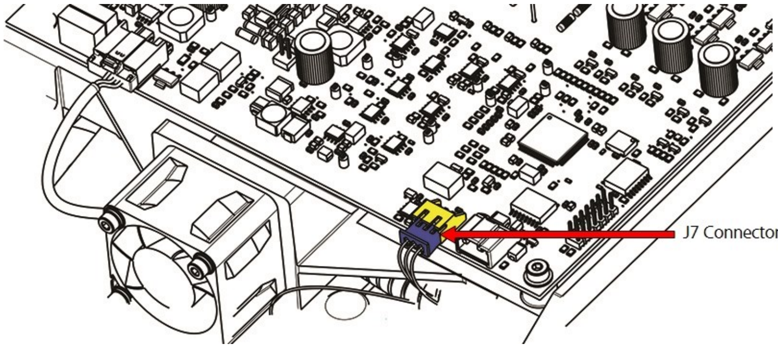


7. Remove the Soft Start assembly and place it in a safe location.

4.14.5 Soft Start Removal (Open-Top)

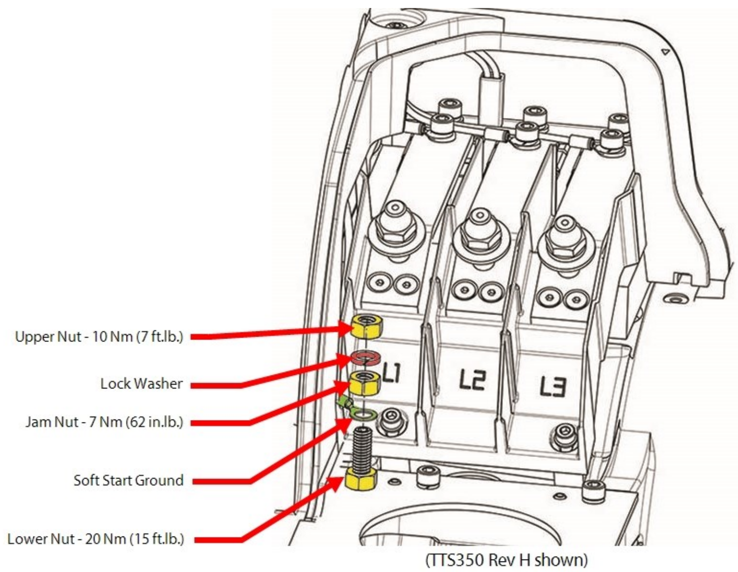
1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Remove the Soft Start Temperature Harness. Refer to Figure 4-104 Open-Top Soft Start J7 Connector.

Figure 4-104 Open-Top Soft Start J7 Connector



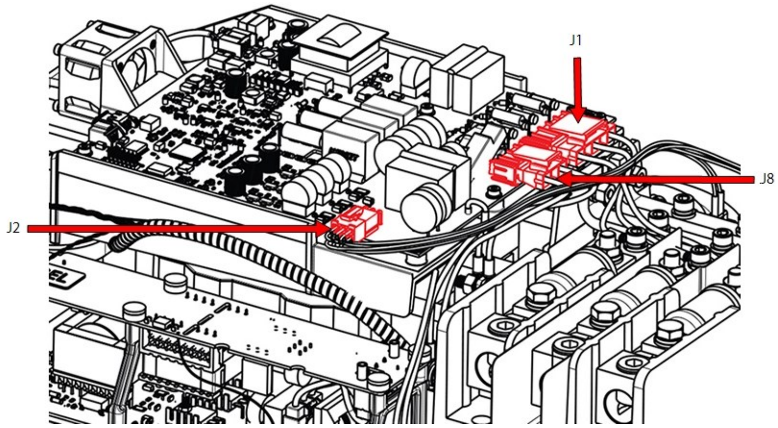
3. Disconnect the Soft Start ground wire by removing the nut and mains input ground wire from the ground post on the compressor housing at 3 phase connection point. Refer to Figure 4-105 Ground Location.

Figure 4-105 Ground Location



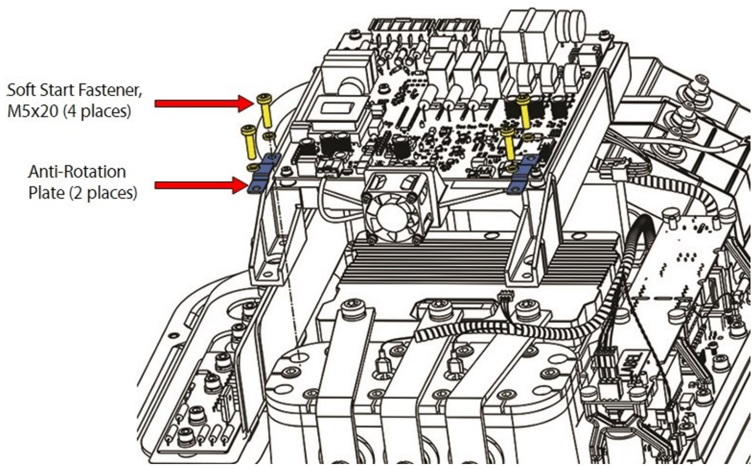
4. Unplug cable connectors J1, J2, and J8 from the Soft Start.

Figure 4-106 Open-Top Soft Start Connector Removal



5. Remove the M5x20 fasteners that secure the Soft Start mounting bracket to the compressor. Refer to Figure 4-107 Open-Top Soft Start Removal.

Figure 4-107 Open-Top Soft Start Removal

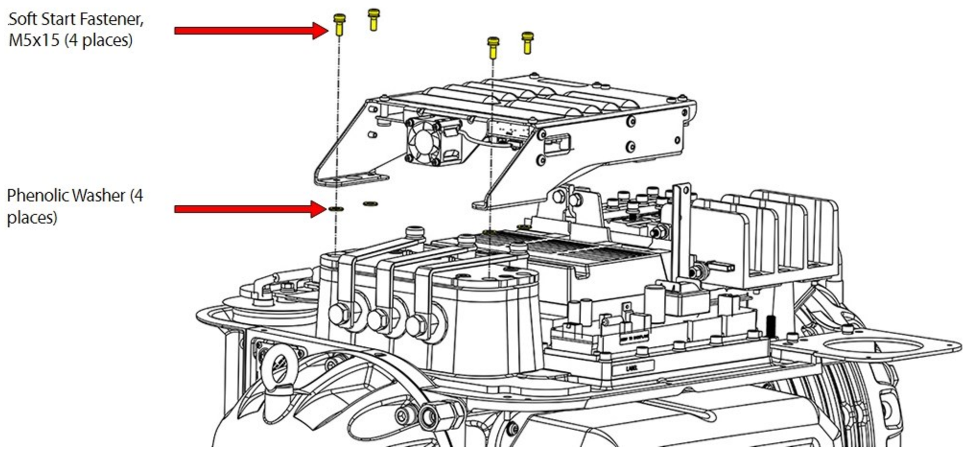


6. Remove the Soft Start assembly and place it in a safe location.

4.14.6 Soft Start Installation (Closed-Top)

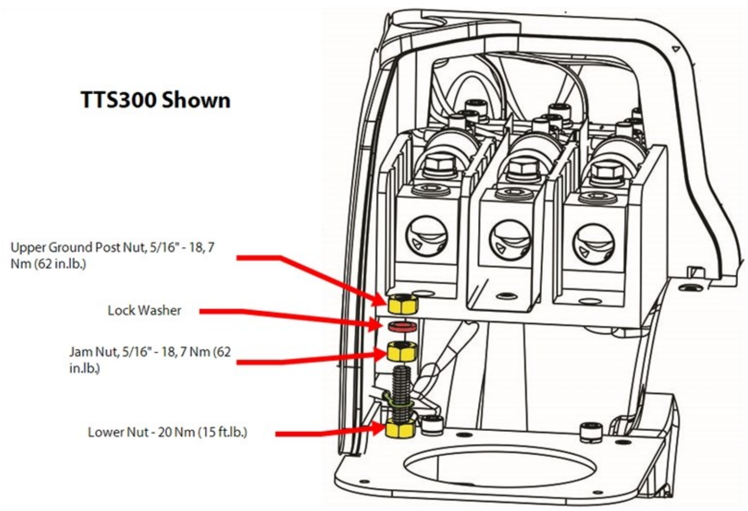
1. Place the Soft Start over the AC Bus Bars (board side up) with the fan toward the IGV.
2. Install connectors J1, J7, and J8.
3. Flip the Soft Start over and place into mounting position.
4. Finger tighten the fasteners and then torque to 5 Nm (44 in.lb.). Refer to Figure 4-108 Closed-Top-Soft Start Installation on page 122.

Figure 4-108 Closed-Top-Soft Start Installation



5. Install the J9 Soft Start Temperature Sensor connector. Refer to Figure 4-99 Closed-Top Soft Start J9 Connector on page 118.
6. Connect the Soft Start ground wire and mains input ground wire onto the ground post on the compressor housing and install the spring washer and nut, then torque the top nut to 7 Nm (62 in.lb.).

Figure 4-109 Ground Stud Location

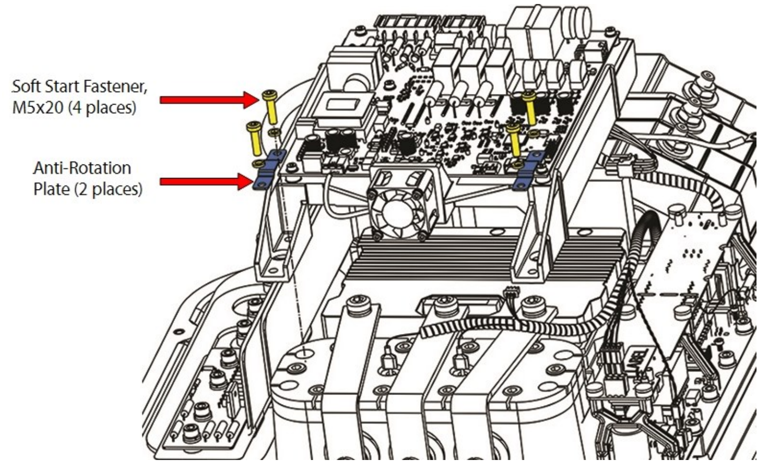


7. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
8. Return the compressor to normal operation.

4.14.7 Soft Start Installation (Open-Top)

1. Place the Soft Start into mounting position.
2. Finger tighten the fasteners and then torque to 5 Nm (44 in.lb.). Refer to Figure 4-110 Open-Top Soft Start Installation on page 123.
3. Install connectors J1, J2, and J8.

Figure 4-110 Open-Top Soft Start Installation



4. Install the J7 Soft Start Temperature Sensor connector Figure 4-104 Open-Top Soft Start J7 Connector on page 120.
5. Connect the Soft Start ground wire and mains input ground wire on the ground post on the compressor housing and install the spring washer and nut, then torque the top nut to 7 Nm (62 in.lb.).
6. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
7. Return the compressor to normal operation.

4.14.8 Soft Start Fan Removal and Installation

New Soft Start Fan kits include an adapter board that may not be required. Refer to the specific spare part kit instructions for adapter board usage.

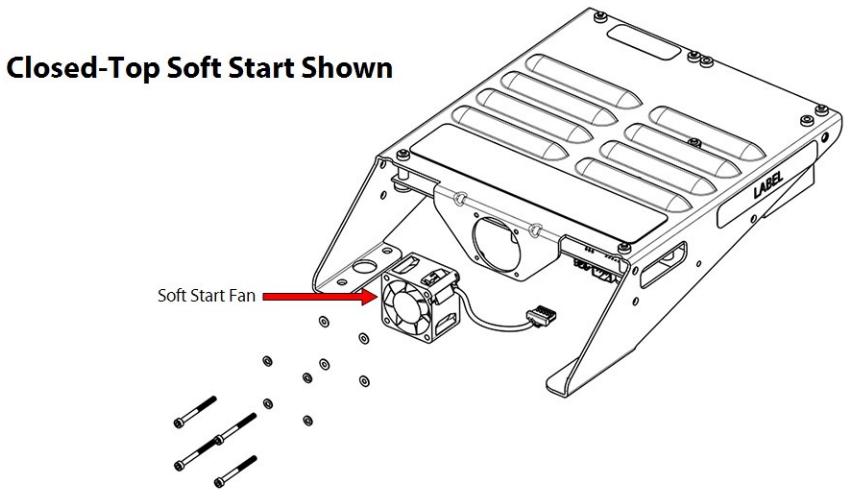
• • • CAUTION• • •

Use of the adapter board on Open-Top Soft Starts and on Soft Starts with revision Q and later may cause the fan not to start leading to Soft Start over-temperature faults. Not incorporating the adapter board on Soft Starts with revision P and earlier may cause premature failure of the Soft Start Fan. Refer to the spare part instructions for Soft Start revision identification.

4.14.9 Soft Start Fan Removal

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Unplug the Fan Power Supply from the Soft Start. Refer to Figure 4-114 Soft Start Fan Connector on page 125.
   - J5 on the Closed-Top Soft Start
   - J3 on the Open-Top Soft Start
3. Remove the four (4) mounting fasteners securing the cooling fan to the Soft Start Bracket. Be careful not to drop the fasteners onto the compressor components. Refer to Figure 4-111 Soft Start Without Adapter on page 124.

Figure 4-111 Soft Start Without Adapter

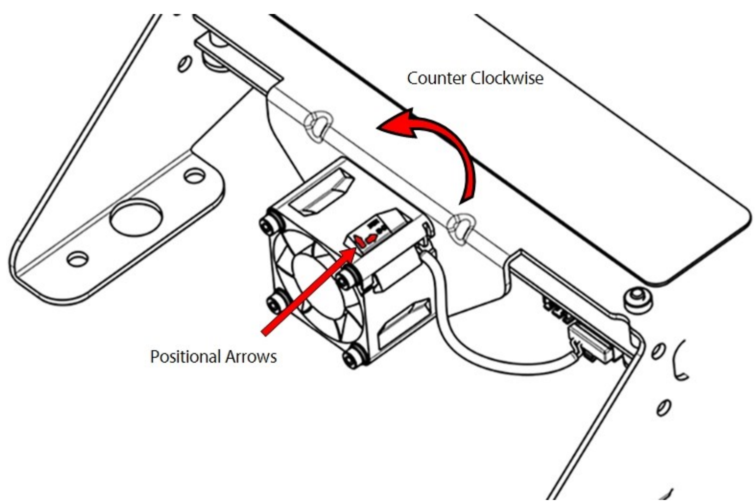


4.14.10 Soft Start Fan Installation

1. Orient the fan so the arrows are pointing counter clockwise and toward the Soft Start. Figure 4-112 Soft Start Fan Orientation shows a view of the Closed-Top Soft Start where the fan arrows should be pointing.

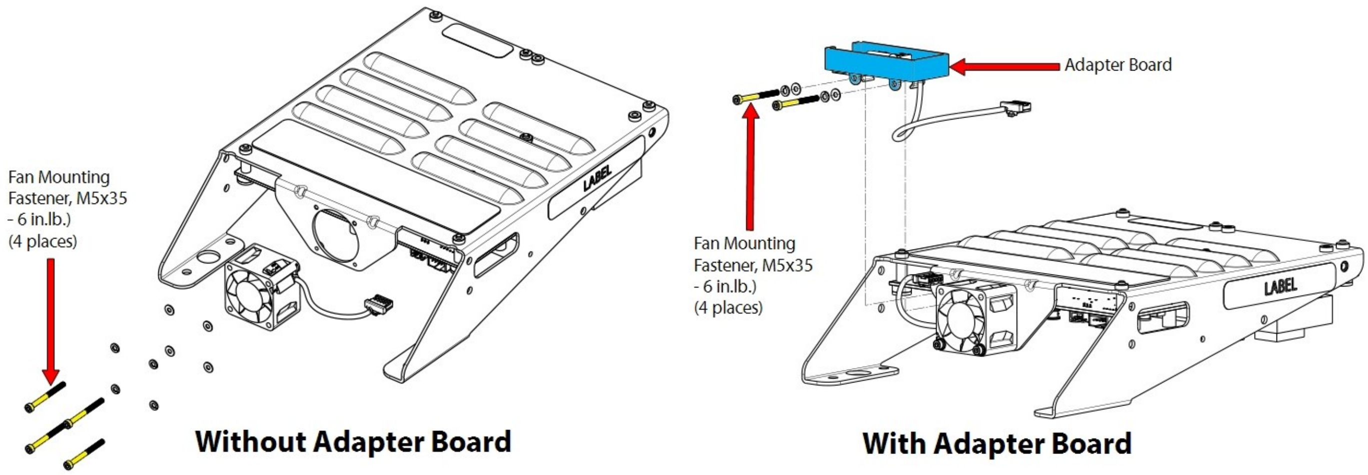
NOTE
Once the fan is installed on Open-Top Soft Starts, the fan arrows will be located on the bottom right corner of the fan and will no longer be visible. When the adapter boards are used, the arrows will only be visible from the bottom side of the Soft Start.

Figure 4-112 Soft Start Fan Orientation



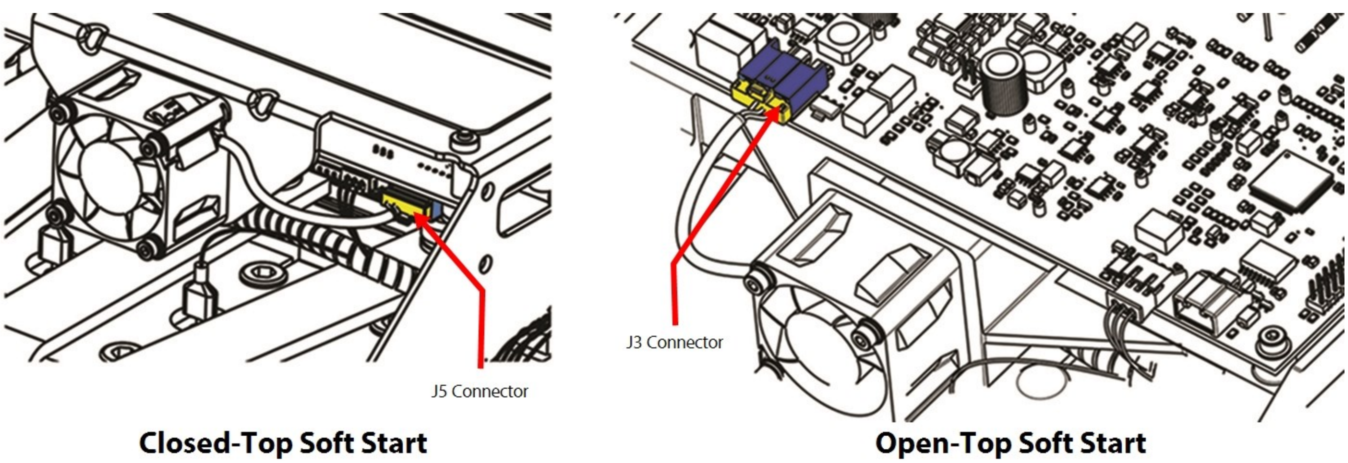
2. Install the four (4) fasteners to secure the fan and adapter board (if equipped) to the Soft Start and torque to 6 in.lb. Refer to Figure 4-113 Soft Start Fan Installation on page 125.

Figure 4-113 Soft Start Fan Installation



3. Plug the connector of the new fan into the Soft Start Board. Refer to Figure 4-114 Soft Start Fan Connector.
   - J5 on the Closed-Top Soft Start
   - J3 on the Open-Top Soft Start

Figure 4-114 Soft Start Fan Connector



4. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
5. Return the compressor to normal operation.

4.14.10.1 Soft Start Torque Specifications

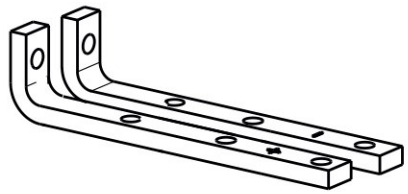
Table 4-25 Soft Start Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
Soft Start fastener, M5x15 or M5x20	5	-	44
Soft Start Fan fastener, M5x35	-	-	6
Upper Nut, 5/16" - 18 UNC	7	-	62
Jam Nut, 5/16" - 18 UNC	7	-	62
Lower Nut, 5/16" - 18 UNC	20	15	177
Cover Fastener, M5x15	1.5	-	13

4.15 SCR DC Bus Bar - TTS300/TGS230

The SCR DC Bus Bars pass the DC voltage from the output of the SCRs to the DC Capacitor Bus Bar Assembly. This procedure does not show the removal of the Soft Start since it is not required. However, if extra room is desired, the Soft Start can be removed to provide better access to the fasteners that secure the SCR DC Bus Bars to the DC Capacitor Bus Bar Assembly.

Figure 4-115 SCR DC Bus Bars

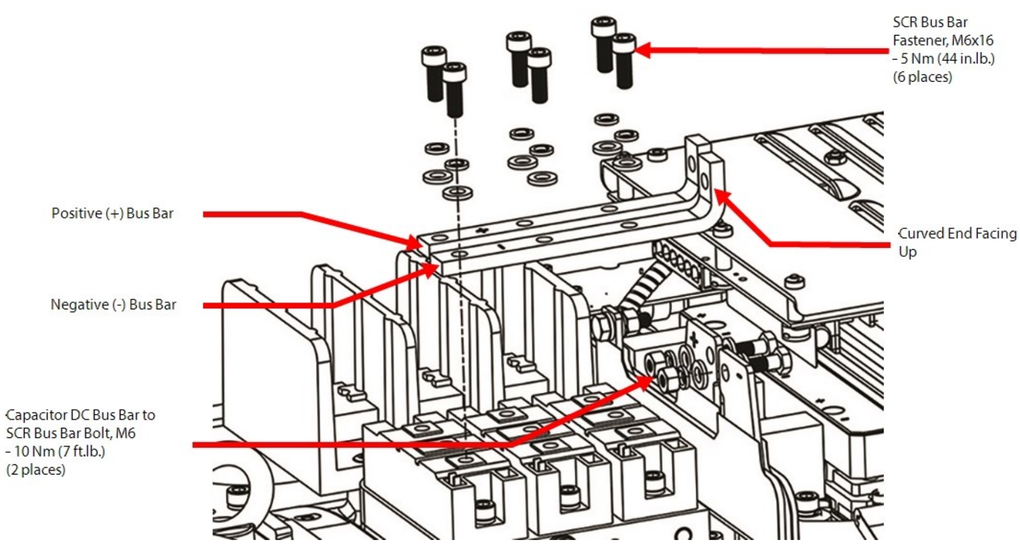


4.15.1 SCR DC Bus Bar Removal and Installation

4.15.1.1 SCR DC Bus Bar Removal - TTS300/TGS230

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Using a 10 mm wrench/socket, remove the bolts that secure the (+) and (-) SCR DC Bus Bars to the DC Capacitor Bus Bars. Refer to Figure 4-116 SCR DC Bus Bar Removal - TTS300/TGS230 for this and the next two (2) steps.
3. Remove the six (6) M6x16 fasteners that secure the (+) and (-) SCR DC Bus Bars to the SCRs.
4. Remove the SCR DC Bus Bars.

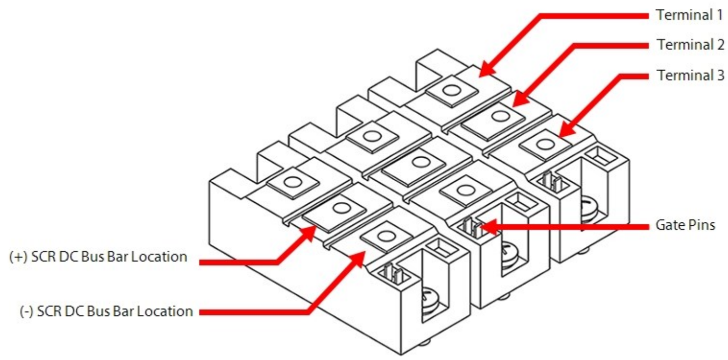
Figure 4-116 SCR DC Bus Bar Removal - TTS300/TGS230



4.15.1.2 SCR DC Bus Bar Installation - TTS300/TGS230

1. Place the negative bus bar on the SCRs. The negative bus bar should be next to the SCR Gate pins (aligned with the holes identified as #3 on the SCRs). Refer to Figure 4-117 SCR DC Bus Bar to SCR Alignment on page 127 for this and the following step.

Figure 4-117 SCR DC Bus Bar to SCR Alignment



2. Install the positive bus bar beside the negative bus bar (aligned with holes identified as #2 on the diodes).
3. The curved section of the bus bar should be installed upwards.
4. Insert and finger-tighten the six (6) M6x16 SCR DC Bus Bar fasteners.
5. Insert and finger-tighten the two (2) M6x20 Bus Bar bolts and M6 nuts to secure the SCR DC Bus Bars to the Capacitor DC Bus Bar.
6. Torque the six (6) M6x16 SCR DC Bus Bar fasteners to 5 Nm (44 in.lb.).
7. Hold the two (2) M6x20 Bus Bar bolts with a wrench and torque the M6 nuts to 10 Nm (7 ft.lb.).
8. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
9. Return the compressor to normal operation.

4.15.1.3 SCR DC Bus Bar Torque Specifications

Table 4-26 SCR DC Bus Bar Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
SCR DC Bus Bar fastener, M6x16	5	-	44
DC Capacitor Bus Bar to SCR Bus Bar Nut, M6	10	7	89
Cover Fastener, M5x15	1.5	-	13

4.16 Soft Start SCR Gate Cable

There are two (2) different styles of this cable, one for the Closed-Top Soft Start and one for the Open-Top Soft Start. Refer to Figure 4-118 Soft Start SCR Gate Cable (Closed-Top Soft Starts) and Figure 4-119 Soft Start SCR Gate Cable (Open-Top Soft Starts) for the examples of each.

The following steps provide detail on how to replace the Soft Start SCR Gate Cable. Prior to removal, note the location of the harness routing as this will minimize the installation time of the new harness.

4.16.1 Soft Start SCR Gate Cable Connections

Figure 4-118 Soft Start SCR Gate Cable (Closed-Top Soft Starts)

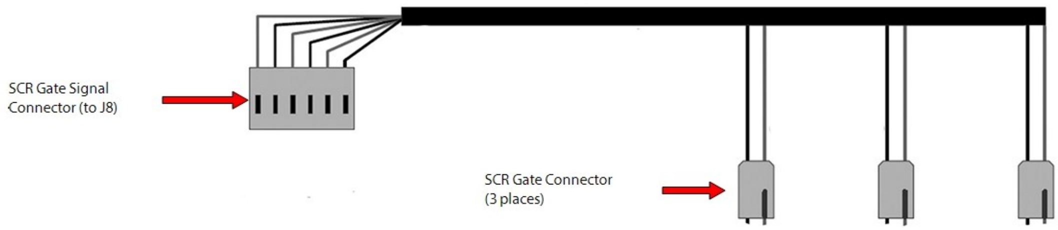
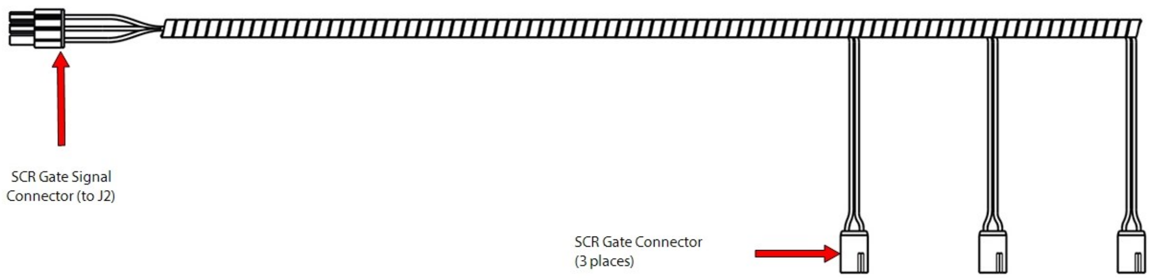


Figure 4-119 Soft Start SCR Gate Cable (Open-Top Soft Starts)



4.16.2 Soft Start SCR Gate Cable Removal and Installation

4.16.2.1 Soft Start SCR Gate Cable Removal

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Remove the six (6) Soft Start SCR Gate Cable connectors from the SCRs. This may require the use of needle-nose pliers. Refer to the following figures for this and the next step for the appropriate compressor model.
   - Figure 4-120 Soft Start SCR Gate Cable Removal - TTS300/TGS230 on page 129
   - Figure 4-121 Soft Start SCR Gate Cable Removal at SCR - TTS/TGS/TTH/TGH Models Rev. F and Earlier (Except TTS300/TGS230) on page 129
   - Figure 4-122 Soft Start SCR Gate Cable Removal at SCR - TTS/TGS/TTH/TGH Models Rev. H (Except TTS300/TGS230) on page 129
3. Remove the SCR Gate Cable from the Soft Start.
   a. For compressors with the Closed-Top Soft Start, remove the J8 connector.
   b. For compressors with the Open-Top Soft Start, remove the J2 connector.

Figure 4-120 Soft Start SCR Gate Cable Removal - TTS300/TGS230

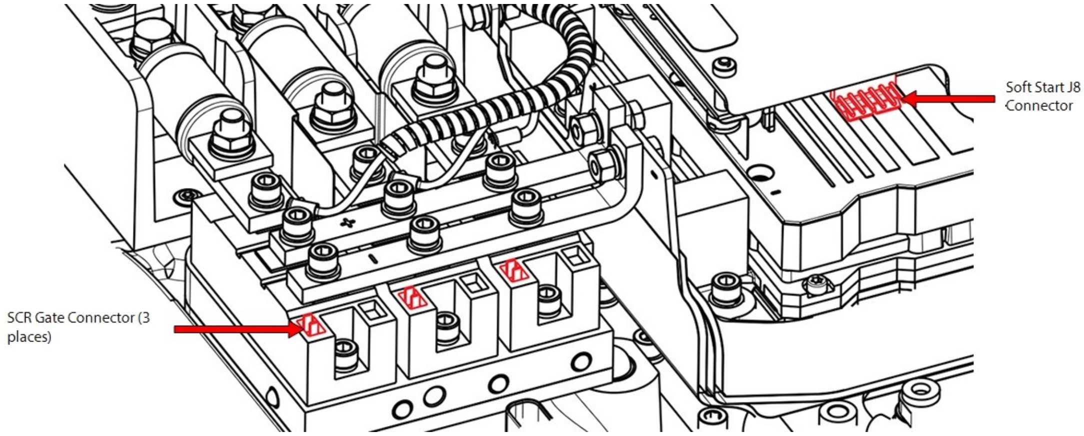


Figure 4-121 Soft Start SCR Gate Cable Removal at SCR - TTS/TGS/TTH/TGH Models Rev. F and Earlier (Except TTS300/TGS230)

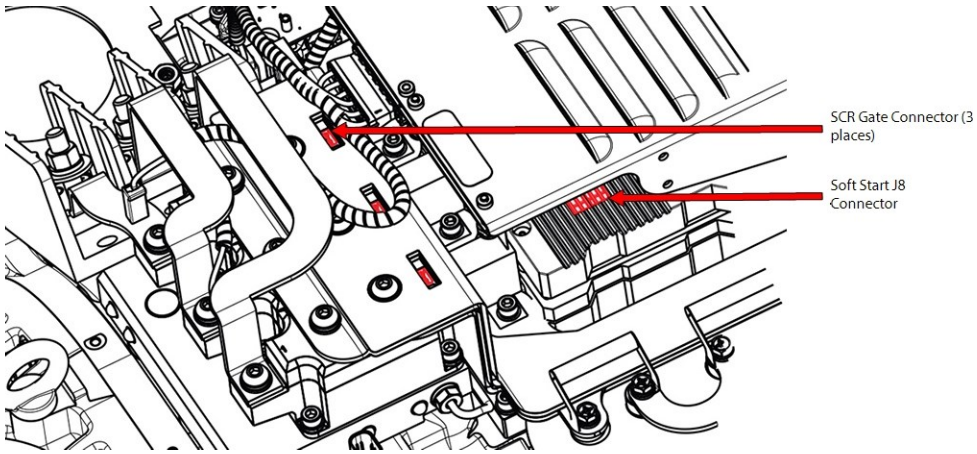
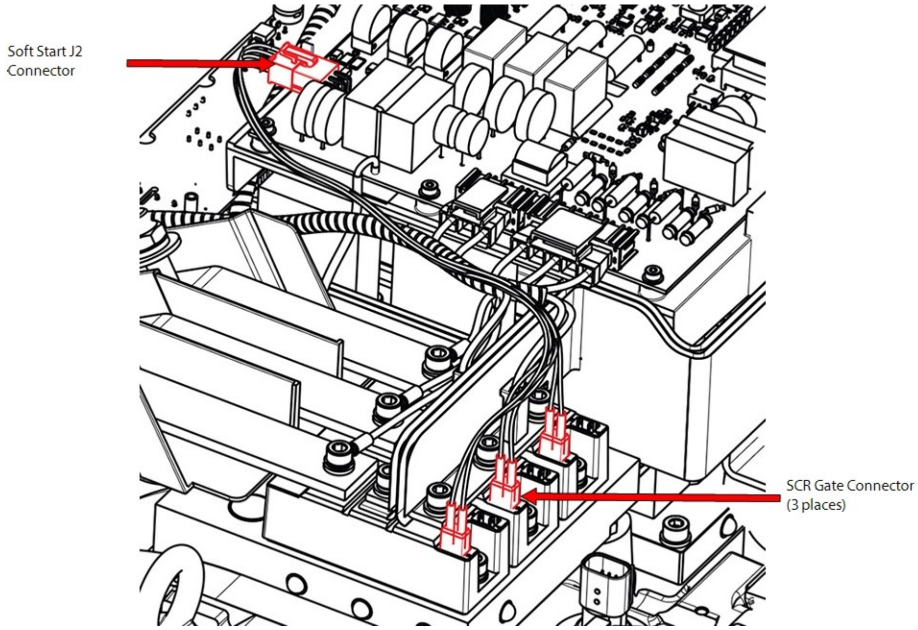


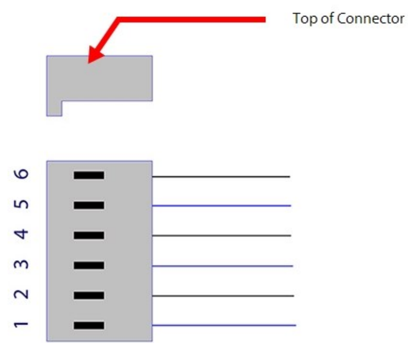
Figure 4-122 Soft Start SCR Gate Cable Removal at SCR - TTS/TGS/TTH/TGH Models Rev. H (Except TTS300/TGS230)



4.16.2.2 Soft Start SCR Gate Cable Installation

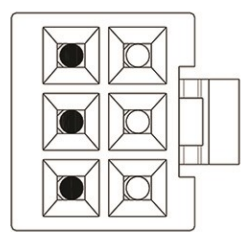
1. Connect the SCR Gate Cable to the Soft Start.
   a. For compressors with the Closed-Top Soft Start, install the J8 connector.
      - Be sure to align the pins properly so as not to bend them or misalign the plug. The flat portion of the connector goes to the top. Refer to Figure 4-123 Closed-Top Soft Start J8 Connector Top.

Figure 4-123 Closed-Top Soft Start J8 Connector Top



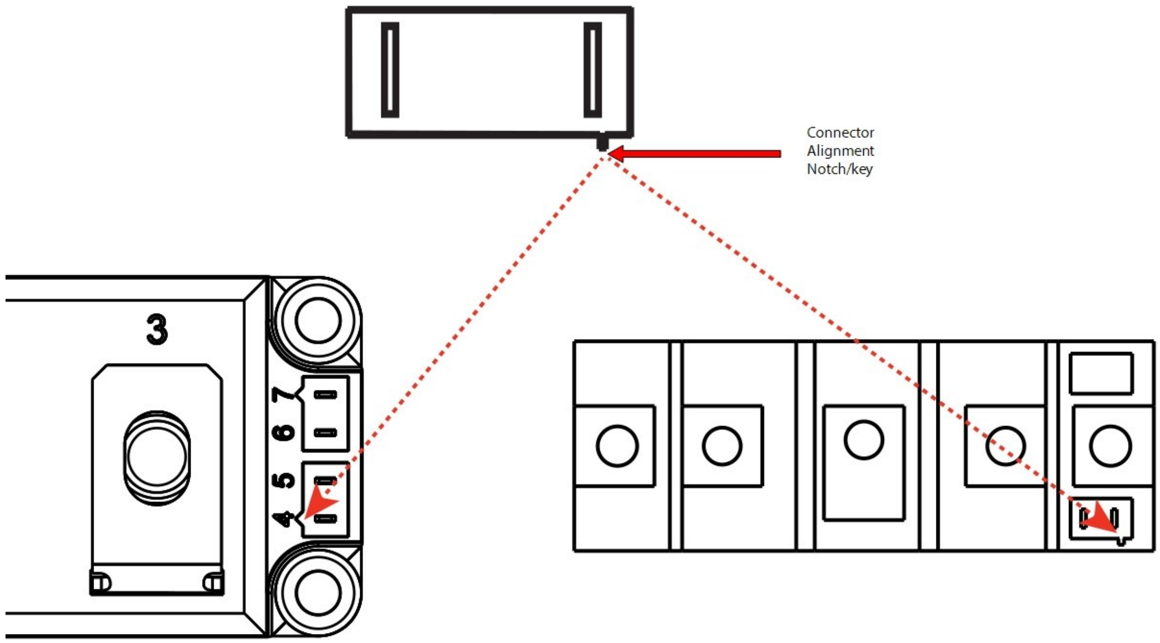
   b. For compressors with the Open-Top Soft Start, install the J2 connector.

Figure 4-124 Open-Top Soft Start J2 Connector



2. Once the Cable Harness has been installed onto the Soft Start, the cable should be routed toward the SCRs. SCR Gate connectors must be installed in correct order for proper compressor operation.
3. Plug each pigtail into its respective SCR making sure you line up the “key” on the pigtail connector to the “key” of the SCR itself. This may require the use of small forceps or needle nose pliers. Refer to Figure 4-125 SCR Gate Connector Alignment on page 131 for the two (2) different styles of SCRs.

Figure 4-125 SCR Gate Connector Alignment



4. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
5. Return the compressor to normal operation.

4.17 Soft Start AC/DC Harness

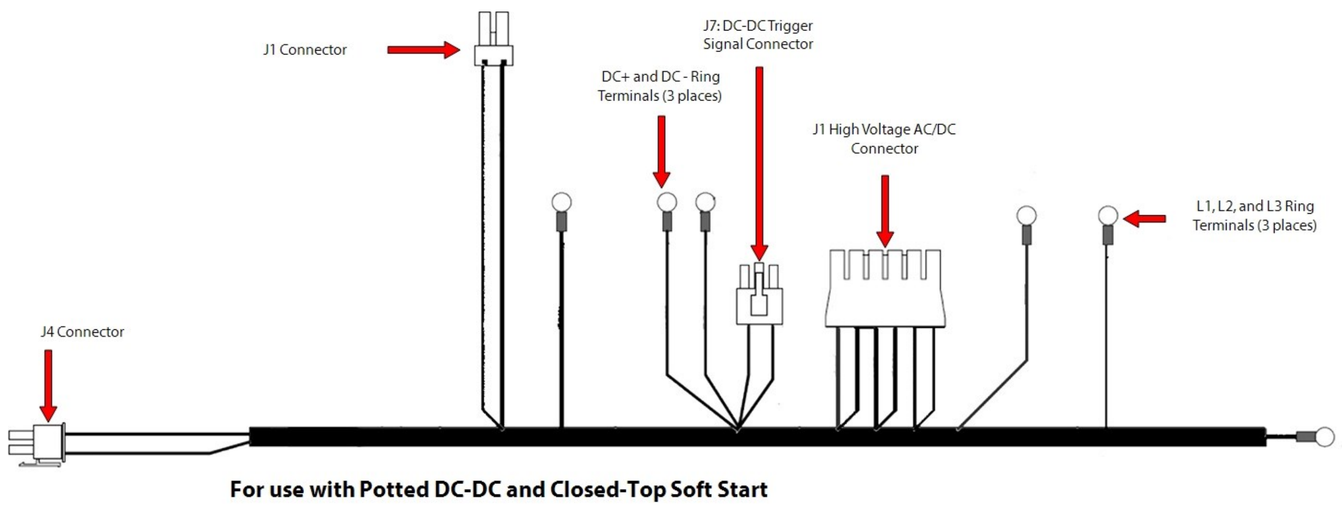
The Soft Start AC/DC Cable Harness provides the Mains AC voltage phases and DC Bus voltage to the Soft Start, and passes the DC Bus and 15 VAC to the Potted DC-DC. There are different styles of Soft Start AC/DC Harnesses. The installed harness will vary depending on the style of DC-DC, Soft Start, and compressor model and revision.

The following steps provide detail on how to replace the Soft Start AC/DC Harness. Not all harness variations are shown here, but the major differences that impact removal and installation are described in this manual. Please refer to the Spare Parts Selection Guide for illustrations of the various Soft Start AC/DC Harnesses.

Prior to removal, note the location of the harness routing as this will minimize the installation time of the new harness.

4.17.1 Soft Start AC/DC Harness Connections

Figure 4-126 Soft Start AC/DC Harness Connections - TTS300/TGS230



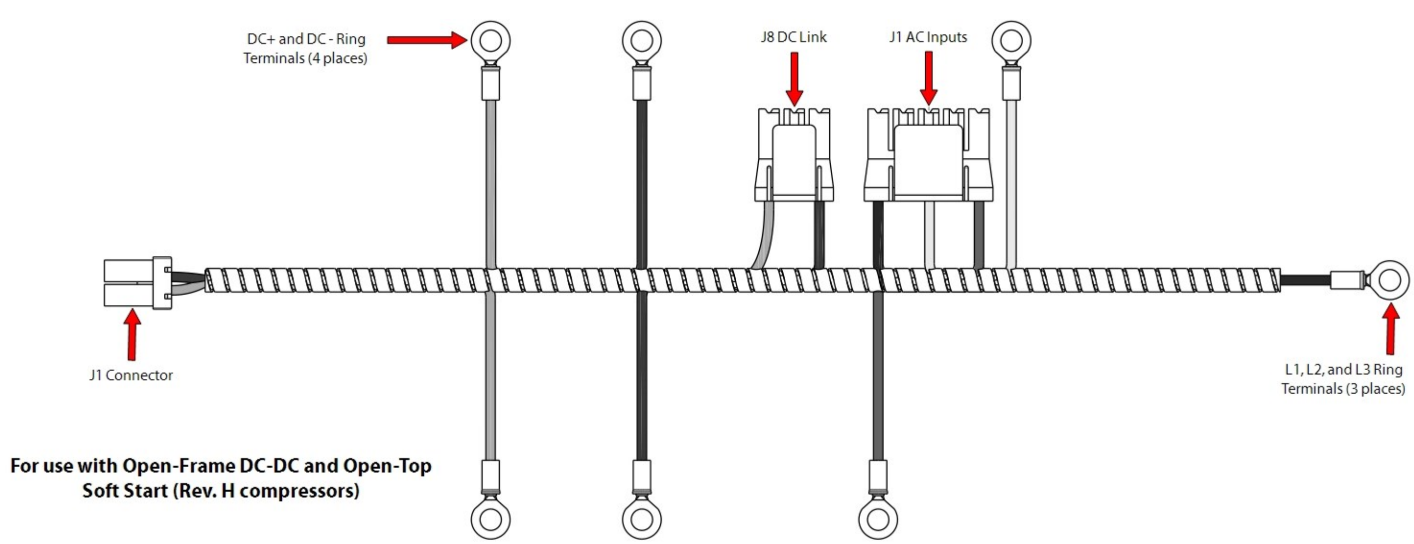
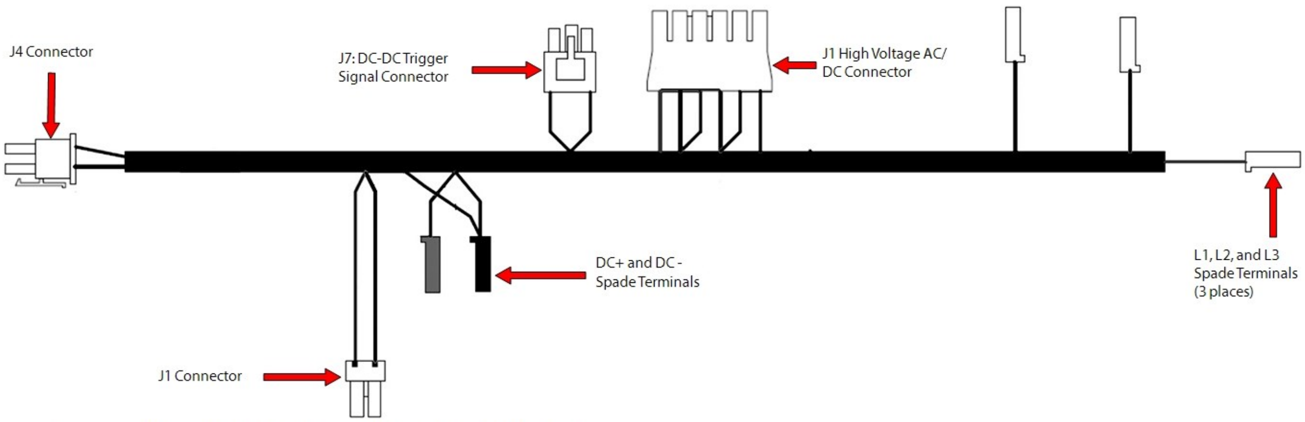
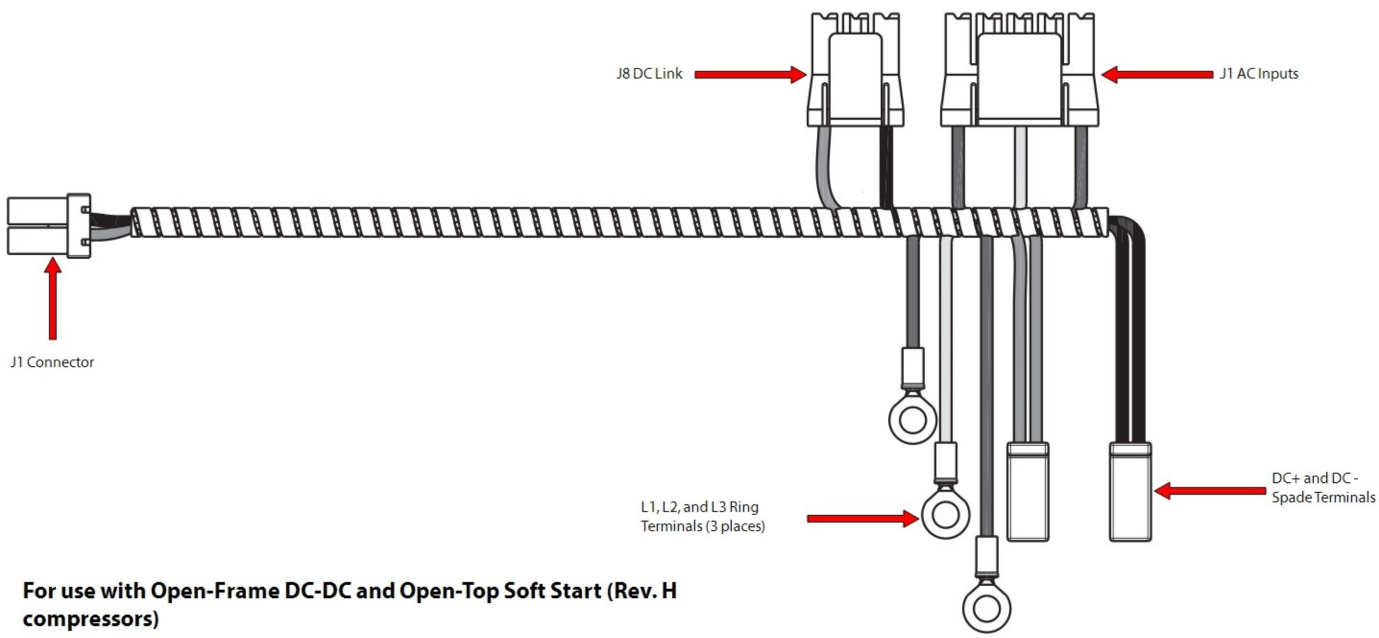


Figure 4-127 Soft Start AC/DC Harness Connections - TTS/TGS/TTH/TGH (Except TTS300/TGS230)



For use with potted DC-DC and Closed-Top Soft Start



For use with Open-Frame DC-DC and Open-Top Soft Start (Rev. H compressors)

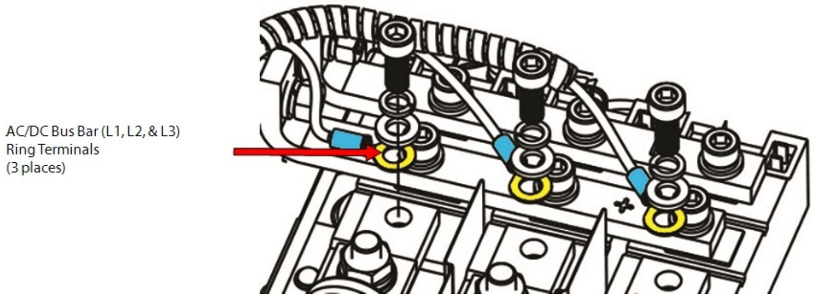
4.17.2 Soft Start AC/DC Harness Removal and Installation

NOTE
For TTS300/TGS230 Compressors, it may be helpful to remove the Soft Start and/or the Open-Frame DC-DC to gain better access for this procedure.

4.17.2.1 Soft Start AC/DC Harness Removal - TTS300/TGS230

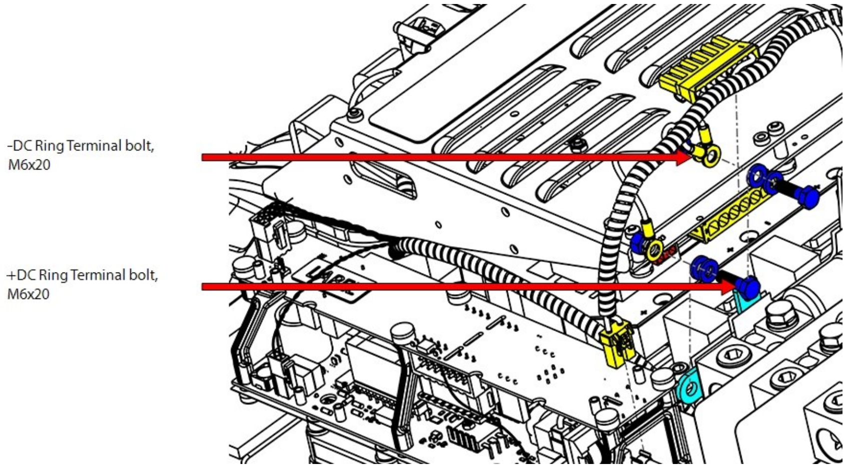
1. Isolate compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Disconnect the three (3) ring terminals labeled L1, L2, and L3 from the AC Bus Bars. Refer to Figure 4-128 Input Ring Terminal Removal - TTS300/TGS230 on page 134.

Figure 4-128 Input Ring Terminal Removal - TTS300/TGS230



3. Disconnect the two (2) -DC ring terminals from the -DC bus bar by removing the attaching hardware. Refer to Figure 4-129 DC Ring Terminal Removal - TTS300/TGS230 for this and the following step.
4. Disconnect the +DC ring terminal from the +DC bus bar by removing the attaching hardware.

Figure 4-129 DC Ring Terminal Removal - TTS300/TGS230



5. Remove the DC-DC Connections – If the DC-DC is the potted style, remove connectors J1 and J4. If the DC-DC is the open-frame style, only J1 will need to be removed. Refer to Figure 4-130 DC-DC Connectors (Open Frame) and Figure 4-131 DC-DC Connectors (Potted) on page 135.

Figure 4-130 DC-DC Connectors (Open Frame)

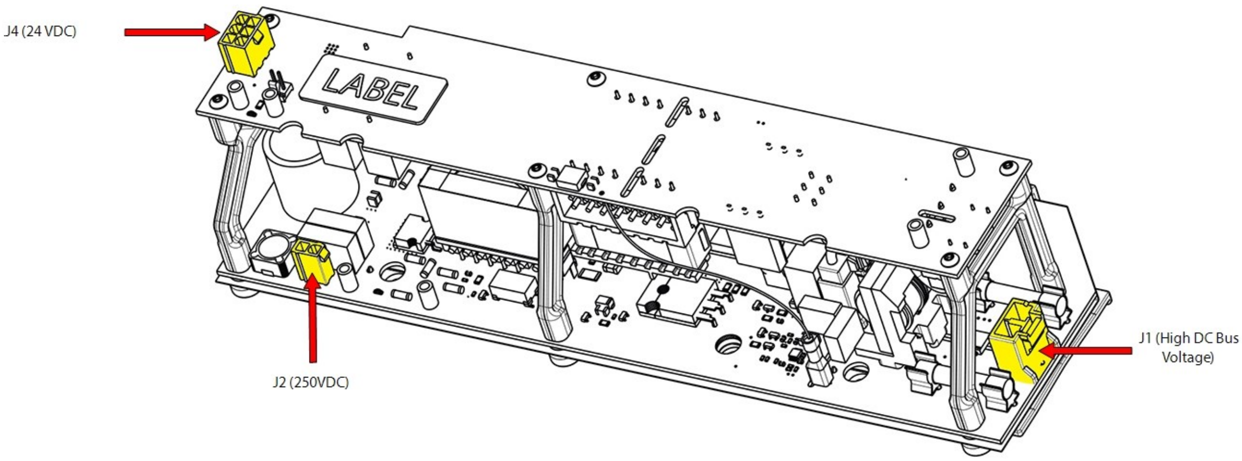
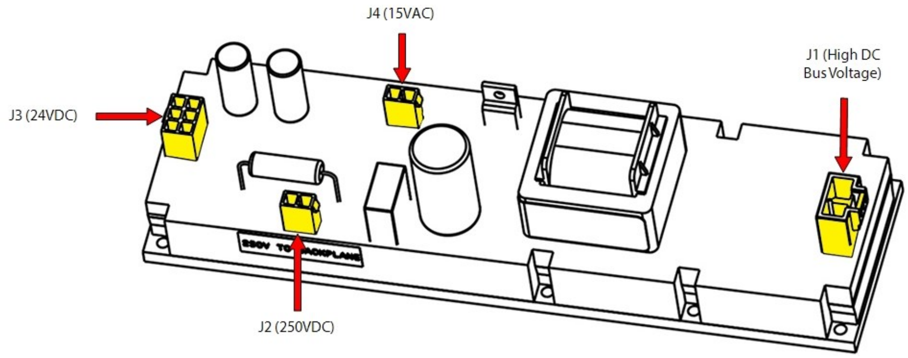


Figure 4-131 DC-DC Connectors (Potted)



6. If the DC-DC Converter is the potted style, remove the J7 connector from the Soft Start. Refer to Figure 4-132 Closed-Top Soft Start J1 and J7 Removal for this and the following step.

NOTE
TT/TG compressors utilizing the open frame DC-DC design do not utilize the Closed-Top Soft Start J7: Trigger Signal connector.

7. Remove the Soft Start AC/DC Harness from the Softstart.
    a. For compressors with the Closed-Top Soft Start, remove the J1 and J7 (if equipped) connector. Refer to Figure 4-132 Closed-Top Soft Start J1 and J7 Removal.
    b. For compressors with the Open-Top Soft Start, remove connectors J1 and J8. Refer to Figure 4-133 Open-Top Soft Start J1 and J8 Removal on page 136.

Figure 4-132 Closed-Top Soft Start J1 and J7 Removal

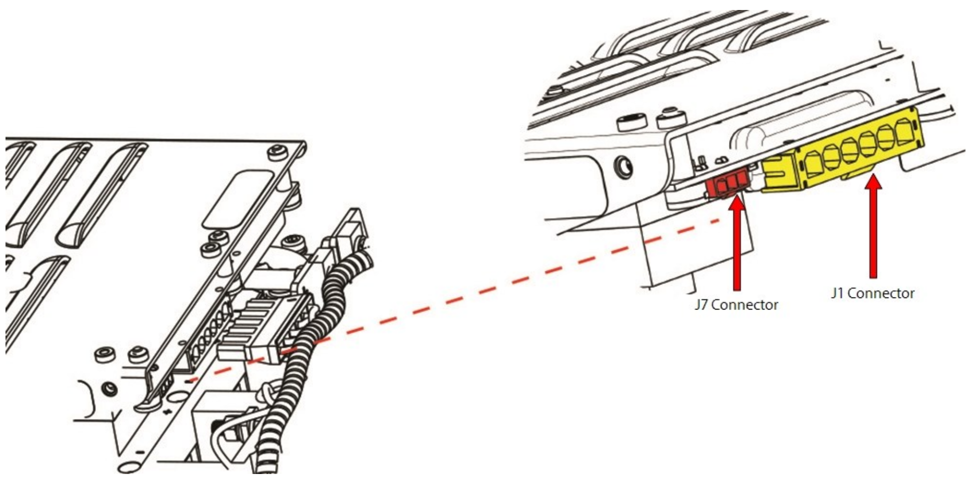
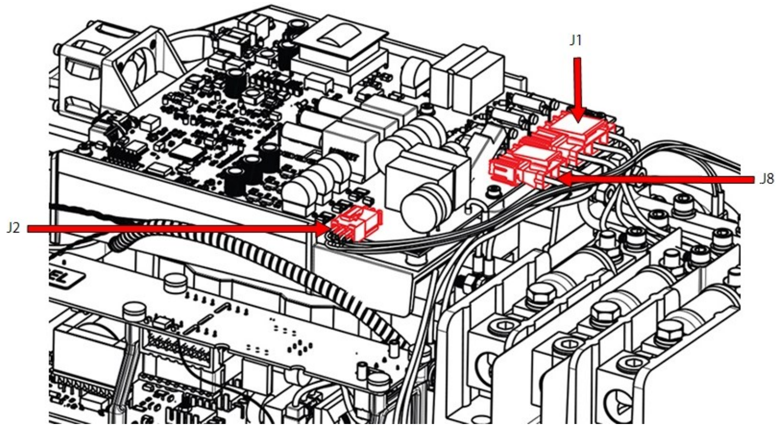


Figure 4-133 Open-Top Soft Start J1 and J8 Removal



8. Remove the harness.

4.17.2.2 Soft Start AC/DC Harness Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230)

1. Isolate compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Disconnect the L1, L2, and L3 terminals from the AC Bus Bars.
   a. For Revision F and earlier compressors, refer to Figure 4-134 AC Input Spade and DC Spade Connector Removal - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230).
   b. For Rev H compressors, refer to Figure 4-135 AC Input Ring and DC Spade Connector Removal - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230) on page 137.
3. Disconnect the -DC and +DC spade terminals from the DC bus bar.
   a. For Revision F and earlier compressors refer to Figure 4-134 AC Input Spade and DC Spade Connector Removal - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230).
   b. For Rev H compressors, refer to Figure 4-135 AC Input Ring and DC Spade Connector Removal - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230) on page 137.

Figure 4-134 AC Input Spade and DC Spade Connector Removal - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230)

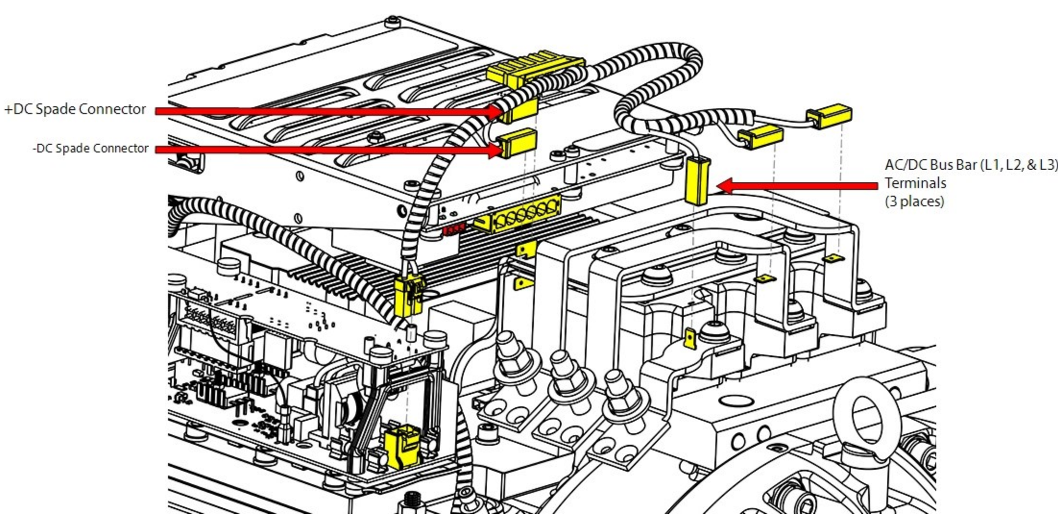
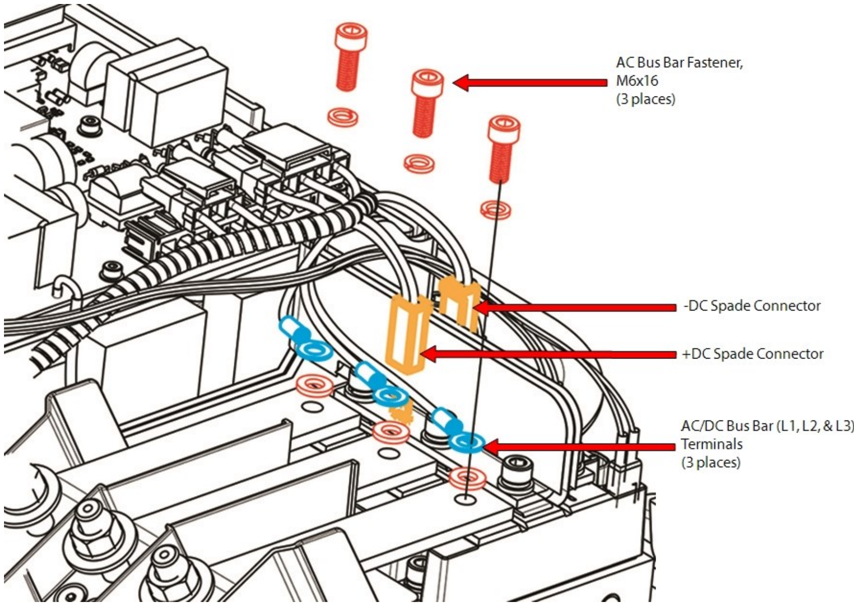


Figure 4-135 AC Input Ring and DC Spade Connector Removal - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230)



4. Remove the DC-DC Connections.
    a. If the DC-DC is the potted style, remove connectors J1 and J4. Refer to Figure 4-131 DC-DC Connectors (Potted) on page 135.
    b. If the DC-DC is the open-frame style, only J1 will need to be removed. Refer to Figure 4-130 DC-DC Connectors (Open Frame) on page 134.
5. Remove the Soft Start AC/DC Harness from the Soft Start.
    a. For compressors with the Closed-Top Soft Start, remove the J1 and J7 (if equipped) connector. Refer to Figure 4-132 Closed-Top Soft Start J1 and J7 Removal on page 135.

NOTE
Compressors utilizing the open frame DC-DC design do not utilize the J7: Trigger Signal connector.

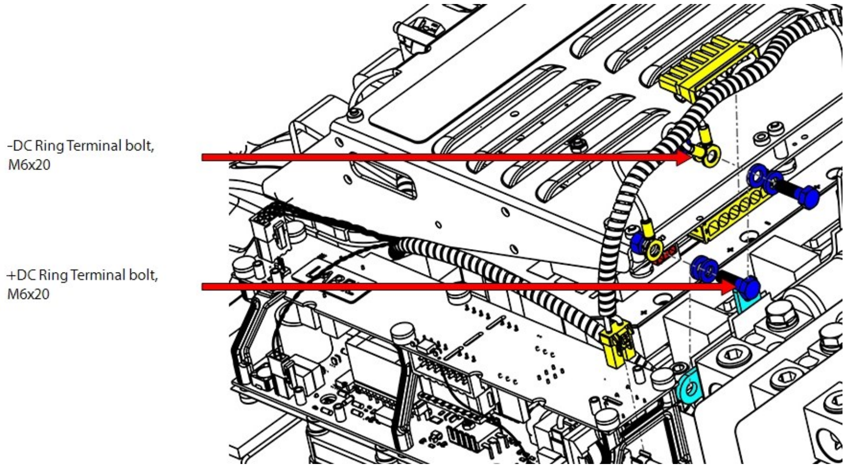
    b. For compressors with the Open-Top Soft Start, remove connectors J1 and J8. Refer to Figure 4-133 Open-Top Soft Start J1 and J8 Removal on page 136.
6. Remove the harness.

4.17.2.3 Soft Start AC/DC Harness Installation - TTS300/TGS230

NOTE
For TTS300/TGS230 Compressors, it may be helpful to remove the Soft Start and/or the Open-Frame DC-DC to gain better access for this procedure.

1. Place the wiring harness on top of the compressor. Refer to Figure 4-136 Soft Start AC/DC Harness Position - TTS300/TGS230 on page 138 for this and the next five (5) steps.

Figure 4-136 Soft Start AC/DC Harness Position - TTS300/TGS230



2. Install the “J1: High DC Bus Voltage” Soft Start connector.
3. Connect the +DC ring terminal to the +DC bus bar with the attaching hardware.
4. Connect the two (2) -DC ring terminals to the -DC bus bar with the attaching hardware. Torque the fasteners to 10 Nm (89 in.lb.).
5. Connect the three (3) ring terminals labeled L1, L2, and L3 to the AC Bus Bars. Torque the M6x16 fasteners to 5 Nm (44 in.lb.).
6. If the DC-DC Converter is the potted style, install the J7 Soft Start connector.
7. Install the J1 DC-DC connector to the DC-DC Converter. Refer to Figure 4-130 DC-DC Connectors (Open Frame) on page 134. if this compressor contains the Open Frame DC-DC Converter, or to Figure 4-131 DC-DC Connectors (Potted) on page 135.
8. If the DC-DC Converter is the potted style, install the J4 connector to the DC-DC Converter. Refer to Figure 4-131 DC-DC Connectors (Potted) on page 135.
9. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
10. Return the compressor to normal operation.

4.17.2.4 Soft Start AC/DC Harness Installation - TTS/TGS/TTH/TGH (Except TTS300/TGS230)

1. Place the wiring harness on top of the compressor.
2. Install the Soft Start AC/DC Harness onto the Soft Start.
   a. For compressors with the Closed-Top Soft Start, install the J1 and J7 (if equipped) connector. Refer to Figure 4-132 Closed-Top Soft Start J1 and J7 Removal on page 135.

NOTE
For TTS300/TGS230 Compressors, it may be helpful to remove the Soft Start and/or the Open-Frame DC-DC to gain better access for this procedure.

   b. For compressors with the Open-Top Soft Start, install connectors J1 and J8. Refer to Figure 4-133 Open-Top Soft Start J1 and J8 Removal on page 136.
3. Install the DC-DC connections.
   a. If the DC-DC is the potted style, install connectors J1 and J4. Refer to Figure 4-131 DC-DC Connectors (Potted) on page 135.

b. If the DC-DC is the open-frame style, only J1 will need to be installed. Refer to Figure 4-130 DC-DC Connectors (Open Frame) on page 134.

4. Install the -DC and +DC spade terminals onto the DC bus bar.

   a. For Revision F and earlier compressors refer to Figure 4-137 AC Input and Spade Connector Installation - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230).

   b. For Rev H compressors, refer to Figure 4-138 AC Input and Spade Connector Installation - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230).

5. Install the L1, L2, and L3 terminals to the AC Bus Bars.

   a. For Revision F and earlier compressors, refer to Figure 4-137 AC Input and Spade Connector Installation - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230).

   b. For Rev H compressors, refer to Figure 4-138 AC Input and Spade Connector Installation - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230).

Figure 4-137 AC Input and Spade Connector Installation - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230)

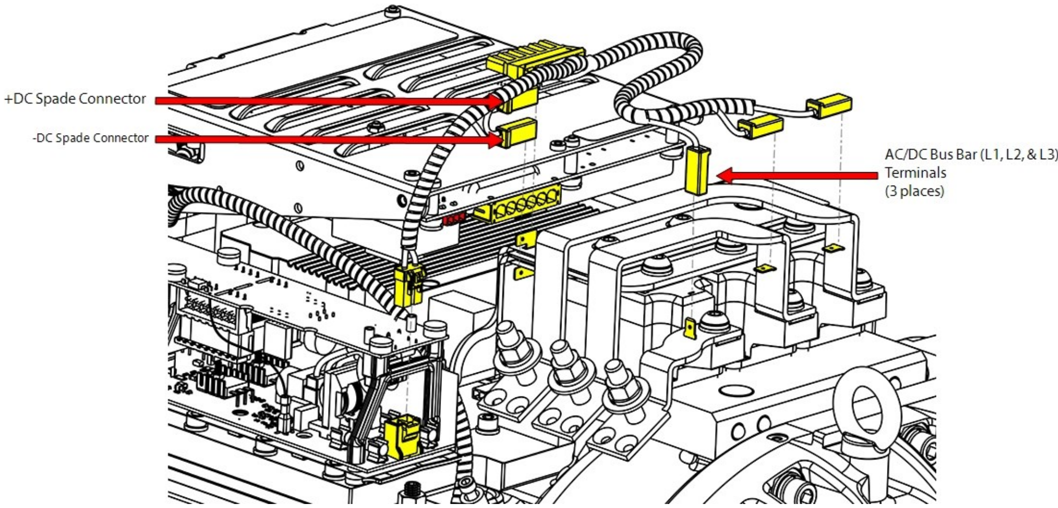
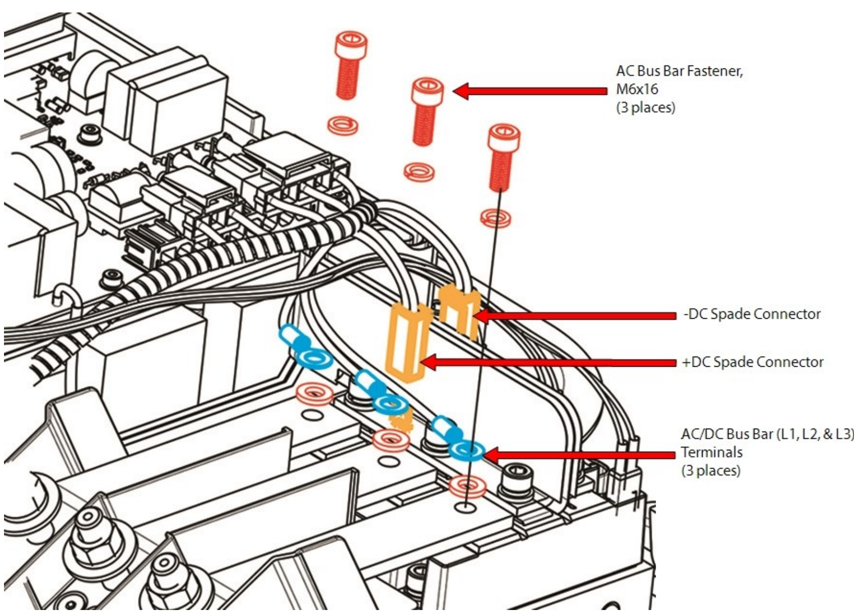


Figure 4-138 AC Input and Spade Connector Installation - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230)



6. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
7. Return the compressor to normal operation.

4.17.2.5 Soft Start AC/DC Harness Torque Specifications

Table 4-27 Soft Start AC/DC Harness Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
AC Bus Bar to SCR fastener, M5x16	5	-	44
Soft Start DC+ & DC- to DC Bus Bolt/nut (TTS300/TGS230 only)	10	7	89
Cover Fastener, M5x15	1.5	-	13

4.18 Silicone-Controlled Rectifier

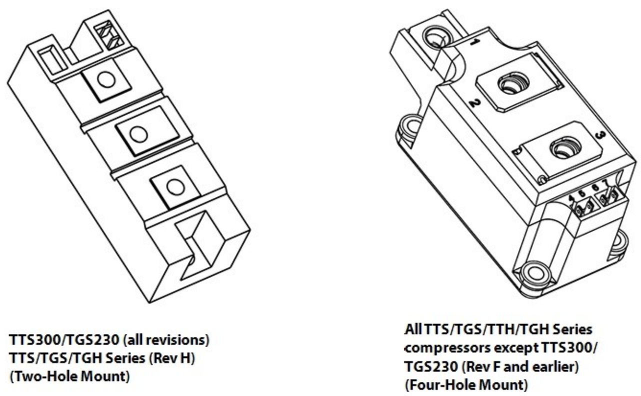
The AC input voltage is connected to the SCRs by the Mains Input bus bars. The SCRs are used to convert the AC voltage into DC voltage. SCRs maintain the high voltage DC bus necessary to provide power to the Inverter to run the compressor motor.

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 while the DC capacitors are charging up.

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

There are two (2) different styles used for the compressors. Refer to Figure 4-139 SCR Styles for the visual differences.

Figure 4-139 SCR Styles



4.18.1 SCR Connections

Refer to Figure 4-140 SCR Connections - TTS300/TGS230 and Figure 4-141 SCR Connections - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230) on page 142 to locate the following connections to the SCRs:

- AC input to SCR
- SCR Gate cables to Soft Start
- SCR to DC bus

Figure 4-140 SCR Connections - TTS300/TGS230

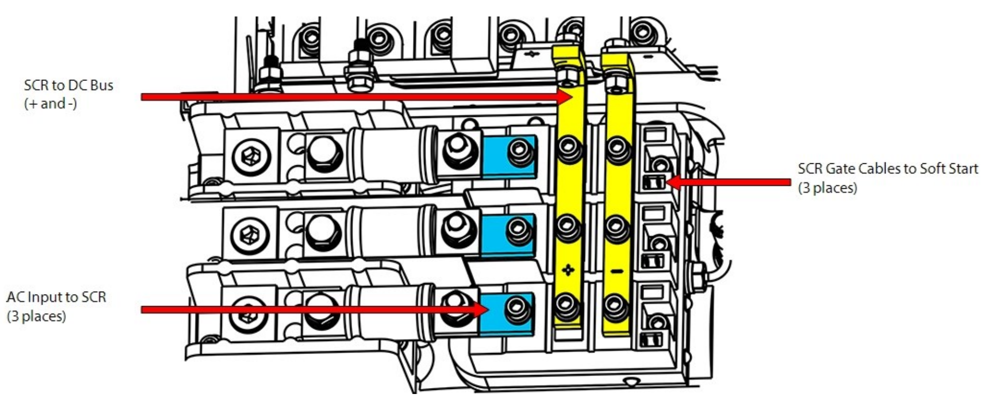


Figure 4-141 SCR Connections - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230)

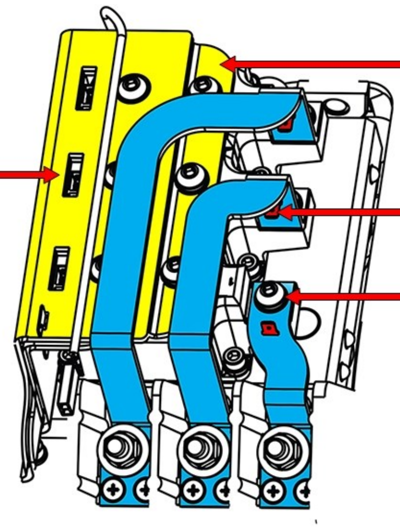
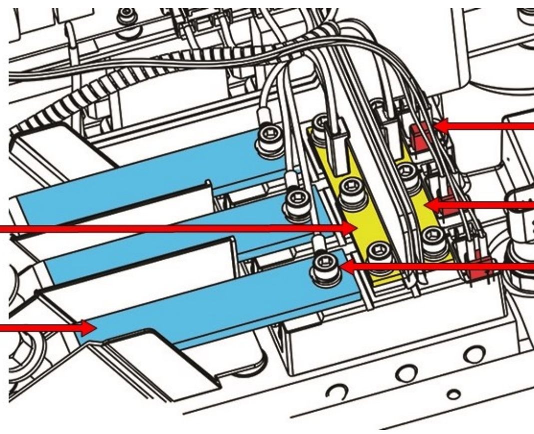


Figure 4-142 SCR Connections - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230)



4.18.2 SCR 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.

4.18.2.1 Diodes Verification - Two-Hole Mount

1. Isolate compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Remove the DC Bus Bars from the SCRs. Refer to Section 4.21.3 DC Capacitor Bus Bar Assembly Removal and Installation on page 168.
3. 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. Refer to Figure 4-143 SCR Terminals - Two-Hole Mount on page 143 and Figure 4-144 SCR Terminals - Four-Hole Mount on page 143 for terminal locations.
4. All other terminals should read infinity or open in both directions (polarity). Refer to Table 4-28 SCR Diode Values on page 144.
5. Perform this test for each SCR.

6. Install the DC Bus Bars to the SCRs. Refer to Section 4.21.3 DC Capacitor Bus Bar Assembly Removal and Installation on page 168.
7. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
8. Return the compressor to normal operation.

Figure 4-143 SCR Terminals - Two-Hole Mount

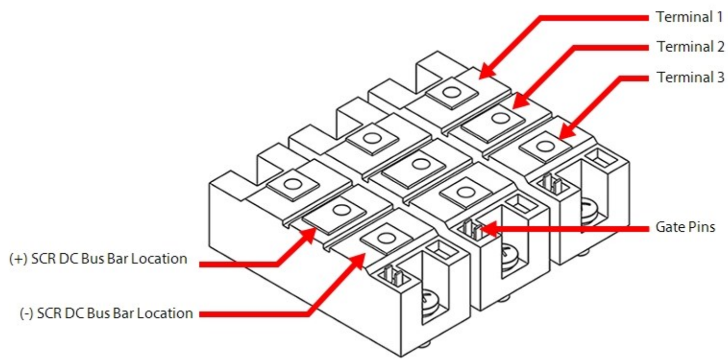
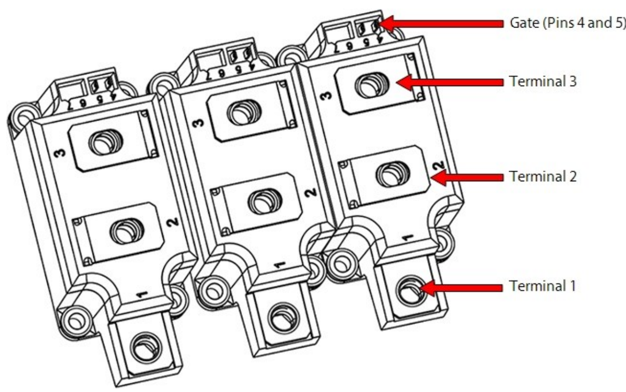


Figure 4-144 SCR Terminals - Four-Hole Mount



4.18.2.2 Diodes Verification - Four-Hole Mount

1. Isolate compressor power as described in Section1.8 Electrical Isolation on page 22.
2. Remove the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
3. Remove the AC mains input terminals and bus bars. Refer to Section 4.11.2 3-Phase Main Voltage Input Terminal Block Removal and Installation on page 102.
4. Remove the Capacitor Assembly. Refer to Section 4.21.3 DC Capacitor Bus Bar Assembly Removal and Installation on page 168.
5. 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. Refer to Figure 4-143 SCR Terminals - Two-Hole Mount and Figure 4-144 SCR Terminals - Four-Hole Mount.
6. All other terminals should read infinity or open in both directions (polarity). Refer to Table 4-28 SCR Diode Values on page 144.
7. Perform this test for each SCR.
8. Install the Capacitor and DC Bus Assembly and verify the SCR Temperature Sensor Cable is not pinched. Refer to Section 4.21.4.4 DC Capacitor Bus Bar Assembly Installation - TTS/TGS/TTH/TGH (Except TTS300/TGS230) on page 174.

9. Install the Terminal Block and AC Bus Bars. Refer to Section 4.11.2 3-Phase Main Voltage Input Terminal Block Removal and Installation on page 102.
10. Connect the Soft Start AC wires to the AC Bus Bars.
11. Install the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
12. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
13. Return the compressor to normal operation.

Table 4-28 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

4.18.2.3 Gates Verification

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Using needle-nose pliers, carefully remove the SCR Gate Cable Harness from the SCRs. Refer to Figure 4-140 SCR Connections - TTS300/TGS230 and Figure 4-141 SCR Connections - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230).
3. Using a multimeter set for resistance measurements, place the leads on the two (2) 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 and the environmental conditions at the time. It is important that the values be consistent between SCRs.

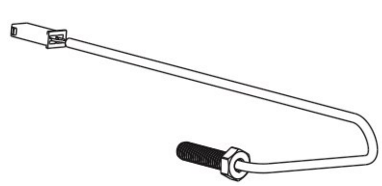
Table 4-29 SCR Gate Resistance Ranges

SCR Model	Range
All models	1 - 25Ω

4.18.2.4 SCR Temperature Sensor

This section applies to TTS/TGS Revision G and earlier compressors only. The TTS/TGS Revision H and TTH compressors do not utilize an SCR Temperature Sensor.

Figure 4-145 SCR Temperature Sensor Assembly



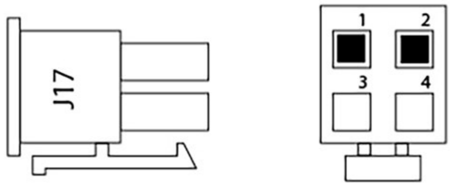
4.18.2.5 SCR Temperature Sensor Verification

1. Isolate the compressor power as described Section 1.8 Electrical Isolation on page 22.
2. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on

page 54.

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

Figure 4-146 J17 Connector



4. Using a multimeter set for resistance measurements, place the leads in terminal 1 and 2 of the cable plug. Refer to Figure 4-146 J17 Connector. The value should correspond with a negative temperature coefficient (NTC) thermistor 10KΩ @ 70°F (21° C). Refer to Figure 4-273 Temperature vs. Resistance on page 246.

4.18.2.6 SCR Temperature Sensor General Removal

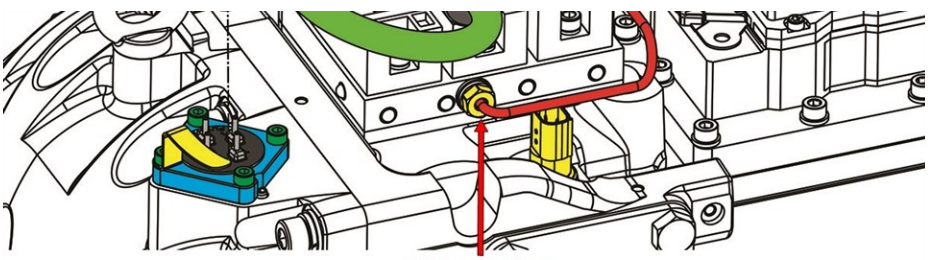
NOTE
The SCR Temperature Sensor is NOT in the refrigerant circuit and does not require refrigerant recovery.

1. Isolate the compressor power as described Section 1.8 Electrical Isolation on page 22.
2. Remove the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
3. Continue to Section 4.18.2.7 SCR Temperature Sensor Removal - TTS300/TGS230 for TT300/TG230 compressors and for all other TT/TG compressors, continue to Section 4.18.2.8 SCR Temperature Sensor Removal - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230) on page 146.

4.18.2.7 SCR Temperature Sensor Removal - TTS300/TGS230

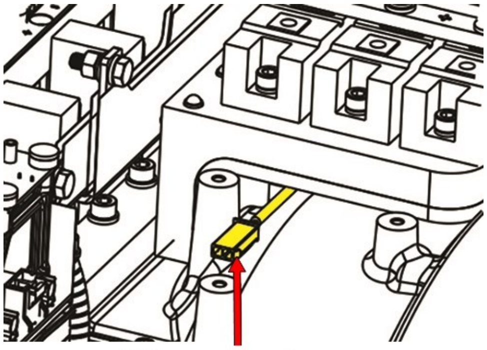
1. Disconnect compressor controller cable from the Discharge P/T sensor and move the cable aside to access the SCR temperature sensor. Refer to Figure 4-147 SCR Temperature Sensor location - TTS300/TGS230.

Figure 4-147 SCR Temperature Sensor location - TTS300/TGS230



2. Remove the Main Voltage Input Terminal Block. Refer to Section 4.11.2.2 Specific 3-Phase Main Voltage Input Terminal Block Removal - TTS300/TGS230 on page 102.
3. Disconnect the SCR Temperature Sensor from the Compressor Controller Harness and gently pull the sensor cable under the SCR Cooling Manifold from the discharge side of the compressor. Refer to Figure 4-148 SCR Temperature Sensor Connector - TTS300/TGS230 on page 146.

Figure 4-148 SCR Temperature Sensor Connector - TTS300/TGS230

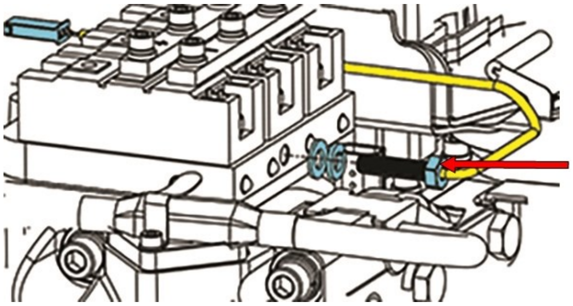


4. Remove the SCR Temperature Sensor from the SCR Cooling Manifold. Refer to Figure 4-149 SCR Temperature Sensor Removal -TTS300/TGS230.

• • • CAUTION • • •

Be careful to not damage the wire exiting the SCR Temperature Sensor during removal.

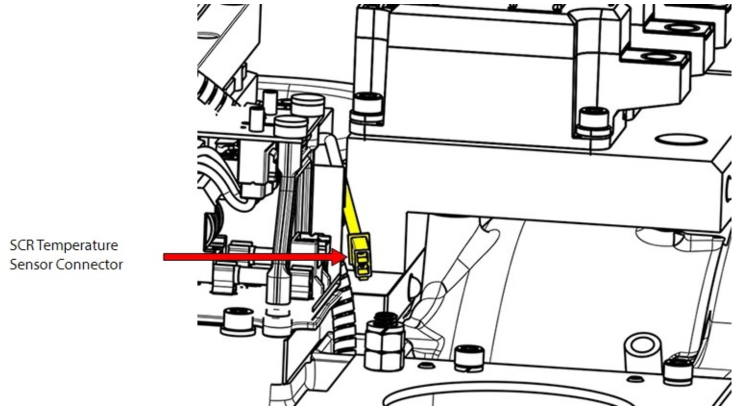
Figure 4-149 SCR Temperature Sensor Removal -TTS300/TGS230



4.18.2.8 SCR Temperature Sensor Removal - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230)

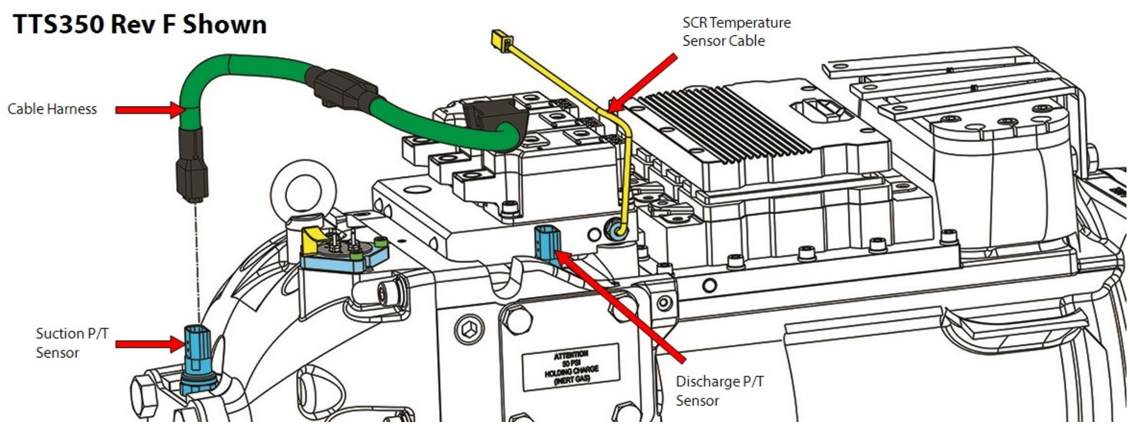
1. Disconnect the Soft Start AC wires from the AC Bus Bars.
2. Remove the Terminal Block and AC Bus Bars as an assembly. Refer to Section 4.11.2.3 3-Phase Main Voltage Input Terminal Block Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230) on page 103.
3. Remove the Capacitor and DC Bus Assembly. Refer to Section 4.21.4.2 DC Capacitor Bus Bar Assembly Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230) on page 170.
4. Remove the SCR Temperature Sensor cable from under the DC Bus Bar Assembly from the discharge side of the compressor. Refer to Figure 4-150 SCR Temperature Sensor Connector - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230) on page 147.

Figure 4-150 SCR Temperature Sensor Connector - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230)



5. Disconnect compressor controller cable from the Discharge P/T sensor and move cable aside to access SCR temperature sensor.

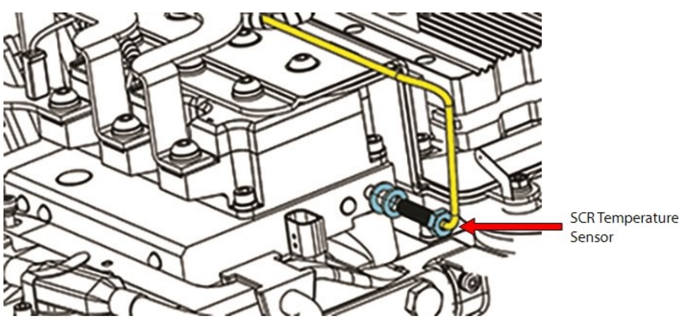
Figure 4-151 Discharge Pressure/Temperature Sensor Connector Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230)



6. Remove the SCR Temperature Sensor from the SCR Cooling Manifold. Refer to Figure 4-152 SCR Temperature Sensor Removal - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230).

• • • CAUTION • • •
Be careful to not damage the wire exiting the SCR Temperature Sensor during removal.

Figure 4-152 SCR Temperature Sensor Removal - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230)



4.18.2.9 SCR Temperature Sensor Installation - TTS300/TGS230

1. Carefully thread the SCR Temperature Sensor into the SCR Cooling Manifold and torque to 6 Nm (53 in.lbs.).

• • • CAUTION • • •

Be careful to not damage the wire exiting the SCR Temperature Sensor when tightening.

2. Carefully slide the sensor cable under the SCR Cooling Manifold from the discharge side of the compressor
3. Connect the SCR Temperature Sensor to the Compressor controller Harness. Refer to Figure 4-148 SCR Temperature Sensor Connector - TTS300/TGS230 on page 146.
4. Install the Terminal Block. Refer to Section 4.11.2.2 Specific 3-Phase Main Voltage Input Terminal Block Removal - TTS300/TGS230 on page 102.
5. Connect the discharge pressure/temperature sensor connector if it was removed.
6. Continue to Section 4.18.2.11 SCR Temperature Sensor General Installation.

4.18.2.10 SCR Temperature Sensor Installation - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230)

1. Carefully thread the SCR Temperature Sensor into the SCR Cooling Manifold and torque to 6 Nm (53 in.lbs.).

• • • CAUTION • • •

Be careful to not damage the wire exiting the SCR Temperature Sensor when tightening.

2. Connect the discharge pressure/temperature sensor connector if it was removed.
3. Install the SCR Temperature Sensor Cable in the same location. It should be on top of the SCR Cooling Manifold and next to the Inverter. Refer to Figure 4-150 SCR Temperature Sensor Connector - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230) on page 147.
4. Connect the SCR Temperature Sensor Cable to the Compressor Controller Cable Harness.
5. Install the Capacitor and DC Bus Assembly and verify the SCR Temperature Sensor Cable is not pinched. Refer to Section 4.21.4.4 DC Capacitor Bus Bar Assembly Installation - TTS/TGS/TTH/TGH (Except TTS300/TGS230) on page 174.
6. Install the Terminal Block and AC Bus Bars. Refer to Section 4.11 3-Phase Main Voltage Input Terminal Block on page 99.
7. Connect the Soft Start AC wires to the AC Bus Bars.
8. Continue to Section 4.18.2.11 SCR Temperature Sensor General Installation.

4.18.2.11 SCR Temperature Sensor General Installation

1. Install the Soft Start. Refer to Section 4.14 Soft Start on page 113.
2. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
3. Return the compressor to normal operation.

4.18.2.12 SCR Temperature Sensor Torque Specifications

Table 4-30 SCR Temperature Sensor Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
SCR Temperature Sensor (excludes TTH/TGH and Rev H compressors)	6	-	53

4.18.3 SCR Removal and Installation

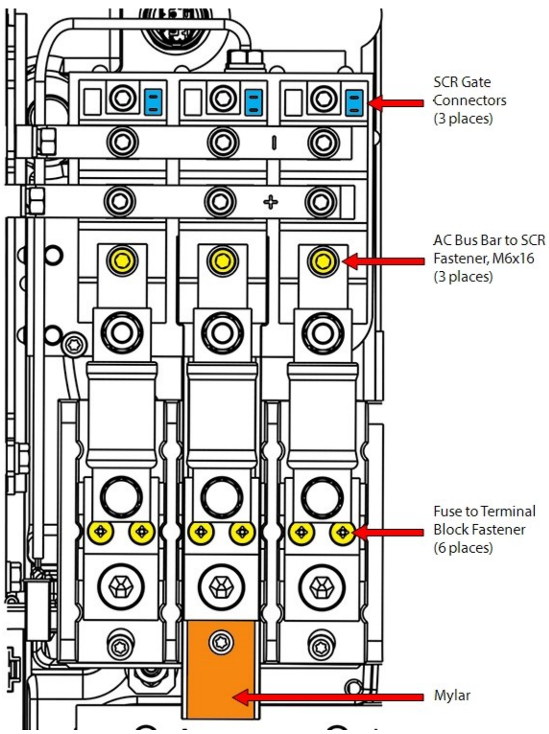
4.18.3.1 SCR General Removal

1. Isolate the compressor power as described in Section1.8 Electrical Isolation on page 22.
2. Remove the mains input cables from the Terminal Block.
3. Continue to Section 4.18.3.2 SCR Removal - TTS300/TGS230 for TTS300/TGS230 compressors; for all other TT/TG compressors, continue to Section 4.18.3.3 SCR Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230) on page 150.

4.18.3.2 SCR Removal - TTS300/TGS230

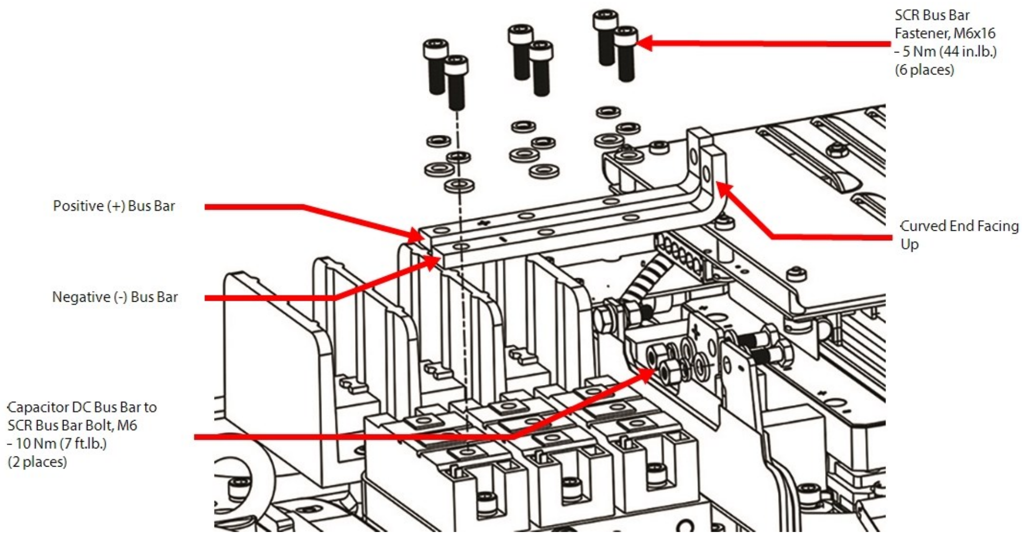
1. Disconnect the SCR Gate connectors from each rectifier. Refer to Figure 4-153 Fuse Block Assemblies - TTS300/TGS230 for this and the following four (4) steps.
2. Remove the three (3) fasteners that connect the fast-acting fuses to the SCRs.
3. Remove the six (6) Fuse to Terminal Block fasteners that secure the fuses to the Terminal Block Adapter.
4. Remove the fuses.
5. Remove the insulating Mylar.

Figure 4-153 Fuse Block Assemblies - TTS300/TGS230



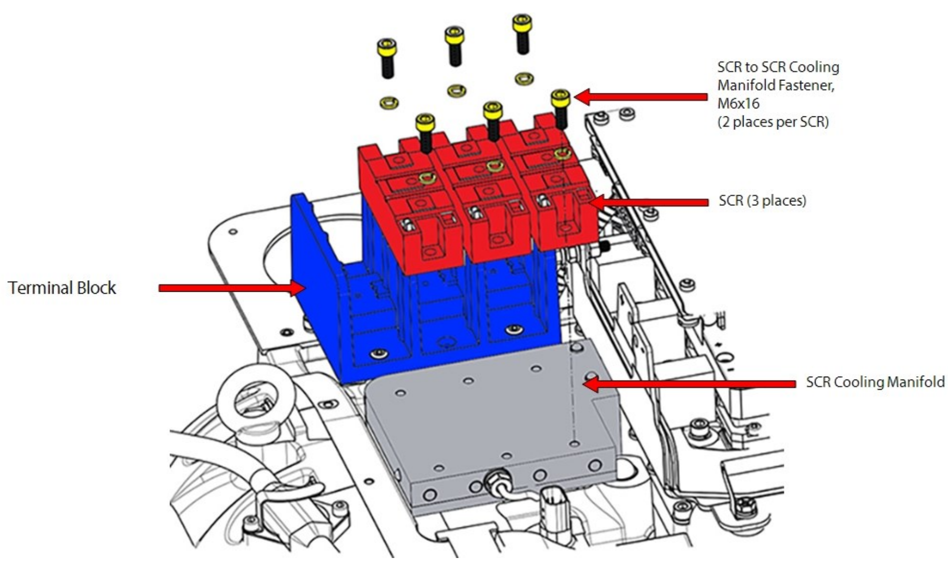
6. Remove the bolts that secure the (+) and (-) SCR Bus Bars to the DC Bus Bars. Refer to Figure 4-154 DC Bus Bar Removal - TTS300/TGS230 on page 150 and Figure 4-155 SCR Removal - TTS300/TGS230 on page 150 for this and the following two (2) steps.
7. Remove the six (6) M6x16 fasteners that secure the (+) and (-) SCR Bus Bars to the SCRs.
8. Remove the DC Bus Bars.

Figure 4-154 DC Bus Bar Removal - TTS300/TGS230



9. Remove the two (2) M6x16 fasteners that secure each SCR to the SCR Cooling Manifold and remove the SCRs. Refer to Figure 4-155 SCR Removal - TTS300/TGS230 for this and the following step.
10. Clean the heat sink paste from the SCR and Manifold using a cloth and isopropyl alcohol.

Figure 4-155 SCR Removal - TTS300/TGS230



11. Continue to Section 4.18.3.4 SCR Installation - TTS300/TGS230 on page 153.

4.18.3.3 SCR Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230)

1. Remove the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
2. Remove the SCR Gate Cables from the SCRs. Refer to Figure 4-156 -SCR Gate Cable and AC/DC Harness Connections - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230) on page 151 and Figure 4-157 SCR Gate Cable and AC/DC Harness Connections - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230) on page 151.

Figure 4-156 -SCR Gate Cable and AC/DC Harness Connections - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230)

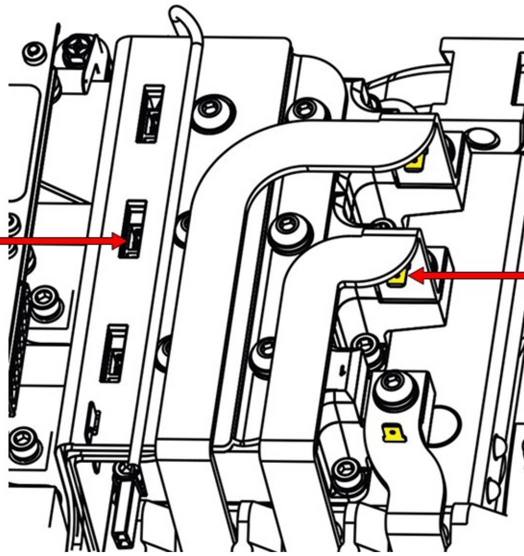
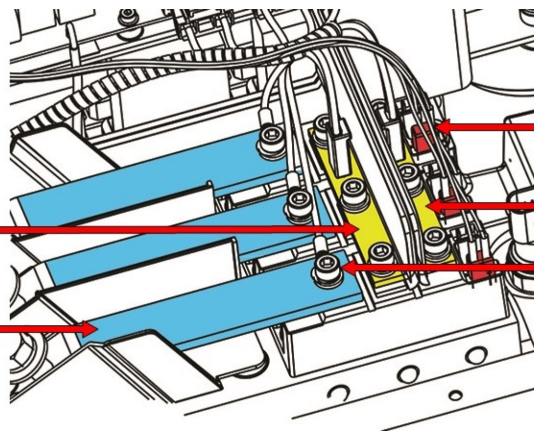


Figure 4-157 SCR Gate Cable and AC/DC Harness Connections - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230)



3. Remove the AC mains input terminals and bus bars. Refer to Section 4.11.2 3-Phase Main Voltage Input Terminal Block Removal and Installation on page 102.
4. Remove the Snubber Capacitors from the Inverter. Refer to Section 4.20 Snubber Capacitors on page 164.
5. Disconnect the DC Bus Bar from the SCRs and remove the DC Capacitor Bus Bar Assembly. Refer to Section 4.21.3 DC Capacitor Bus Bar Assembly Removal and Installation on page 168.

Figure 4-158 SCR Bus Fastener Removal - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230)

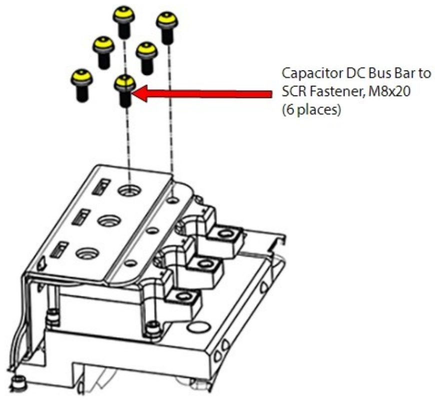
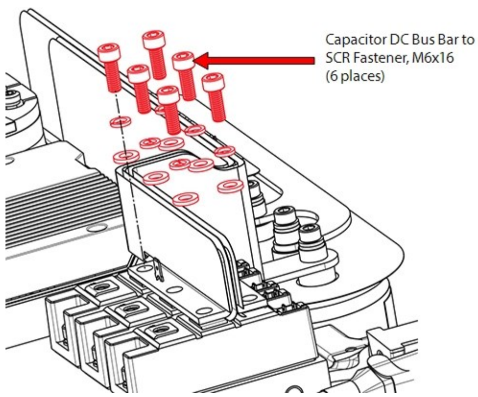


Figure 4-159 SCR Bus Fastener Removal - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230)



6. Remove the DC Capacitor Bus Bar Assembly. Refer to Section 4.21.3 DC Capacitor Bus Bar Assembly Removal and Installation on page 168.
7. Remove the SCRs.
   a. For Revision F and earlier compressors, remove the 12 M6x16 fasteners that secure the SCRs to the SCR Cooling Manifold and remove the SCRs. Refer to Figure 4-160 SCR Removal - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230).
   b. For Revision H compressors, remove the two (2) M6x16 fasteners that secure each SCR to the SCR Cooling Manifold and remove the SCRs.

Figure 4-160 SCR Removal - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230)

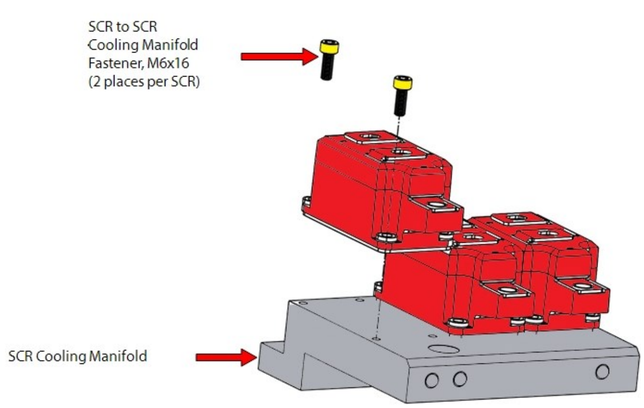
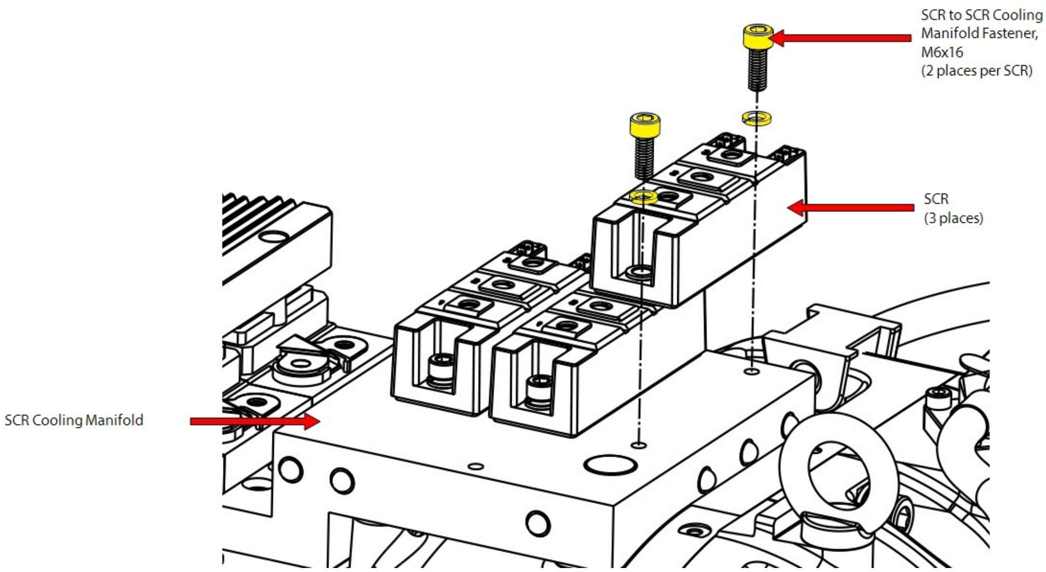


Figure 4-161 SCR Removal - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230)

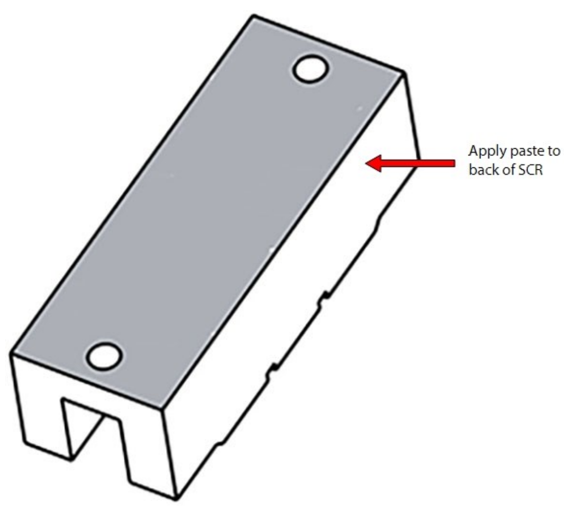


8. Clean the heat sink paste from the SCR and Manifold using a cloth and isopropyl Alcohol.
9. Continue to Section 4.18.3.5 SCR Installation - TTS/TGS/TTH/TGH (Except TTS300/TGS230) on page 155.

4.18.3.4 SCR Installation - TTS300/TGS230

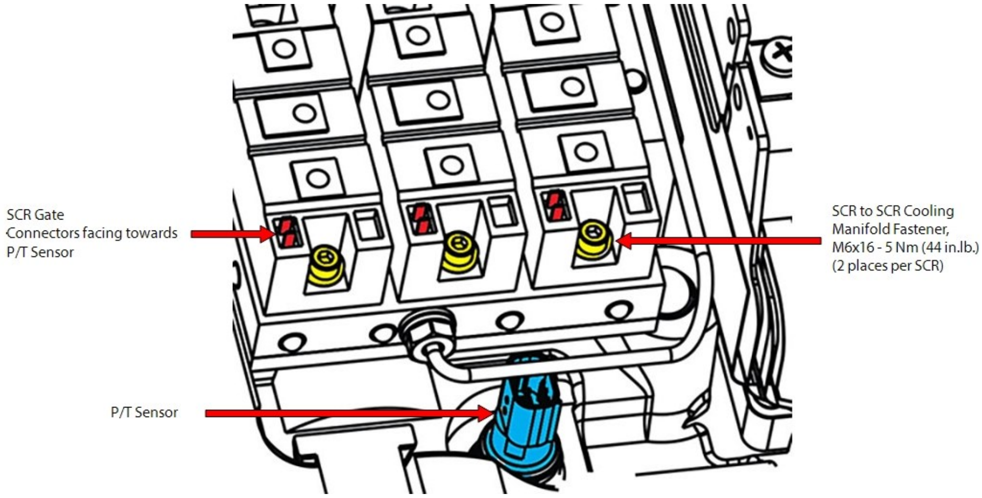
1. Clean the contact surfaces of SCR Cooling Manifold.
2. If the SCRs are to be reused, clean their mounting surface (backside) to ensure the surface is free of any contaminants.
3. Spread a thin and uniform coat of Dow Corning Silicone Heat Sink paste (or equivalent) entirely over the bottom of each SCR surface. Refer to Figure 4-162 SCR Heat Sink Paste Application - TTS300/TGS230.

Figure 4-162 SCR Heat Sink Paste Application - TTS300/TGS230



4. Install the SCRs on the SCR Cooling Manifold. The SCR Gate Connectors should be on the same side as the Discharge P/T Sensor. Refer to Figure 4-163 SCR Orientation - TTS300/TGS230 on page 154 for this and the following step.
5. Insert and finger-tighten the six (6) M6x16 SCR to SCR Cooling Manifold fasteners.

Figure 4-163 SCR Orientation - TTS300/TGS230



6. Place the negative bus bar on the SCRs. The negative bus bar should be next to the SCR Gate Connectors (aligned with the holes identified as #3 on the SCRs). Refer to Figure 4-164 Bus Bar Installation - TTS300/TGS230 and Figure 4-165 Bus Bar Locations - TTS300/TGS230 on page 155.
7. Install the positive bus bar beside the negative bus bar (aligned with holes identified as #2 on the diodes).
8. The curved section of the bus bar should be installed upwards. Refer to Figure 4-164 Bus Bar Installation - TTS300/TGS230.
9. Insert and finger-tighten the six (6) M6x16 Bus Bar fasteners. Refer to Section 4.15.1 SCR DC Bus Bar Removal and Installation on page 126 for this and the following step.
10. Insert and finger-tighten the two (2) M6x20 Bus Bar bolts and M6 nuts to secure the SCR Bus Bars to the Capacitor DC Bus Bar.

Figure 4-164 Bus Bar Installation - TTS300/TGS230

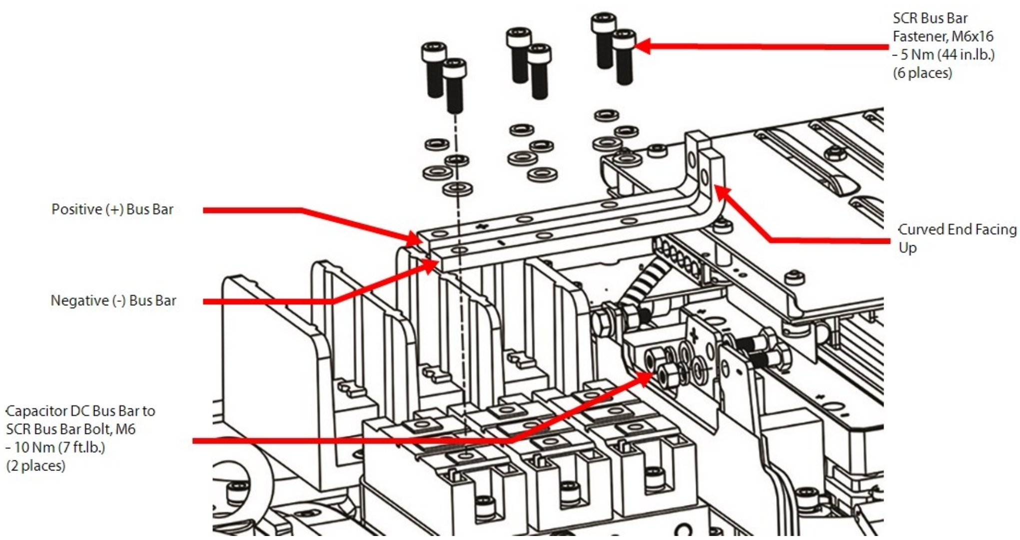
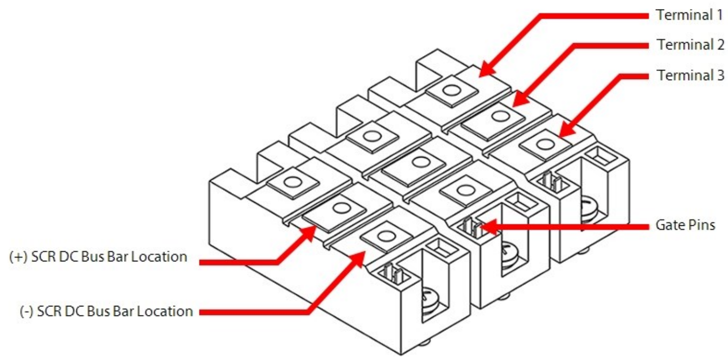


Figure 4-165 Bus Bar Locations - TTS300/TGS230

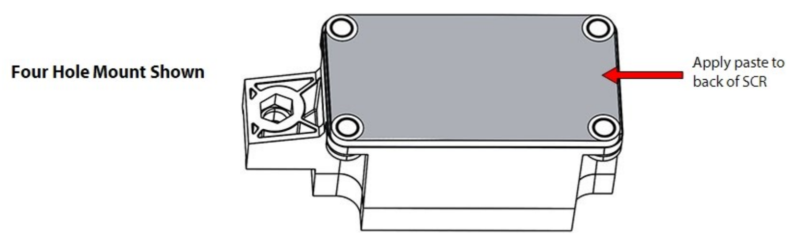


11. Torque the six (6) M6x16 SCR to SCR Cooling Manifold fasteners to 5 Nm (44 in.lb.).
12. Torque the six (6) M6x16 SCR Bus Bar fasteners to 5 Nm (44 in.lb.).
13. Torque the two (2) Capacitor DC Bus Bar to SCR Bus Bar fasteners to 10 Nm (7 ft.lb.).
14. Mount the three (3) fuse block assemblies on top of the Terminal Block Adapter, then install the two (2) fasteners for each of the three (3) fuse block assemblies and torque to 4 Nm (35 in.lb).
15. Install the three (3) M6x16 fasteners that connect the fast-acting fuses to the SCRs and torque to 5 Nm (44 in.lb).
16. Install the mains input cables to the Terminal Block and torque to 20 Nm (15 ft.lb.).
17. Continue to Section 4.18.3.6 SCR General Installation on page 156.

4.18.3.5 SCR Installation - TTS/TGS/TTH/TGH (Except TTS300/TGS230)

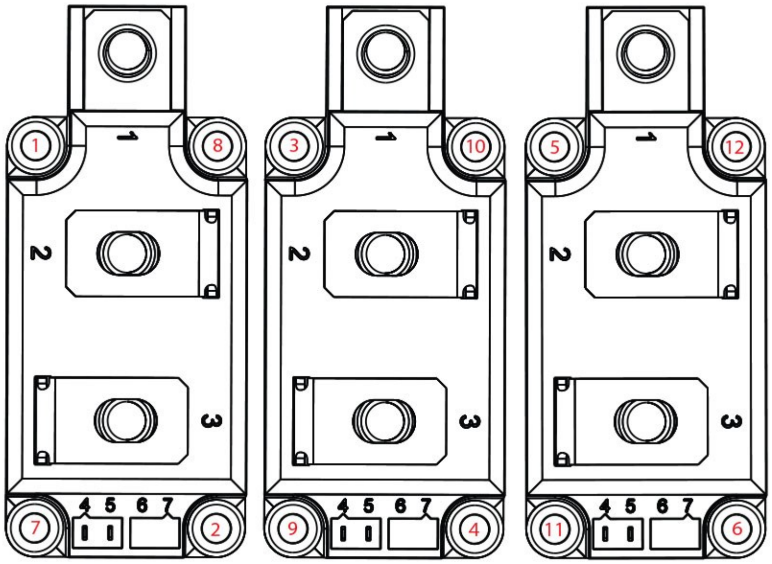
1. Clean the contact surfaces of SCR Cooling Manifold.
2. If the SCRs are to be reused, clean their mounting surface (backside) to ensure the surface is free of any contaminants.
3. Spread a thin and uniform coat of Dow Corning Silicone Heat Sink paste (or equivalent) entirely over the bottom of each SCR surface. Refer to Figure 4-166 SCR Heat Sink Paste Application - TTS/TGS/TTH/TGH (Except TTS300/TGS230).

Figure 4-166 SCR Heat Sink Paste Application - TTS/TGS/TTH/TGH (Except TTS300/TGS230)



4. Install the three (3) SCRs.
   a. For Revision F and earlier compressors, finger-tighten the 12 M6x16 fasteners, then tighten in a crisscross pattern in two (2) stages. Refer to Figure 4-167 SCR Torque Sequence - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230) on page 156.
      - Stage 1: Tighten to 2 Nm (18 in.lb.)
      - Stage 2: Tighten to a final torque of 5 Nm (44 in.lb.)
   b. For Revision H compressors, tighten the six (6) M6x16 fasteners to 5 Nm (44 in.lb).

Figure 4-167 SCR Torque Sequence - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230)



5. Install the DC Capacitor Bus Bar Assembly. Refer to Section 4.21.3 DC Capacitor Bus Bar Assembly Removal and Installation on page 168.
6. Install the AC mains input terminals and bus bars. Refer to Section 4.12.2 Input Mains Bus Bar Installation on page 109.
7. Install the mains input cables to the Terminal Block and torque to 21 Nm (15 ft.lb.).
8. Install the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
9. Continue to Section 4.18.3.6 SCR General Installation.

4.18.3.6 SCR General Installation

1. Apply dielectric grease at the top of SCR fasteners to prevent moisture and corrosion.
2. Connect the two (2) SCR Gate connectors to each SCR.
3. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
4. Return the compressor to normal operation.

4.18.3.7 SCR Torque Specifications

Table 4-31 SCR Torque Specifications

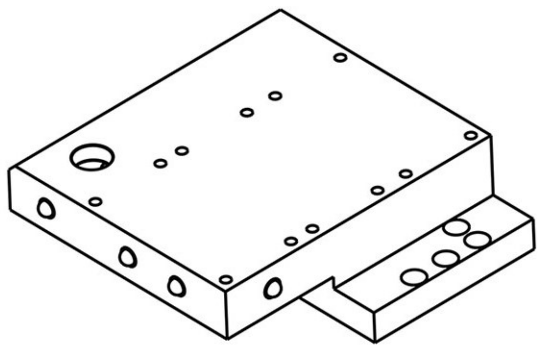
Description	Nm	Ft.Lb.	In.Lb.
TTS300/TGS230 AC Bus Bar to SCR fastener, M6x16	5	-	44
TTS300/TGS230 DC Bus Bars to SCR fastener, M6x16	5	-	44
DC Capacitor Bus Bar to SCR Bus Bar Bolt, M6	10	7	89
SCR to SCR Cooling Manifold fastener, M6x16	5	-	44
SCR to SCR Cooling Manifold fastener, M6x16 (Rev H excluding TTS300/TGS230)	5	-	44
TTS300/TGS230 Fuse to Terminal Block fastener	4	-	35
Terminal Block Mounting fastener, M5x45 (excludes TTS300/TGS230 compressors)	4	-	35
AC Bus Bar to SCR fastener, M8x20 (excludes TTS300/TGS230 compressors)	9	-	80
Capacitor DC Bus Bar to SCR fastener, M8x20 (excludes TTS300/TGS230 compressors)	9	-	80
Mains Input Pressure Screw, 11/16" - 16 UNC (TTS300/TGS230 compressors only)	20	15	177
Mains Input Nut, 3/8" - 16 UNC (excludes TTS300/TGS230 compressors)	21	15	186

4.19 SCR Cooling Manifold

The SCRs are fastened to the SCR Cooling Manifold which removes heat from the SCRs using the refrigerant that passes through it after exiting the Inverter Cooling Manifold. Refer to Section 2.2 Motor and Power Electronics Cooling on page 33.

There are different styles of SCR Cooling Manifold. The installed manifold will vary depending on the compressor model, applied options, and revision. While not all SCR Cooling Manifolds are shown here, the removal and installation steps from the various TTS/TTH/TGS/TGH compressors are the same.

Figure 4-168 SCR Cooling Manifold



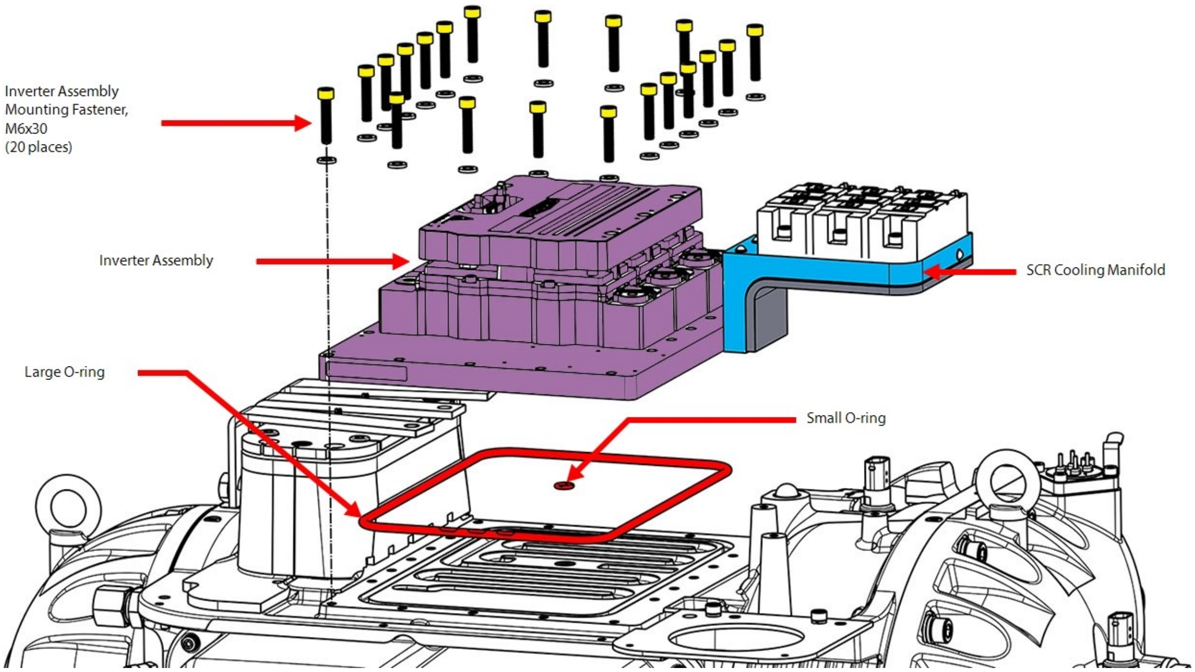
4.19.1 SCR Cooling Manifold General Removal Steps

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Isolate the compressor and recover the refrigerant according to industry standards. Refer to Section 3.1 Refrigerant Containment on page 41.
3. Remove the mains input cables from the Terminal Block.
4. Remove the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
5. For TTS300/TGS230 compressors, continue to Section 4.19.2 SCR Cooling Manifold Specific Removal Steps - TTS300/TGS230 and for all other TTS/TGS/TTH/TGH compressors, continue to Section 4.19.3 SCR Cooling Manifold Specific Removal Steps - TTS/TGS/TTH/TGH (Except TTS300/TGS230) on page 159.

4.19.2 SCR Cooling Manifold Specific Removal Steps - TTS300/TGS230

1. Remove the Fuses. Refer to Section 4.11.2.2 Specific 3-Phase Main Voltage Input Terminal Block Removal - TTS300/TGS230 on page 102.
2. Remove the Capacitor Cover. Refer to Section 4.1.4.1 Capacitor Cover Removal and Installation on page 55.
3. If the SCR Cooling Manifold is to be replaced, remove the SCR Bus Bars. Refer to Section 4.15.1 SCR DC Bus Bar Removal and Installation on page 126.
4. Remove the SCRs. Refer to Section 4.18.3.2 SCR Removal - TTS300/TGS230 on page 149.
5. Remove the DC Bus Bars and Capacitor Assembly. Refer to Section 4.15.1 SCR DC Bus Bar Removal and Installation on page 126.
6. Remove the Inverter. Refer to Section 4.22.6 Inverter Removal and Installation on page 179.

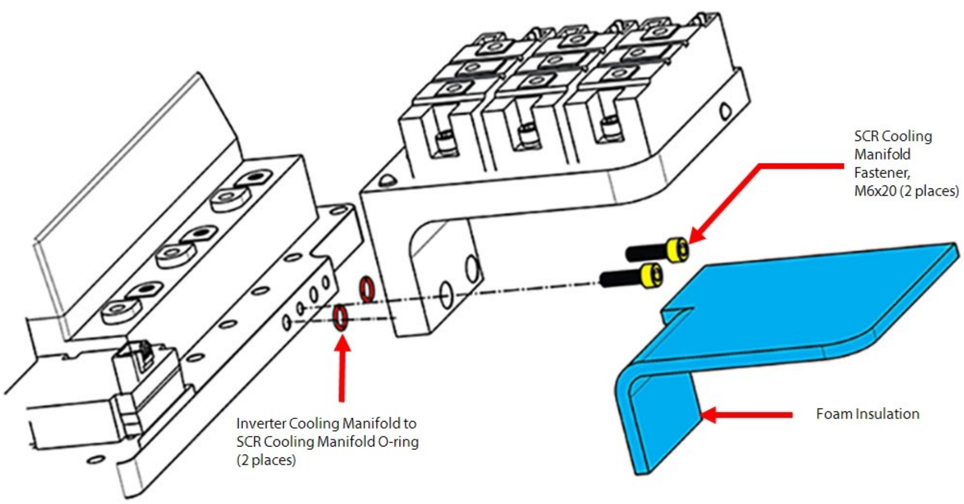
Figure 4-169 Inverter Assembly Removal - TTS300/TGS230



NOTE
Figure 4-169 Inverter Assembly Removal - TTS300/TGS230 shows the SCRs still mounted on the cooling plate. It is recommended that they are removed prior to the removal of the SCR Cooling Manifold.

7. Carefully peel back the foam to gain access to the two (2) M6x20 fasteners. Remove the two (2) SCR Cooling Manifold fasteners and remove the assembly. Refer to Figure 4-170 SCR Cooling Manifold Removal - TTS300/TGS230 for this and the following step.
8. Remove and discard the two (2) O-rings.

Figure 4-170 SCR Cooling Manifold Removal - TTS300/TGS230



NOTE

Do not completely remove the foam insulation, only pull back what is needed to access the two (2) fasteners.

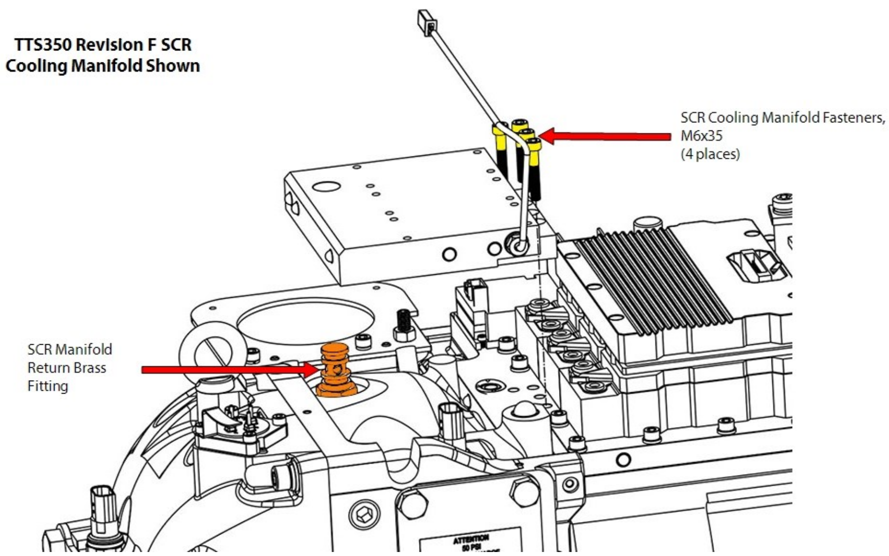
4.19.3 SCR Cooling Manifold Specific Removal Steps - TTS/TGS/TTH/TGH (Except TTS300/TGS230)

1. Remove the Terminal Block Assembly. Refer to Section 4.11.2 3-Phase Main Voltage Input Terminal Block Removal and Installation on page 102.
2. Remove the DC Bus Bars and Capacitor Assembly. Refer to Section 4.21.3 DC Capacitor Bus Bar Assembly Removal and Installation on page 168.
3. If the SCR Cooling Manifold is to be replaced, remove the SCRs. Refer to Section 4.18.3.3 SCR Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230) on page 150.
4. Remove the four (4) M6x35 SCR Cooling Manifold fasteners that secure the SCR Cooling Manifold to the Inverter Heat Sink Plate. Refer to Figure 4-171 SCR Cooling Manifold Removal for this and the following step.
5. Remove the SCR Cooling Manifold.

NOTE

Removal of the SCR Cooling Manifold will require the manifold to rocked back and forth to disengage it from the SCR Manifold Return Brass Fitting. If necessary, use a flat-blade screwdriver to gently pry the manifold upward. Use extreme caution to not damage any of the components.

Figure 4-171 SCR Cooling Manifold Removal



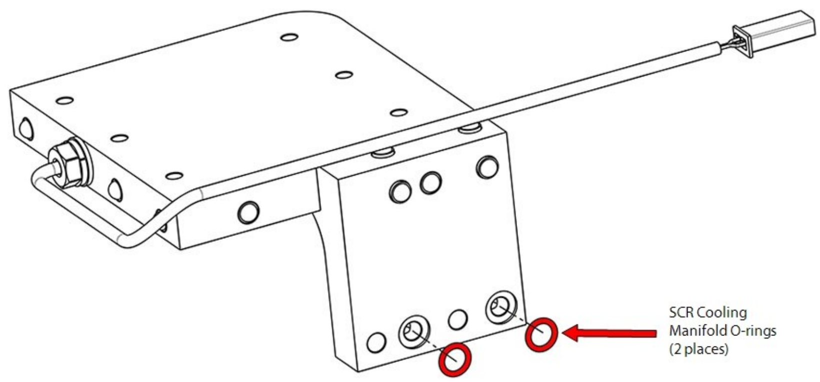
NOTE

Figure 4-171 SCR Cooling Manifold Removal illustrates a TTS350 compressor. The removal and installation process for TTH/TGH compressors is the same, with the exception of the SCR Temperature Sensor as that is not used on the TTH/TGH compressors.

4.19.4 SCR Cooling Manifold Specific Installation Steps - TTS300/TGS230

1. Apply O-Lube to the O-rings and install them into the SCR cooling manifold. Refer to Figure 4-172 SCR Manifold O-ring Installation - TTS300/TGS230.

Figure 4-172 SCR Manifold O-ring Installation - TTS300/TGS230



2. Install the SCR Cooling Manifold to the Inverter Cooling Manifold using the two (2) M6x20 fasteners. Torque to 7 Nm (62 in.lb.).
3. Secure the insulation onto the backside of the SCR Cooling Manifold.
4. Install the Inverter. Refer to Section 4.22.6.3 Compressor Specific Inverter Installation Steps - TTS300/TGS230 on page 185.

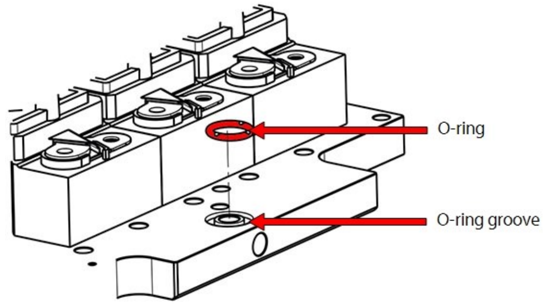
NOTE
It is recommended that the new fasteners supplied with the kit be used to ensure proper torque is obtained.

5. If the SCRs were removed previously, install the SCRs to the SCR cooling manifold. Torque the SCR fasteners to 5 Nm (44 in.lb.). Refer to Section 4.18.3.4 SCR Installation - TTS300/TGS230 on page 153.
6. Install the DC Bus Bar and Capacitor Assembly. Refer to Section 4.21.4.3 DC Capacitor Bus Bar Assembly Installation - TTS300/TGS230 on page 174.
7. Install the Terminal Block and torque the M5x15 fasteners to 3 Nm (27 in.lb.). Refer to Section 4.11.2 3-Phase Main Voltage Input Terminal Block Removal and Installation on page 102.
8. Install the Capacitor Cover. Refer to Section 4.1.4.1 Capacitor Cover Removal and Installation on page 55.
9. Install the fuse assemblies. Torque the six (6) fasteners to 4 Nm (35 in.lb.).
10. Install the mains input cables to the Terminal Block and torque to 20 Nm (15 ft.lb.).
11. Leak test and evacuate the compressor in accordance with standard industry practices.
12. Continue to Section 4.19.6 SCR Cooling Manifold General Installation Steps on page 162.

4.19.5 SCR Cooling Manifold Specific Installation Steps - TTS/TGS/TTH/TGH (Except TTS300/TGS230)

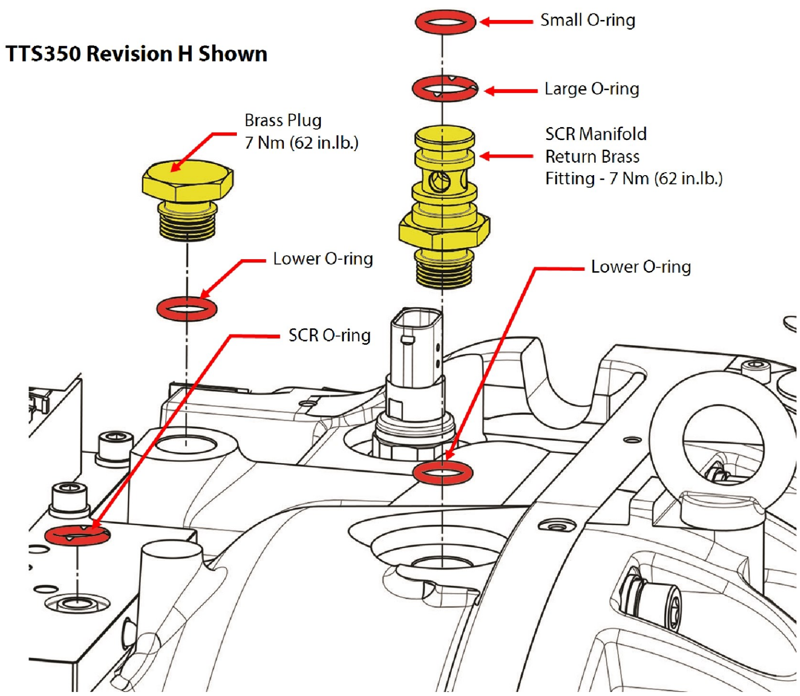
1. Clean the O-ring groove on top of the Inverter Cooling Manifold with a lint-free cloth.
2. Apply O-Lube to a new Inverter Heat Sink O-ring and place in the O-ring grove in the Inverter Heat Sink Plate and install. Refer to Figure 4-173 Inverter Heat Sink Plate O-ring Installation - TTS/TGS/TTH/TGH (Except TTS300/TGS230) on page 161.

Figure 4-173 Inverter Heat Sink Plate O-ring Installation - TTS/TGS/TTH/TGH (Except TTS300/TGS230)



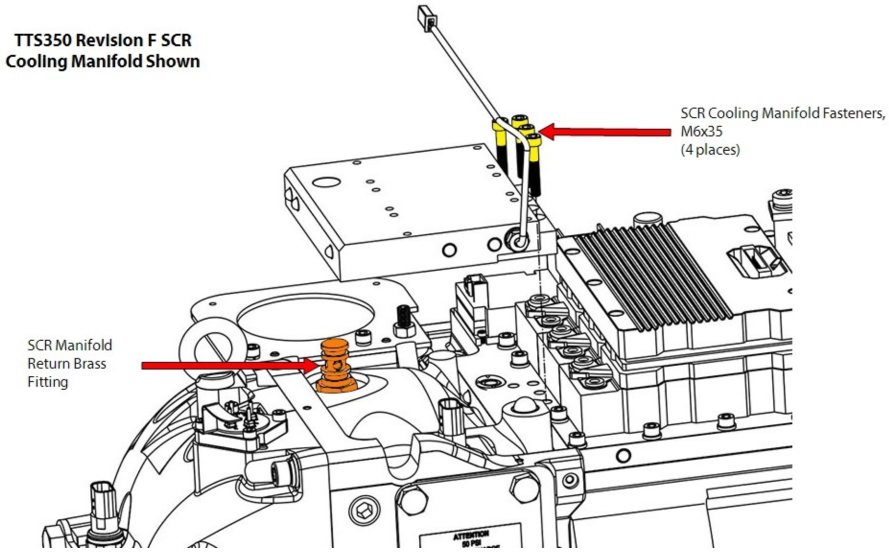
3. Clean the O-ring grooves in the SCR Manifold Return Brass Fitting with a lint-free cloth.
4. Install two (2) new O-rings on the SCR Manifold Return Brass Fitting (smaller one on top). Apply O-lube to each O-ring before installation. Refer to Figure 4-174 SCR Manifold Return Brass Fitting O-ring Installation - TTS/TGS/TTH/TGH (Except TTS300/TGS230).

Figure 4-174 SCR Manifold Return Brass Fitting O-ring Installation - TTS/TGS/TTH/TGH (Except TTS300/TGS230)



5. Carefully install the SCR Cooling Manifold over the SCR Manifold Return Brass Fitting. Press down firmly to ensure proper seating of the O-rings into the plate.
6. Install the four (4) M6x35 SCR Cooling Manifold fasteners and torque to 7 Nm (62 in. lb.).

Figure 4-175 SCR Cooling Manifold Installation - TTS/TGS/TTH/TGH (Except TTS300/TGS230)



7. Leak test and evacuate the compressor in accordance with standard industry practices.
8. Connect the compressor cable harness to the IGV Motor feedthrough, suction and discharge sensors, and SCR Temperature sensor (if applicable).
9. If the SCRs were removed previously, install the SCRs to the SCR cooling manifold. Torque the SCR fasteners to 5 Nm (44 in.lb.).
10. Install the DC Bus Bar and Capacitor assembly over the Inverter. Refer to Section 4.21.3 DC Capacitor Bus Bar Assembly Removal and Installation on page 168.
11. Install the Terminal Block Assembly. Refer to Section 4.11.2.5 3-Phase Main Input Terminal Block Installation - TTH/TGH/TTH/TGH (Except TTS300/TGS230) on page 105.
12. Install the mains input cables to the Terminal Block and torque to 21 Nm (15 ft.lb.).

4.19.6 SCR Cooling Manifold General Installation Steps

1. Install the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
2. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
3. Return the compressor to normal operation.

4.19.7 SCR Cooling Manifold Torque Specifications

Table 4-32 Table 4-33 SCR Cooling Manifold Torque Specifications.

Description	Nm	Ft.Lb.	In.Lb.
TTS300/TGS230 AC Bus Bar to SCR fastener, M6x16	5	-	44
TTS300/TGS230 DC Bus Bars to SCR fastener, M6x16	5	-	44
DC Capacitor Bus Bar to SCR Bus Bar Bolt, M6	10	7	89
SCR to SCR Cooling Manifold fastener, M6x16	5	-	44
TTS300/TGS230 SCR Cooling Manifold Fastener, M6x20	7	-	62
TTS300/TGS230 Fuse to Terminal Block fastener	4	-	35
Soft Start Mounting Fastener, M5x15 or M5x20	5	-	44
Ground Post Top Nut, 5/16" - 18 UNC	7	-	62
Ground Post Second (Jam) Nut, 5/16" - 18 UNC	7	-	62

Description	Nm	Ft.Lb.	In.Lb.
Cover Fastener, M5x15	1.5	-	13
Snubber Capacitor fastener, M6x16	7	-	62
Nylon Capacitor Nuts	7	-	62
Terminal Block Mounting fastener, M5x45 (excludes TTS300/TGS230 compressors)	4	-	35
AC Bus Bar to SCR fastener, M8x20 (excludes TTS300/TGS230 compressors)	9	-	80
Capacitor DC Bus Bar to SCR fastener, M8x20 (excludes TTS300/TGS230 compressors)	9	-	80
Mains Input Pressure Screw, 11/16" - 16 UNC (TTS300/TGS230 compressors only)	20	15	177
Mains Input Nut, 3/8" - 16 UNC (excludes TTS300/TGS230 compressors)	21	15	186
SCR Cooling Manifold Fastener, M6x35 (Excludes TTS300/TGS230 compressors)	8.5	-	75
Inverter Assembly Mounting fastener, M6x30	8.5	-	75
SCR Manifold Return Brass Fitting	7	-	62
Brass Plug	7	-	62

4.20 Snubber Capacitors

Refer to Section 4.21 DC Capacitor Bus Bar Assembly on page 165 for details on the Snubber Capacitors.

4.21 DC Capacitor Bus Bar Assembly

The DC Bus Bar Assembly includes the bus bars, DC capacitors, Snubber Capacitors, and Bleed Resistors (or Balance Board). Refer to Figure 4-176 DC Bus Components Identification TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230) and Figure 4-177 DC Bus Components Identification TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230) on page 166.

The SCRs output DC voltage to the bus bars.

The 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.

The Snubber Capacitors reduce noise associated with the Inverter switching frequency.

The Bleed Resistors (or Balance Board) are used to discharge the capacitors after power is removed to allow the compressor to be serviced safely.

Figure 4-176 DC Bus Components Identification TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230)

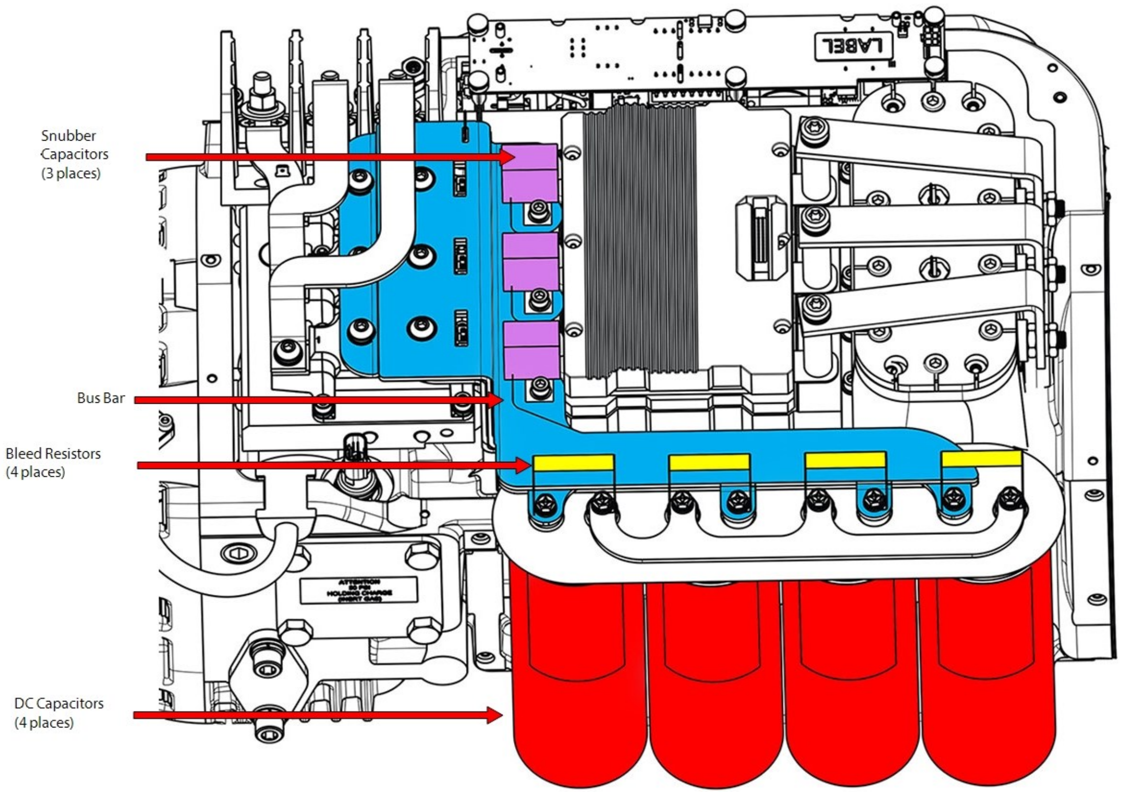
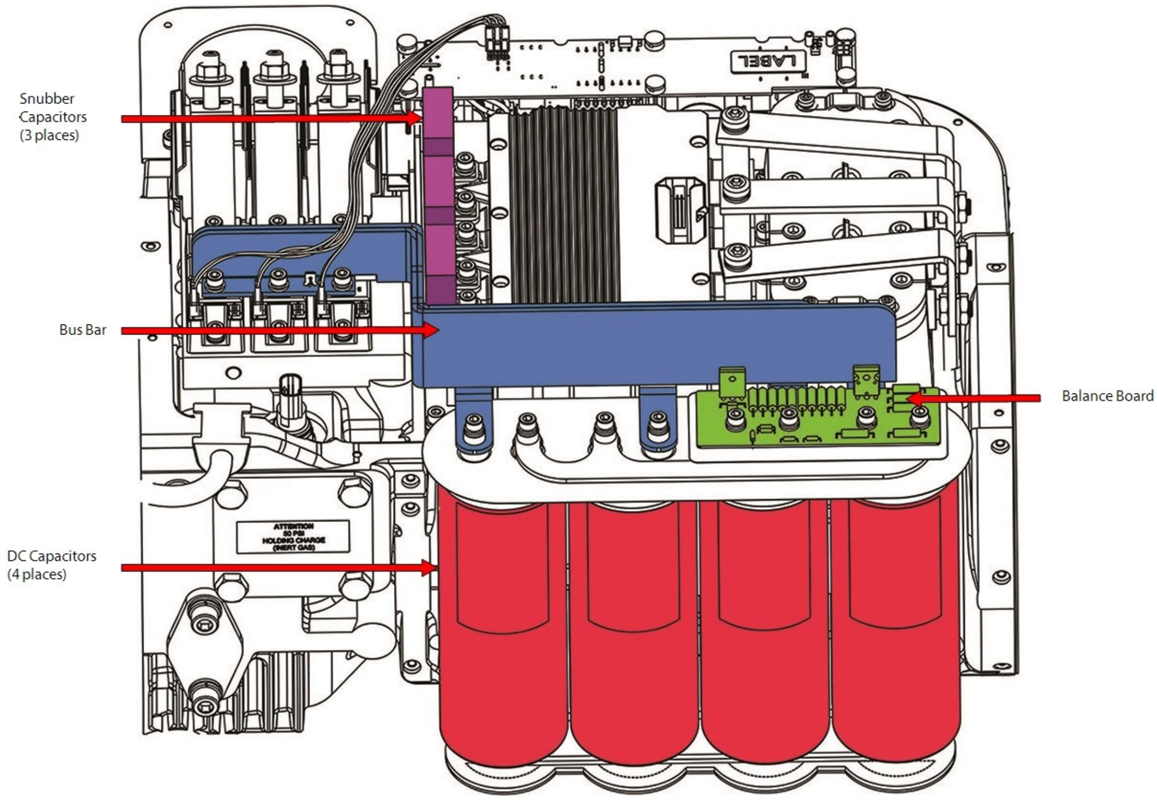


Figure 4-177 DC Bus Components Identification TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230)

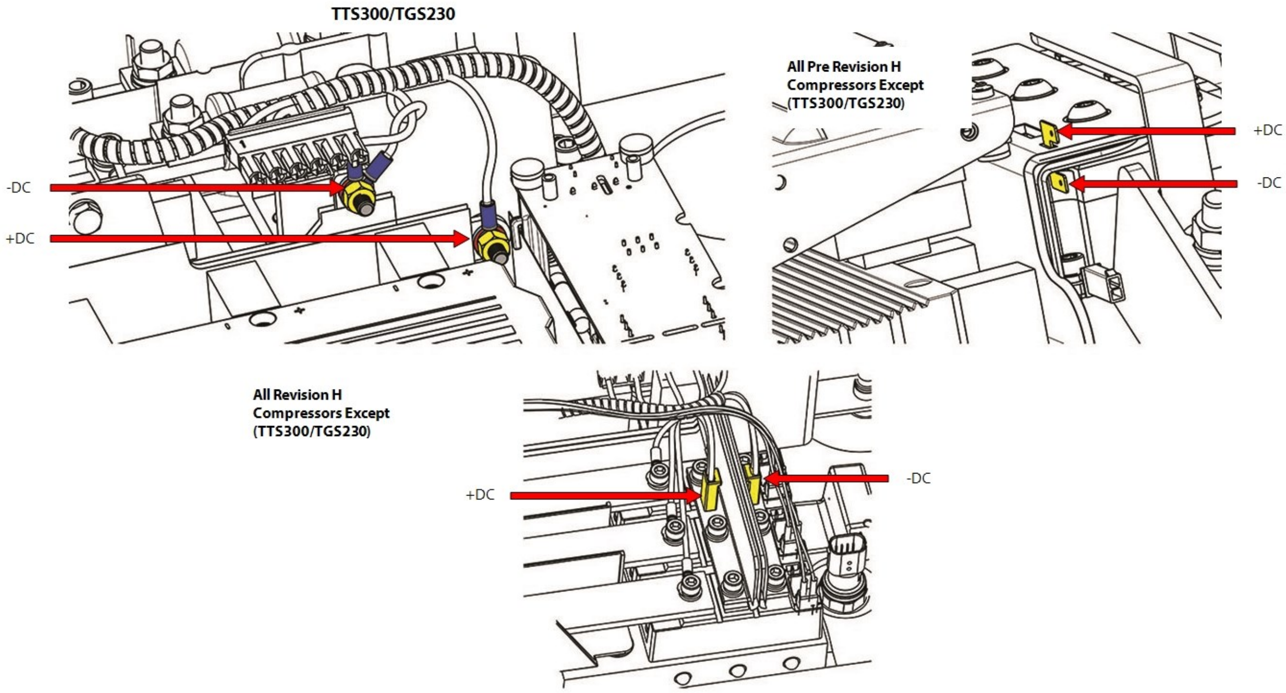


4.21.1 DC Capacitor DC Bus Bar Connections

Refer to Figure 4-178 Soft Start Cable Harness to DC Bus on page 167. for the location of the connections listed below.

1. +DC to Soft Start
2. -DC to Soft Start and DC-DC
3. DC bus to Inverter

Figure 4-178 Soft Start Cable Harness to DC Bus



4.21.2 DC Bus Voltage Verification

Use the DC Bus Test Harness to determine if DC bus voltage is within the correct range for the application. Refer to Section 1.10 DC Bus Test Harness Installation and Removal on page 25.

4.21.2.1 Bleed Resistor Verification

NOTE
This verification step does not apply if the DC Capacitor Bus Bar Assembly contains the Balance Board.

1. Isolate the compressor power as described in Section1.8 Electrical Isolation on page 22 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 TTS300/TGS230 compressors or between 16.2kΩ and 19.8kΩ for TTS350, TTS400, TTS450, TTS500, TTS700, TGS310, TGS380, TGS390, TGS520, TTH375, and TGH375 compressors.

4.21.2.2 Snubber Capacitor Verification

1. Isolate the compressor power as described in Section1.8 Electrical Isolation on page 22.
2. Remove the Soft Start. Refer to Section 4.14 Soft Start on page 113.

3. Remove the Snubber Capacitors. Refer to Figure 4-185 Snubber Capacitor Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230) on page 171.
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.

4.21.3 DC Capacitor Bus Bar Assembly Removal and Installation

• • • CAUTION • • •

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

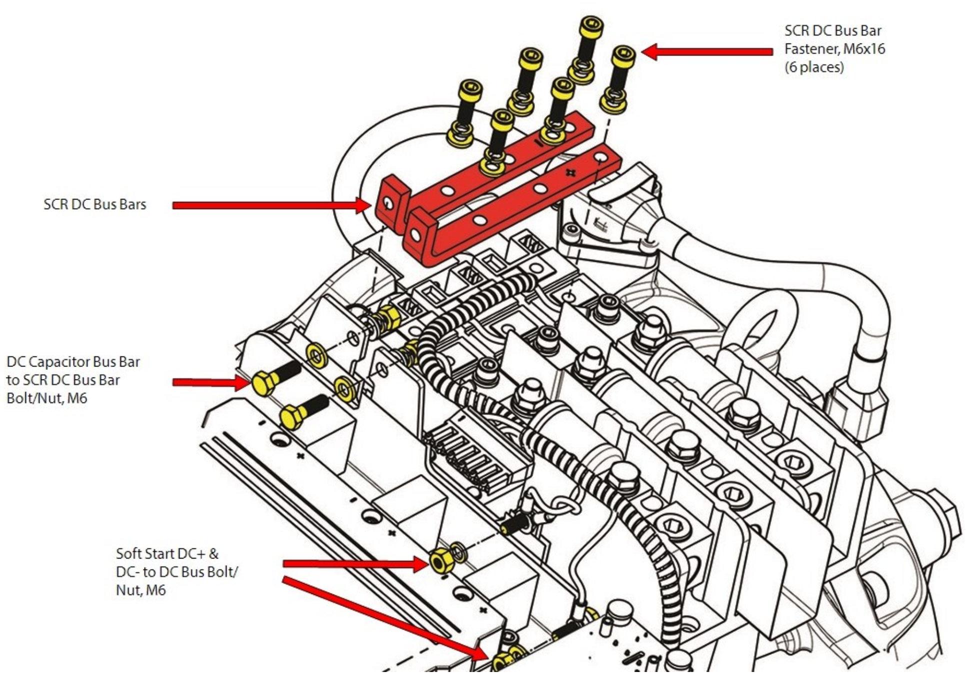
4.21.4 DC Capacitor Bus Bar Assembly General Removal

1. Isolate the compressor power as described in Section1.8 Electrical Isolation on page 22 of this manual.
2. Remove the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
3. Continue to Section 4.21.4.1 DC Capacitor Bus Bar Assembly Removal - TTS300/TGS230 for TTS300/TGS230 compressors and for all other TT/TG compressors, continue to Section 4.21.4.2 DC Capacitor Bus Bar Assembly Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230) on page 170.

4.21.4.1 DC Capacitor Bus Bar Assembly Removal - TTS300/TGS230

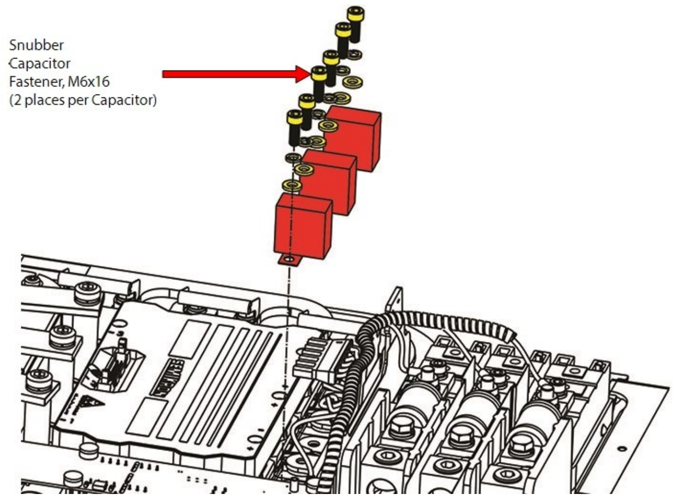
1. Remove the DC Bus Bars from the SCRs. Refer to Figure 4-179 DC Bus Bar and Soft Start Harness Removal - TTS300/TGS230 for this and the following step.
2. Disconnect the DC+ and DC- of the Soft Start harness from the DC bus assembly noting the orientation.

Figure 4-179 DC Bus Bar and Soft Start Harness Removal - TTS300/TGS230



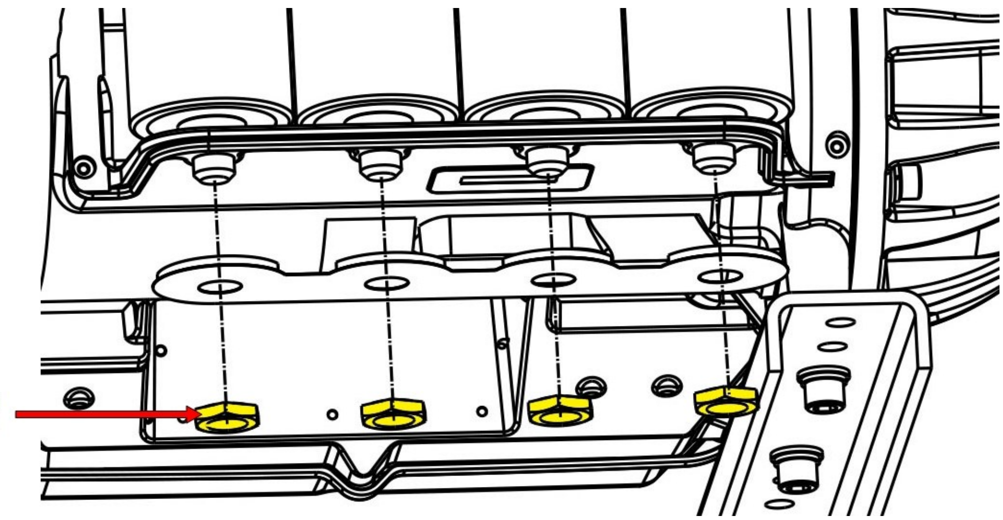
3. Disconnect the snubber capacitors from the Inverter noting the leg orientation of one leg is longer than the other. Refer to Figure 4-180 Snubber Capacitor Removal - TTS300/TGS230 on page 169.

Figure 4-180 Snubber Capacitor Removal - TTS300/TGS230



4. Remove the nylon nuts at the base of the DC Capacitor Bus Bar Assembly, under the main compressor housing. Refer to Figure 4-181 Capacitor Nut Removal - TTS300/TGS230.

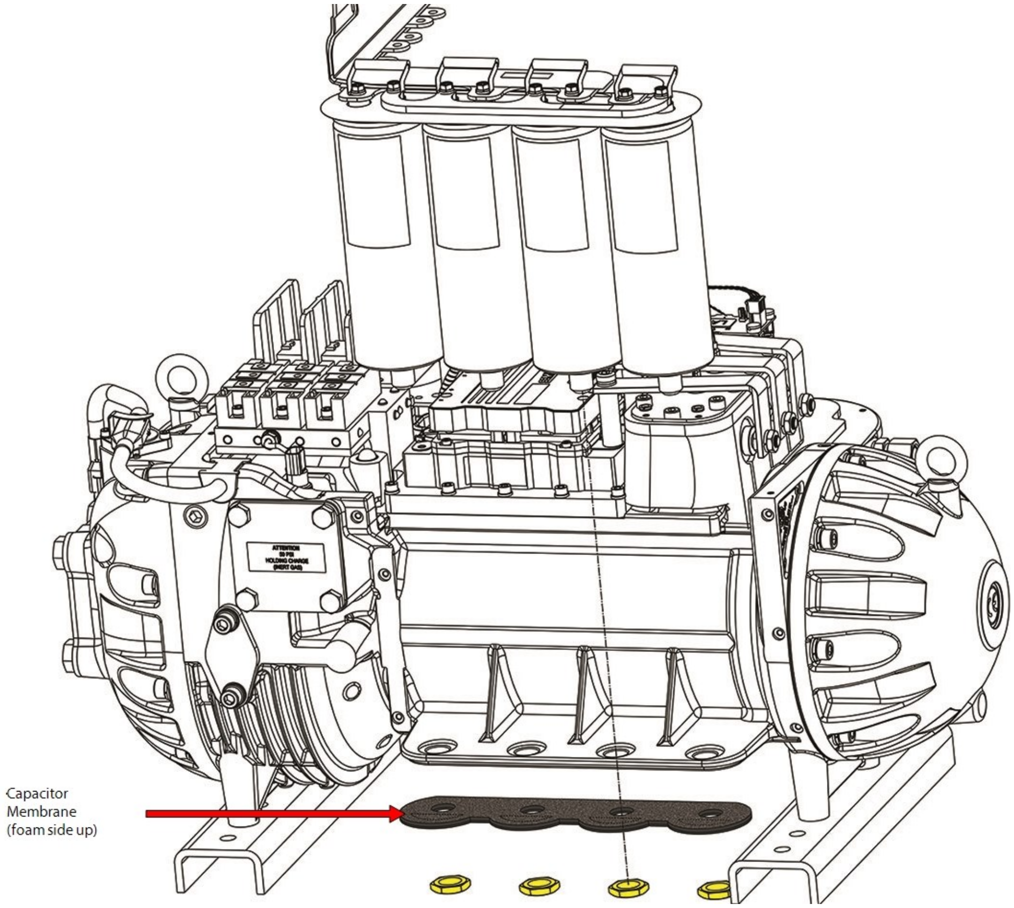
Figure 4-181 Capacitor Nut Removal - TTS300/TGS230



5. Carefully lift the DC Bus Bars and capacitors out as an assembly. Do not remove the bleed resistors or capacitors from the bus bars. Refer to Figure 4-182 Capacitor Assembly Removal - TTS300/TGS230 on page 170.

• • • DANGER! • • •
Bleed Resistors and bus bars may have sharp edges. Use caution and wear appropriate protective gear when removing the capacitor assembly.

Figure 4-182 Capacitor Assembly Removal - TTS300/TGS230



6. Continue to Section 4.21.4.3 DC Capacitor Bus Bar Assembly Installation - TTS300/TGS230 on page 174.

4.21.4.2 DC Capacitor Bus Bar Assembly Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230)

1. Remove the Mains AC Bus Bars as described in Section 4.12.1 Input Mains Bus Bar Removal on page 108.
2. Remove the six (6) DC bus fasteners from the SCRs. Refer to Figure 4-183 SCR Bus Bar Removal - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230) or Figure 4-184 SCR Bus Bar Removal - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230) on page 171.

Figure 4-183 SCR Bus Bar Removal - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230)

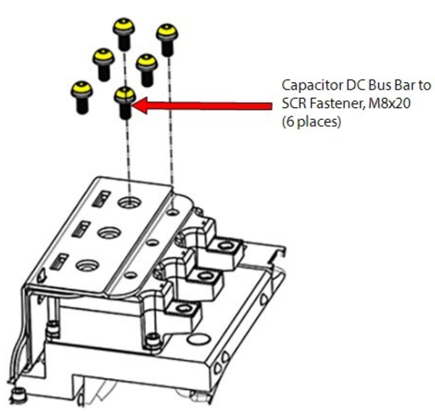
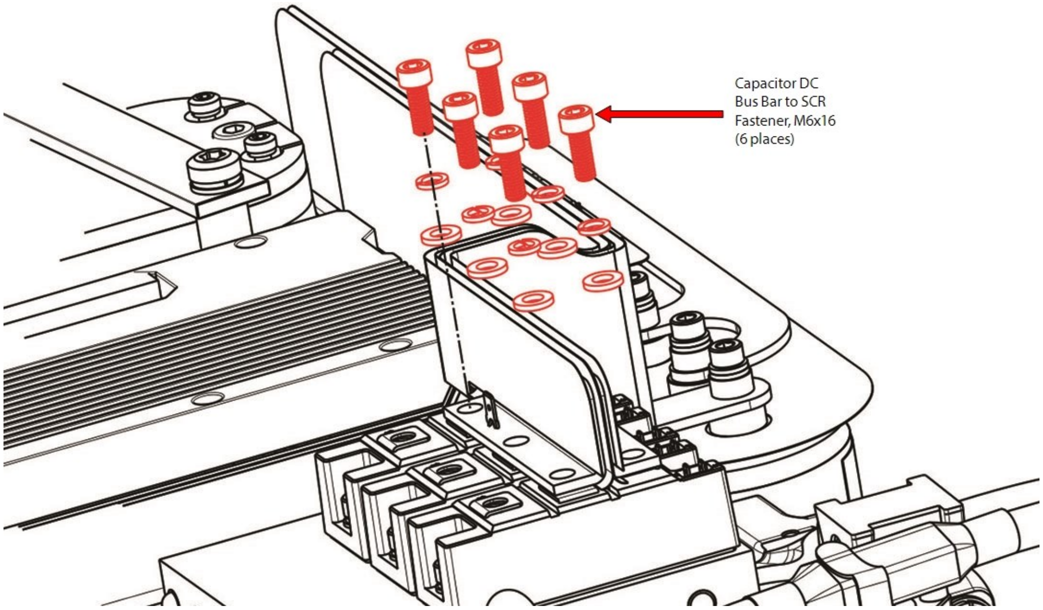
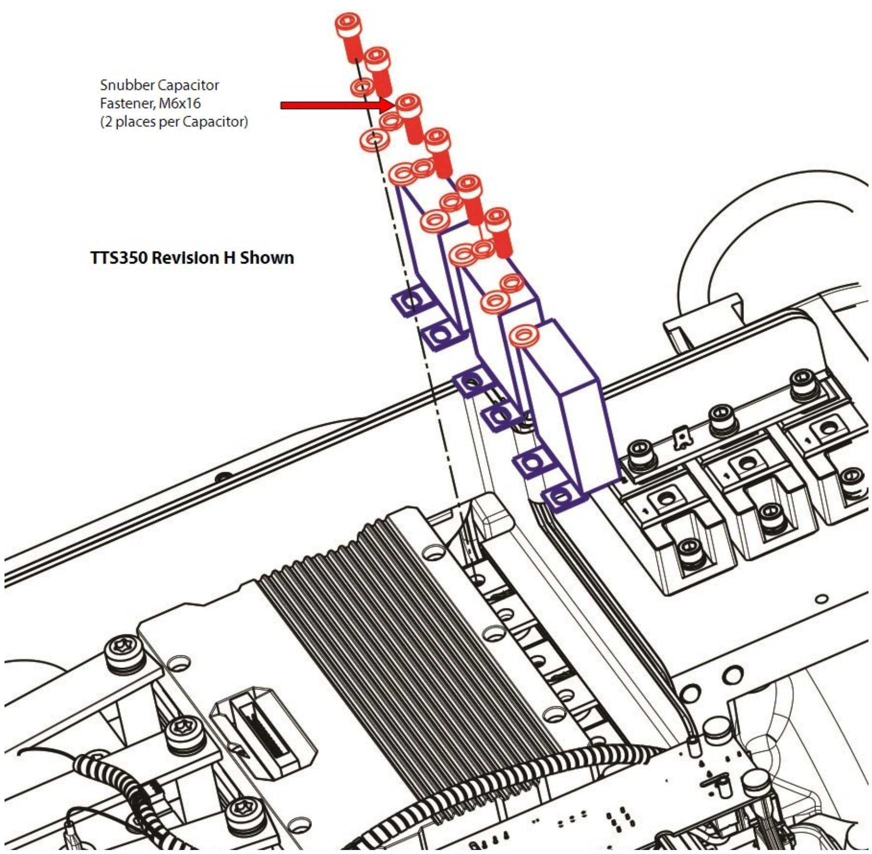


Figure 4-184 SCR Bus Bar Removal - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230)



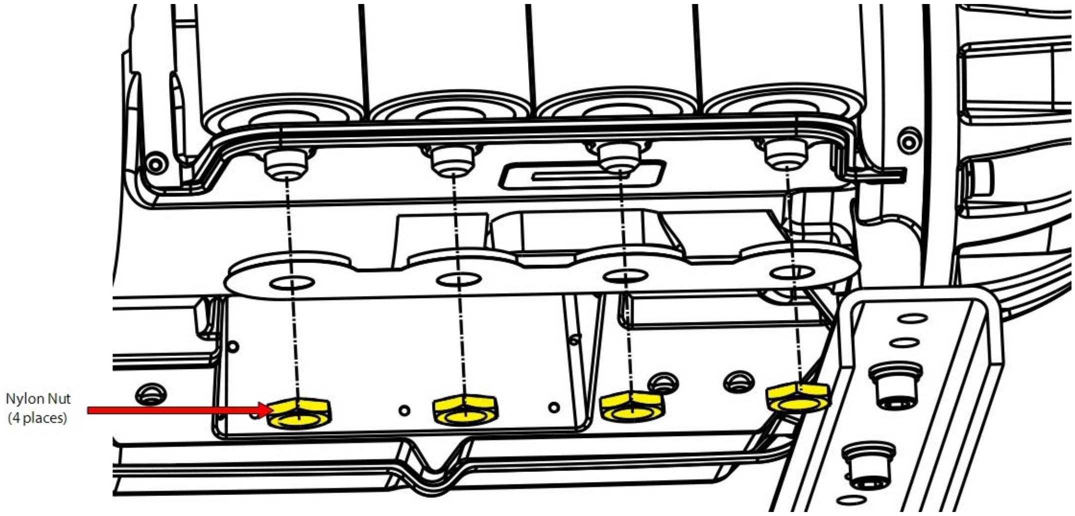
3. Disconnect the snubber capacitors from the Inverter noting the leg orientation of one leg is longer than the other. Refer to Figure 4-185 Snubber Capacitor Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230).

Figure 4-185 Snubber Capacitor Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230)



4. Remove the nylon nuts at the base of the DC Capacitor Bus Bar Assembly, under the main compressor housing. Refer to Figure 4-186 Capacitor Nut Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230).

Figure 4-186 Capacitor Nut Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230)



5. Carefully lift the DC Bus Bars and capacitors out as an assembly. Do not remove the bleed resistors, Balance Board, or capacitors from the bus bars. Refer to Figure 4-187 Capacitor Assembly Removal - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230) on page 173 and Figure 4-188 Capacitor Assembly Removal - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230) on page 173.

• • • DANGER! • • •
Bleed Resistors and bus bars may have sharp edges. Use caution and wear appropriate protective gear when removing the capacitor assembly.

Figure 4-187 Capacitor Assembly Removal - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230)

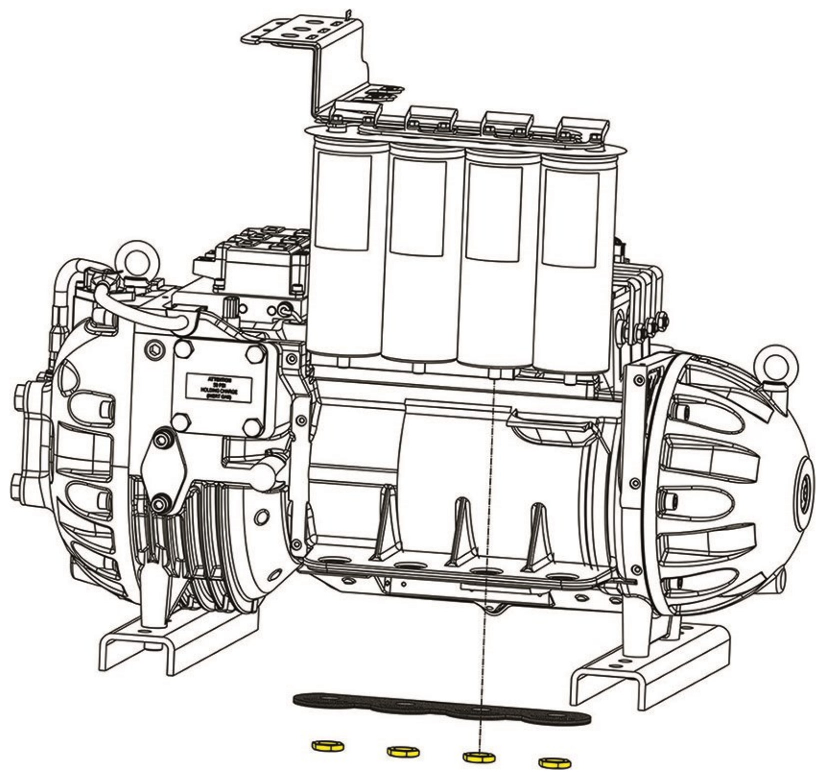
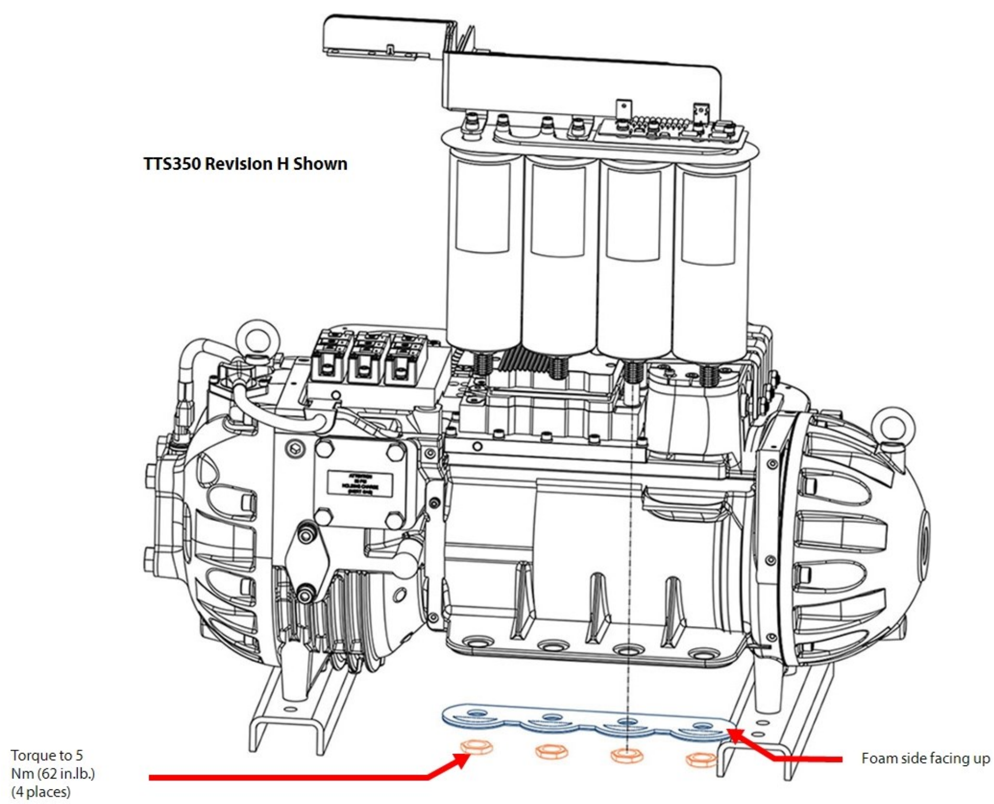


Figure 4-188 Capacitor Assembly Removal - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230)



6. Continue to Section 4.21.5 DC Capacitor Bus Bar Assembly General Installation Steps.

4.21.4.3 DC Capacitor Bus Bar Assembly Installation - TTS300/TGS230

1. Position the DC Bus Bar and Capacitor Assembly into place. Refer to Figure 4-182 Capacitor Assembly Removal - TTS300/TGS230 on page 170.
2. Loosely install the Snubber Capacitors to the Inverter noting the leg orientation. Refer to Figure 4-180 Snubber Capacitor Removal - TTS300/TGS230 on page 169.
3. Loosely install the DC Bus Bars to the SCRs. Refer to Figure 4-179 DC Bus Bar and Soft Start Harness Removal - TTS300/TGS230 on page 168. for this and the following step.
4. Loosely install DC Bus Bars to the DC Bus Assembly.
5. Starting from the side closest to the capacitors, torque the M6x16 Snubber Capacitor fasteners to 7 Nm (62 in.lb.).
6. Connect the DC+ and DC- of the Soft Start harness to the DC bus assembly noting the orientation and torque to 10 Nm (7 ft.lb.). Refer to Figure 4-178 Soft Start Cable Harness to DC Bus on page 167.
7. Torque the six (6) SCR fasteners, to secure the two (2) SCR DC Bus Bars, to 5 Nm (44 in.lb.).
8. Torque the two (2) Capacitor DC Bus Bar to SCR Bus Bar fasteners to 10 Nm (7 ft.lb.).
9. Place the capacitor membrane, foam-side up, underneath the main compressor housing and then Install the nylon nuts to the base of the DC Capacitor Bus Bar Assembly, and torque to 7 Nm (62 in.lb.). Refer to Figure 4-181 Capacitor Nut Removal - TTS300/TGS230 on page 169.
10. Connect the SCR Gate cable harness to the SCRs noting its orientation. Refer to Figure 4-140 SCR Connections - TTS300/TGS230 on page 141.
11. Continue to Section 4.21.5 DC Capacitor Bus Bar Assembly General Installation Steps.

4.21.4.4 DC Capacitor Bus Bar Assembly Installation - TTS/TGS/TTH/TGH (Except TTS300/TGS230)

1. Position the DC Bus Bar and Capacitor Assembly into place.
2. Loosely Install the six (6) DC bus M8x20 fasteners to the SCRs.
3. Loosely install the Snubber Capacitors to the Inverter noting the leg orientation.
4. Starting from the side closest to the capacitors, torque the Snubber Capacitors to 7 Nm (62 in.lb.).
5. Torque the six (6) M6x16 SCR Bus Bar fasteners to 5 Nm (44 in.lb.).
6. Place the capacitor membrane foam-side up, underneath the main compressor housing and install the nylon nuts to the base of the DC Capacitor Bus Bar Assembly, torque to 7 Nm (62 in.lb.).
7. Install the SCR Gate Cables onto the SCRs. Refer to Section 4.16.2.2 Soft Start SCR Gate Cable Installation on page 130.
8. Install the Mains AC bus bar assembly.
9. Continue to Section 4.21.5 DC Capacitor Bus Bar Assembly General Installation Steps.

4.21.5 DC Capacitor Bus Bar Assembly General Installation Steps

1. Install the Soft Start. Refer to Section 4.14.6 Soft Start Installation (Closed-Top) on page 121.
2. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
3. Return the compressor to normal operation.

4.21.6 DC Capacitor Bus Bar Assembly Torque Specifications

Table 4-33 DC Capacitor Bus Bar Assembly Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
Soft Start DC+ & DC- to DC Bus Bolt/nut (TTS300/TGS230 only)	10	7	89
DC Capacitor Bus Bar to SCR Bus Bar Bolt (TTS300/TGS230 only)	10	7	89
DC Bus Bars to SCR fastener, M6x16 (TTS300/TGS230 only)	5	-	44

Description	Nm	Ft.Lb.	In.Lb.
AC Bus Bar to SCR fastener, M8x20 (Excludes TTS300/TGS230 compressors)	9	-	80
Terminal Block Mounting fastener, M5x45 (Excludes TTS300/TGS230 compressors)	4	-	35
Capacitor DC Bus Bar to SCR fastener, M8x20 (excludes TTS300/TGS230 compressors)	9	-	80
Mains Input Pressure Screw, 11/16" - 16 UNC (TTS300/TGS230 compressors only)	20	15	177
Mains Input Nut, 3/8" - 16 UNC (excludes TTS300/TGS230 compressors)	21	15	186
Snubber Capacitor fastener, M6x16	7	-	62
Nylon Capacitor Nut	7	-	62

4.22 Inverter

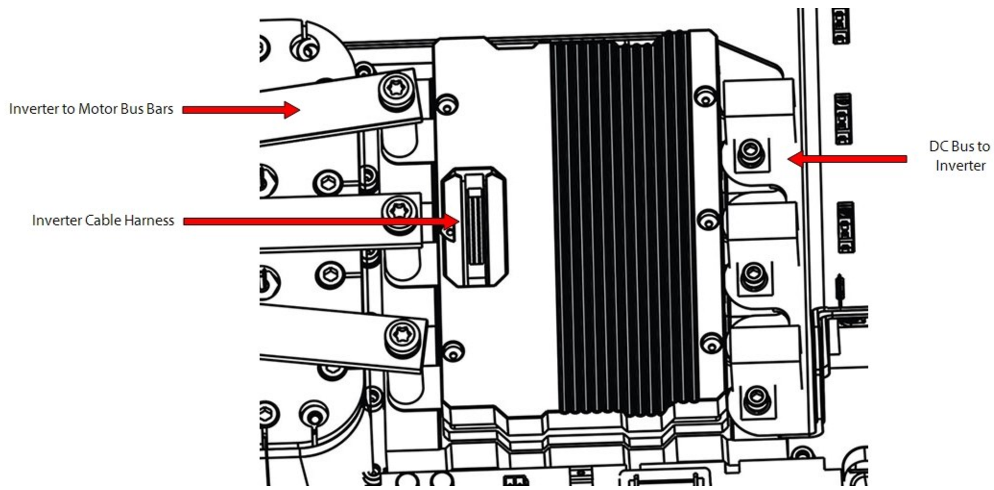
The function of the Inverter is to take the DC bus voltage as an input and generate the AC output voltage to the compressor motor at the required fundamental frequency to generate the requested shaft speed. Voltage to the motor is also controlled to provide the appropriate motor torque.

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.

4.22.1 Inverter Connections

Figure 4-189 Inverter Connections



4.22.2 Inverter Verification

This procedure only verifies the Inverter high-power diodes. The Inverter Control Board cannot be verified in the field unless an inverter tester is used. A faulty Inverter may also appear as an "Inverter Error" fault.

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Remove the Soft Start Module. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
3. Remove the DC Capacitor Bus Bar Assembly. Refer to Section 4.21.3 DC Capacitor Bus Bar Assembly Removal and Installation on page 168.
4. Remove the Copper Tubes and fasteners connecting the motor bus bars to the Inverter Module. Refer to Figure 4-195 Inverter Copper Tube Removal on page 180.
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.

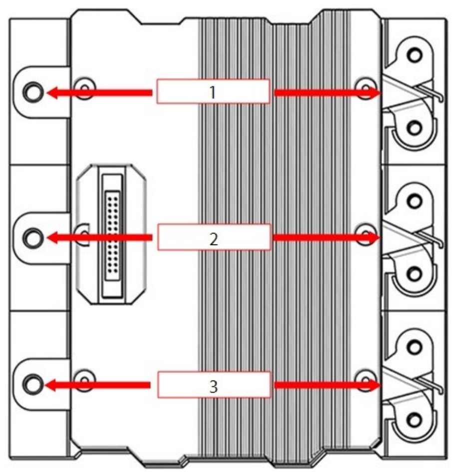
6. Using a multimeter set for diode measurements, place the red (+) multimeter lead on the phase 1 AC terminal and the black (-) multimeter lead on the DC+ terminal. The measured value should be 0.275V – 0.4V. Refer to Figure 4-190 Inverter Diode Measurements (Skiip 613 Shown) on page 177 for this and

the following three (3) steps.

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.
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.
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.
10. Repeat Steps 6 through 9 for the remaining Inverter phases.

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

Figure 4-190 Inverter Diode Measurements (Skiip 613 Shown)



4.22.3 Inverter Cable Harness

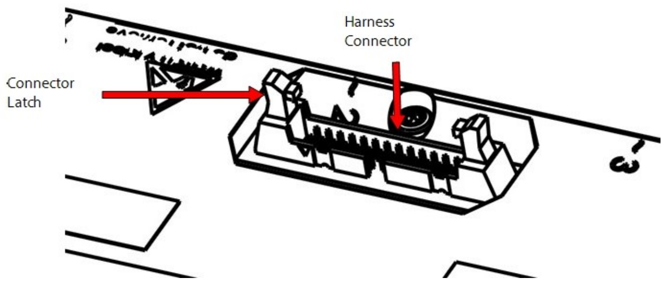
Figure 4-191 Inverter Cable Harness

4.22.4 Inverter Cable Harness Removal and Installation

4.22.4.1 Inverter Cable Harness Removal

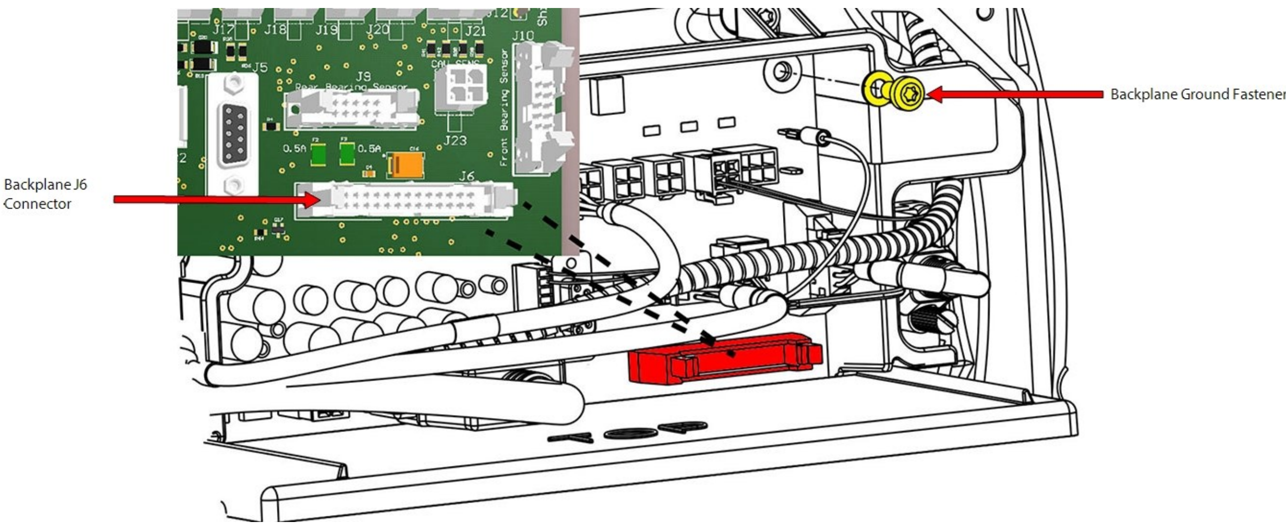
1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
3. Remove the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
4. Use two (2) fingers to simultaneously push outward on the Inverter Cable Harness latches. Refer to Figure 4-192 Harness Removal from Inverter on page 178.

Figure 4-192 Harness Removal from Inverter



5. Verify there are no bent or broken pin connectors.
6. Use the same process to disconnect the Inverter Cable Harness from the Backplane J6 connection.
7. Verify there are no bent or broken pin connectors.
8. Remove the Inverter Cable Harness ground connection from the Backplane. Refer to Figure 4-193 Harness Removal from Backplane.

Figure 4-193 Harness Removal from Backplane

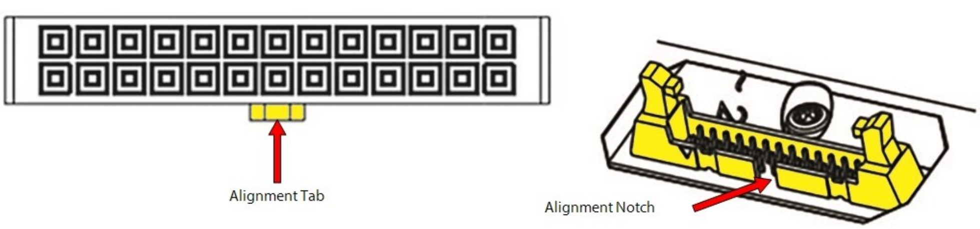


9. Cut any cable ties securing the Inverter Cable Harness and pull through the compressor housing passage.

4.22.4.2 Inverter Cable Harness Installation

1. Insert the Inverter Cable Harness through the compressor passage keeping in mind the ground connection end needs to go to the Backplane.
2. Align the Inverter Cable Harness to the Inverter connector using the alignment tab on the connector. Refer to Figure 4-194 Inverter Connector Alignment.

Figure 4-194 Inverter Connector Alignment



3. Using minimal force, push in on the Inverter Cable Harness connector. While doing this, the latches should fold in once the cable connector has reached the proper depth.
4. Use the same process to connect the Inverter Cable Harness to the Backplane J6 connection.
5. Install the ground connector of the Inverter Cable Harness to the Backplane. Torque the M5x10 fastener to 3 Nm (26.5 in.lb.).
6. Install new cable ties as necessary.
7. Install the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
8. Install the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
9. Install the top covers. 4.1 Compressor Covers on page 52.
10. Return the compressor to normal operation.

4.22.5 Inverter Cable Harness Torque Specifications

Table 4-34 Inverter Cable Harness Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
Backplane Ground fastener, M5x10	3	-	26.5
Soft Start Mounting fastener, M5X15	5	-	44
Cover Fastener, M5x15	1.5	-	13

4.22.6 Inverter Removal and Installation

General Removal

1. Isolate compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Isolate the compressor and recover the refrigerant according to industry standards. Refer to Section 3.1 Refrigerant Containment on page 41.
3. Disconnect the mains input wires from the Terminal Block.
4. Remove the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
5. For TT300/TG230 compressors continue to Section 4.22.6.1 Compressor Specific Inverter Removal Steps - TTS300/TGS230, for all other TT/TG/TTH compressors, continue to Section 4.22.6 Inverter Removal and Installation on page 179.

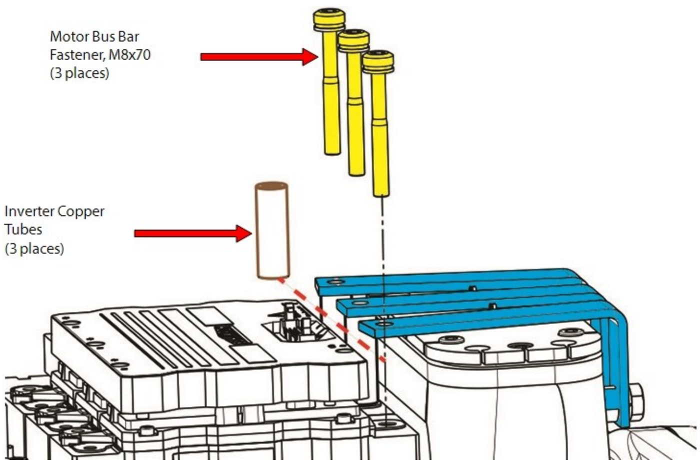
4.22.6.1 Compressor Specific Inverter Removal Steps - TTS300/TGS230

1. Disconnect the two (2) SCR Gate connectors from each rectifier.
2. Remove the Fuse Block Assemblies and Terminal Block from the compressor. Refer to Section 4.11.2 3-Phase Main Voltage Input Terminal Block Removal and Installation on page 102.
3. Remove Snubber Capacitors and DC Bus Assembly. Refer to Section 4.21.4.1 DC Capacitor Bus Bar Assembly Removal - TTS300/TGS230 on page 168.
4. Remove the M8x70 Motor Bus Bar fasteners from the Inverter. Refer to Figure 4-195 Inverter Copper Tube Removal on page 180 and the note below.

NOTE
It is not necessary to completely remove the Motor Bus Bars.

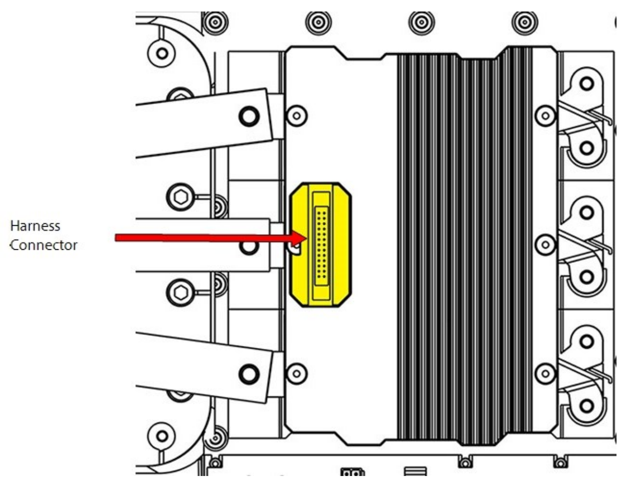
5. Slide out all three (3) Inverter Copper Tubes.

Figure 4-195 Inverter Copper Tube Removal



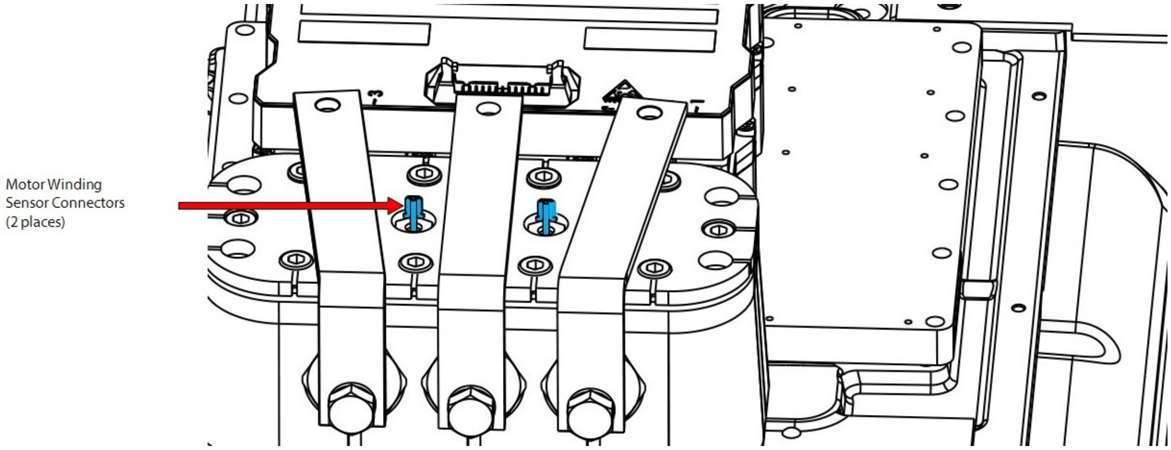
6. Remove the Inverter cable harness from the top of the Inverter. Refer to Figure 4-196 Inverter Cable Harness Removal - TTS300/TGS230.

Figure 4-196 Inverter Cable Harness Removal - TTS300/TGS230



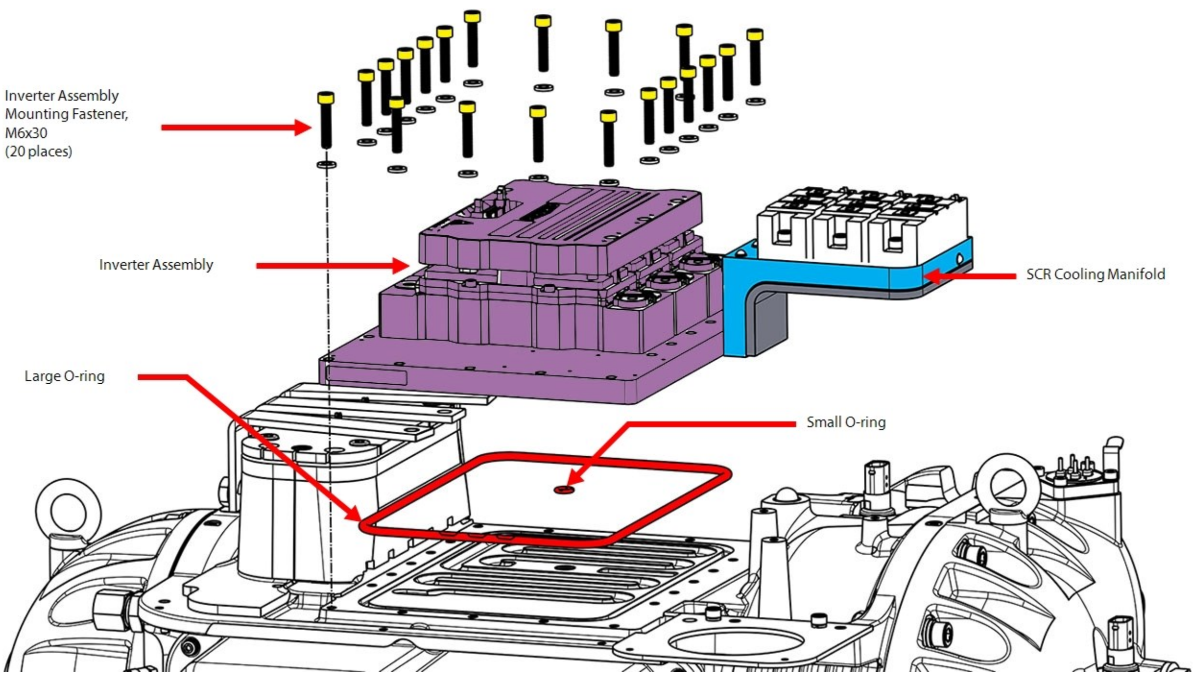
7. Remove the DC-DC from the Inverter Heat Sink Plate. Refer to Section 4.24.3 DC-DC Removal and Installation on page 206.
8. Disconnect the wires from the Motor Winding Sensor. Refer to Figure 4-197 Motor Winding Sensor Connector Removal on page 181.

Figure 4-197 Motor Winding Sensor Connector Removal



9. Remove the upper half of the compressor cable harness. Refer to Section 4.5.2 Compressor Controller Cable Harness Removal and Installation on page 68.
10. Remove the 20 M6x30 fasteners that secure the Inverter to the compressor main housing and carefully remove the Inverter and remove and discard the two (2) O-rings underneath.

Figure 4-198 Inverter Assembly Removal - TTS300/TGS230



NOTE
The SCRs do not need to be removed from the SCR Cooling Manifold when removing the Inverter.

11. Remove the SCR Cooling Manifold. Refer to Section 4.19.2 SCR Cooling Manifold Specific Removal Steps - TTS300/TGS230 on page 157.

12. Remove and discard the two (2) O-rings.
13. Retain the SCR Manifold for use with the new Inverter assembly.

NOTE
Do not completely remove the foam insulation, only pull back what is needed to access the two (2) fasteners.

4.22.6.2 Compressor Specific Inverter Removal Steps - TTS/TGS/TTH/TGH (Except TTS300/TGS230)

Figure 4-199 SCR Connections - TTS/TGS/TTH/TGH Rev. F and Earlier (Except TTS300/TGS230)

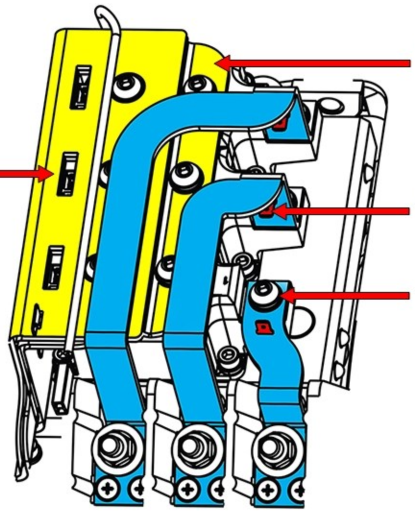
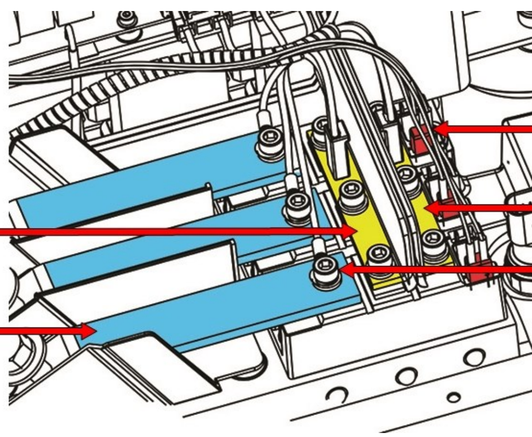


Figure 4-200 SCR Connections - TTS/TGS/TTH/TGH Rev. H (Except TTS300/TGS230)

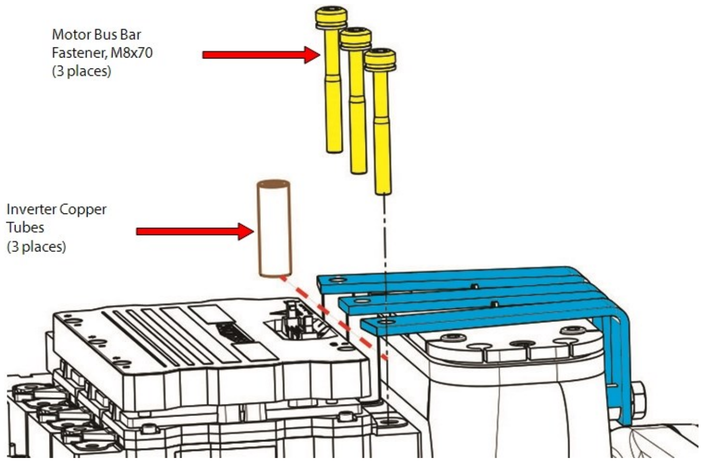


14. Remove the Terminal Block and AC Mains input Bus Bars. Refer to Section 4.11.2 3-Phase Main Voltage Input Terminal Block Removal and Installation on page 102.
15. Remove the Snubber Capacitors and DC Capacitor Bas Bar Assembly. Refer to Section 4.21.4.2 DC Capacitor Bus Bar Assembly Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230) on page 170.
16. Remove the three (3) M8x70 Motor Bus Bar fasteners from the Inverter. Refer to Figure 4-201 Inverter Copper Tube Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230) on page 183 for this and the following step.

NOTE
It is not necessary to completely remove the Motor Bus Bars.

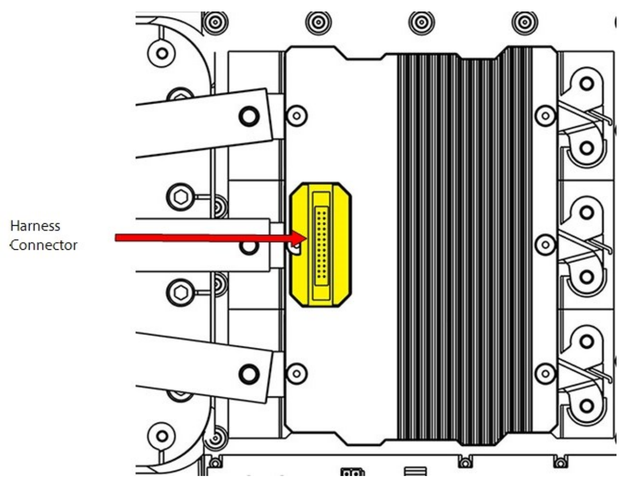
17. Slide out all three (3) Inverter Copper Tubes.

Figure 4-201 Inverter Copper Tube Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230)



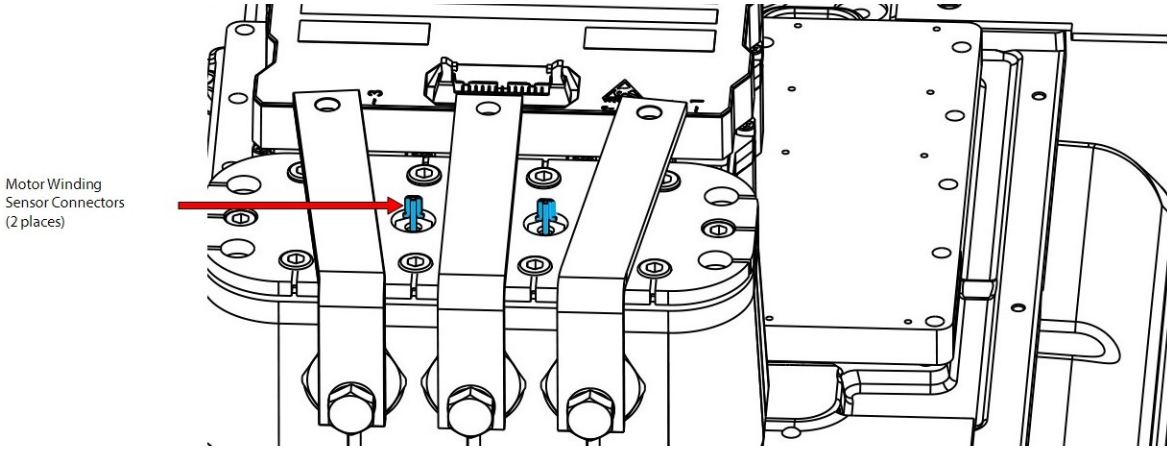
18. Remove the upper half of the compressor cable harness. Refer to Section 4.5.2 Compressor Controller Cable Harness Removal and Installation on page 68.
19. Remove the SCR Cooling Manifold. Refer to Section 4.19.3 SCR Cooling Manifold Specific Removal Steps - TTS/TGS/TTH/TGH (Except TTS300/TGS230) on page 159.
20. Remove the Inverter cable harness from the top of the Inverter. Refer to Figure 4-202 Inverter Harness Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230).

Figure 4-202 Inverter Harness Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230)



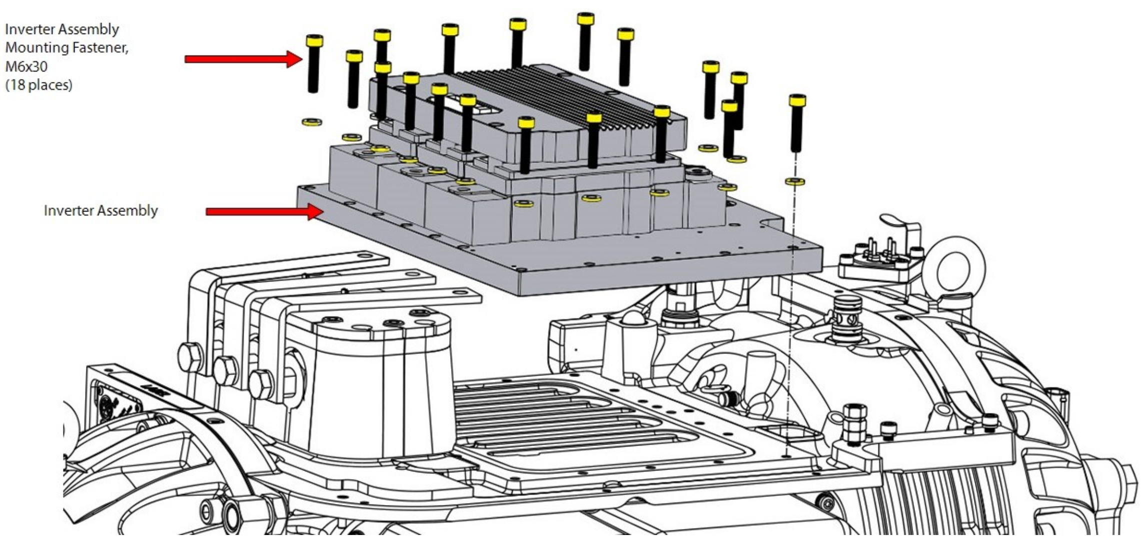
21. Remove the DC-DC from the Inverter Heat Sink Plate. Refer to Section 4.24.3 DC-DC Removal and Installation on page 206.
22. Disconnect the wires from the Motor Winding Sensor. Refer to Figure 4-203 Motor Winding Sensor Removal.

Figure 4-203 Motor Winding Sensor Removal



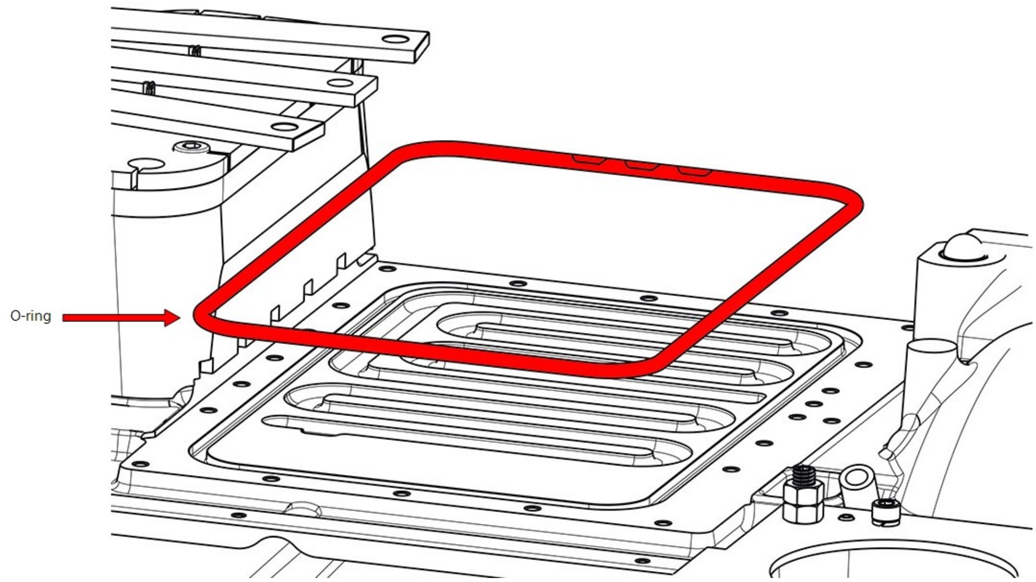
23. Remove the 18 M6x30 fasteners that secure the Inverter to the compressor main housing. Refer to Figure 4-204 Inverter Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230).

Figure 4-204 Inverter Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230)



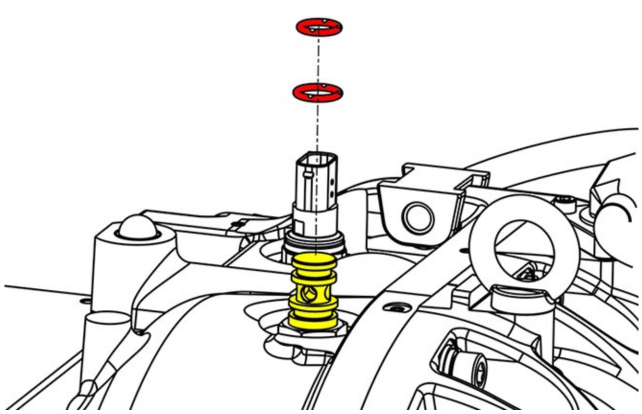
24. Remove and discard the large Inverter O-ring from the compressor housing. Refer to Figure 4-205 Inverter O-ring Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230) on page 185.

Figure 4-205 Inverter O-ring Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230)



25. Carefully remove the two (2) O-rings from the SCR Manifold Return Brass Fitting. Use caution to not damage the surface of the fitting. Refer to Figure 4-206 SCR Manifold Return Brass Fitting Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230) on page 185.

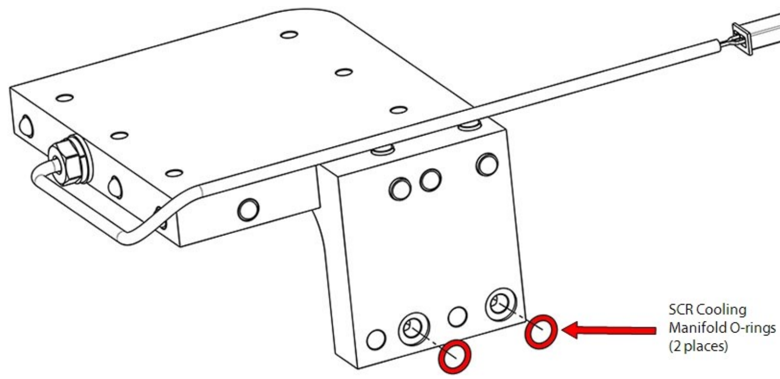
Figure 4-206 SCR Manifold Return Brass Fitting Removal - TTS/TGS/TTH/TGH (Except TTS300/TGS230)



4.22.6.3 Compressor Specific Inverter Installation Steps - TTS300/TGS230

1. Clean O-ring groove in the main compressor housing.
2. Apply O-Lube to the Inverter O-ring and place the O-ring in the compressor housing groove.
3. Apply O-Lube to the O-rings and install them into the SCR cooling manifold. Refer to Figure 4-207 SCR Cooling Manifold O-ring Installation - TTS300/TGS230.

Figure 4-207 SCR Cooling Manifold O-ring Installation - TTS300/TGS230

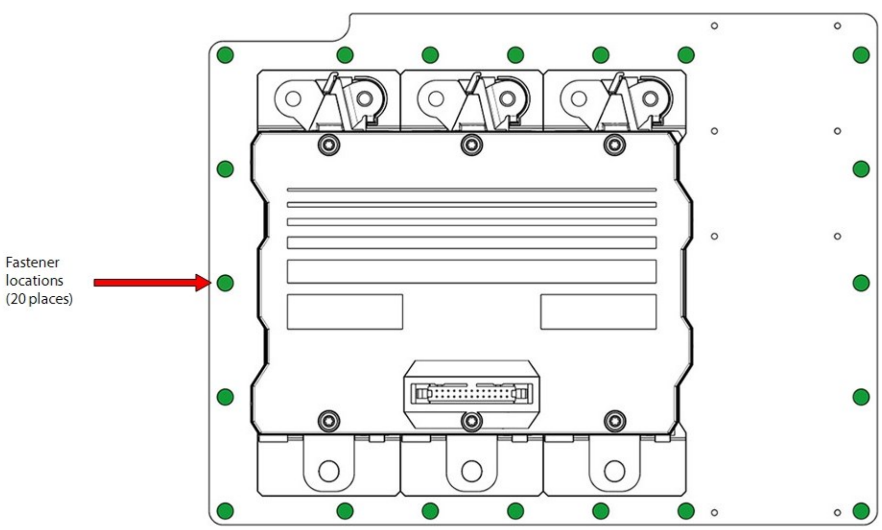


4. Install the SCR Cooling Manifold to the Inverter Cooling Manifold. Refer to Section 4.19.4 SCR Cooling Manifold Specific Installation Steps - TTS300/TGS230 on page 160.
5. Remove the backing material from the cooling manifold of the new Inverter.
6. Install all 20 M6x30 fasteners into the Inverter assembly. This will aid in the alignment when lowering it onto the compressor housing.

NOTE
It is recommended that the new fasteners supplied with the kit be used to ensure proper torque is obtained.

7. Carefully install the Inverter on the compressor housing with the SCR temperature sensor cable (if equipped) run on top where the SCR cooling manifold meets the Inverter Cooling Manifold.
8. Torque the M6x30 Inverter fasteners in a diagonal pattern to 3 Nm (27 in.lb.) on the first pass then to 8.5 Nm (75 in.lb.) on the second pass. Refer to Figure 4-208 Inverter Fastener Locations - TTS300/TGS230.

Figure 4-208 Inverter Fastener Locations - TTS300/TGS230



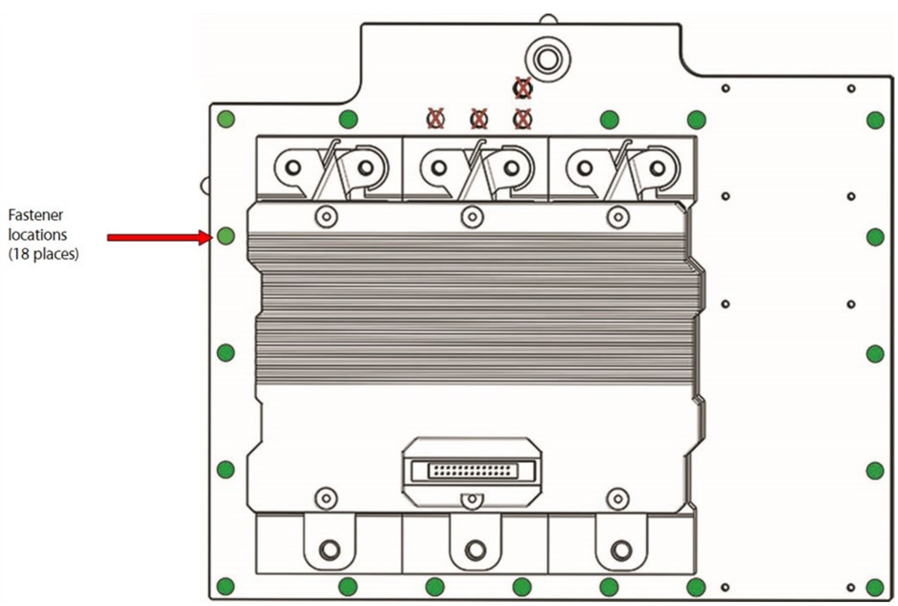
9. Leak test and evacuate the compressor in accordance with standard industry practices.
10. Connect the SCR temperature sensor (if equipped), discharge P/T sensor, IGV motor connection, and the suction P/T sensor.
11. Install the three (3) Copper Tubes and torque the M8x70 Motor Bus Bar fasteners to 14 Nm (10 in.lb.).

12. If a Potted DC-DC Converter is being installed, clean the surface of the Inverter Heat Sink Plate and the DC-DC Converter. The Open-Frame DC-DC Converter does not require heat sink paste.
13. Install the DC-DC Converter. Refer to Section 4.24.3 DC-DC Removal and Installation on page 206.
14. Install the DC bus Bar and Capacitor Assembly and Snubber Capacitors. Refer to Section 4.21.4.3 DC Capacitor Bus Bar Assembly Installation - TTS300/TGS230 on page 174.
15. Install the Terminal block and Fuse assemblies. Refer to Section 4.11.2 3-Phase Main Voltage Input Terminal Block Removal and Installation on page 102.
16. Install the mains input cables to the Terminal Block and torque to 20 Nm (15 ft.lb.). Connect the SCR Gate cable harness to the SCRs noting its orientation.
17. Connect the SCR Gate cable harness to the SCRs noting its orientation.

4.22.6.4 Compressor Specific Inverter Installation Steps - TTS/TGS/TTH/TGH (Except TTS300/TGS230)

1. Clean the O-ring groove in the main compressor housing with a lint-free cloth.
2. Apply O-lube and install the Inverter O-ring in the compressor housing groove.
3. Remove the backing material from the Inverter Cooling Manifold of the new Inverter. Use caution to not damage the bottom sealing surface of the Inverter.
4. Install the 18 M6x30 fasteners into the Inverter assembly with the exception of the four (4) M6x35 SCR Manifold fasteners and carefully lower the assembly onto the compressor housing. Use the installed fasteners to properly line up the Inverter. Refer to Figure 4-209 Inverter Fastener Locations - TTS/TGS/TGH (Except TTS300/TGS230) on page 187.

Figure 4-209 Inverter Fastener Locations - TTS/TGS/TGH (Except TTS300/TGS230)



5. Once the Inverter is in place, finger-tighten the Inverter fasteners in a diagonal pattern and torque to 3 Nm (27 in.lb.) on the first pass, then to 7 Nm (62 in.lb.) on the second pass.
6. Install the SCR Cooling Manifold and SCRs. Refer to Section 4.19.5 SCR Cooling Manifold Specific Installation Steps - TTS/TGS/TTH/TGH (Except TTS300/TGS230) on page 160.
7. Install the three (3) Copper Tubes and torque the M8x70 fasteners to specification.
8. Install the DC-DC Converter to the Inverter cooling manifold. Refer to Section 4.24.3 DC-DC Removal and Installation on page 206.
9. Verify the compressor cable harness (and the SCR Temperature Sensor Cable - if applicable) is properly placed across the cooling manifold.

10. Connect the compressor cable harness to the IGV Motor feedthrough, suction and discharge sensors, and SCR Temperature sensor.
11. Rotate the Retainer Clip until it is directly above the IGV Connector and torque the M5x16 IGV Feedthrough Fastener to 25 Nm (18 ft.lb.).
12. Install the DC Bus Bar and Capacitor assembly and Snubber Capacitors. Refer to Section 4.21.3 DC Capacitor Bus Bar Assembly Removal and Installation on page 168.
13. Install the Terminal Block Assembly. Refer to Section 4.11.2 3-Phase Main Voltage Input Terminal Block Removal and Installation on page 102.
14. Connect the three (3) AC wires from the Soft Start AC/DC cable harness to the appropriate AC bus bar.

Inverter General Installation

1. Connect the Motor Sensor wires.
2. Connect the SCR Gate cable harness to the SCRs noting its orientation. Refer to Section 4.16.2 Soft Start SCR Gate Cable Removal and Installation on page 128.
3. Connect the Inverter cable harness to the top of the Inverter.
4. Install the mains input cables to the Terminal Block and torque to 21 Nm (15 ft.lb.).
5. Install the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
6. Install the top covers. Refer Section to 4.1 Compressor Covers on page 52.
7. Return the compressor to normal operation.

4.22.7 Inverter Card Replacement

This section details the steps to remove and install the Inverter Control Card. If the Inverter proves to be working properly and the Inverter Control Card has been confirmed to have failed, follow the removal and installation steps for the Inverter Control Card.

The replacement Inverter Control Cards are only for the 613 Inverter. Refer to Bulletin B-CN-107-EN Rev B for further details regarding the applicability of the control cards.

4.22.7.1 Inverter Card Removal

1. Isolate compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Remove the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
3. If using the Inverter tester - Remove the DC Capacitor and Bus Assembly. Refer to Section 4.21.3 DC Capacitor Bus Bar Assembly Removal and Installation on page 168.

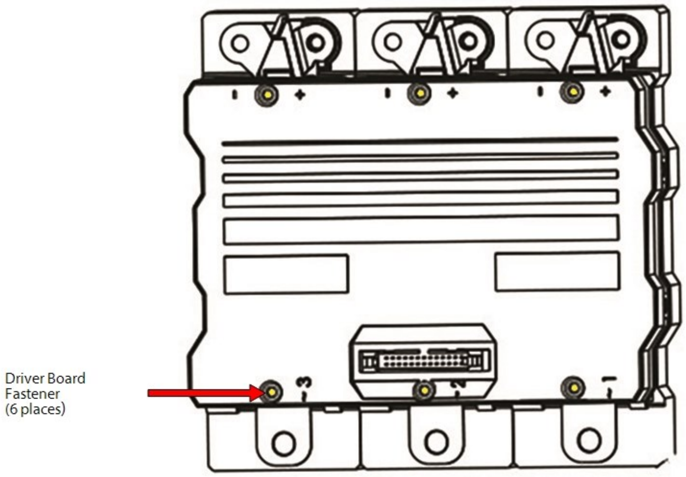
NOTE
The above step is only necessary when using the inverter tester.

4. Disconnect the ribbon cable from the Inverter.

• • • CAUTION • • •
Do not remove the fasteners that secure the Inverter to the compressor main housing.

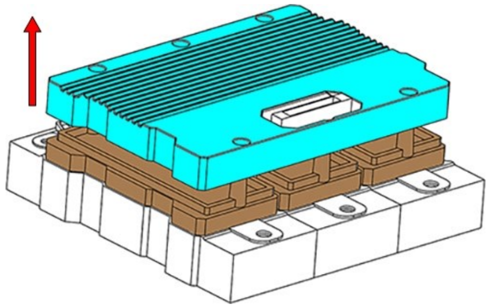
5. Remove the six (6) Driver Board fasteners using a T15 Torx bit. Begin on the outside and work towards the center. Refer to Figure 4-210 Driver Board Fasteners on page 189.

Figure 4-210 Driver Board Fasteners



6. Carefully lift the Driver Board vertically.

Figure 4-211 Carefully lift the Driver Board vertically.



7. Set aside the Driver Board fasteners for re-use.
8. Discard the old Driver Board in accordance with local regulations.

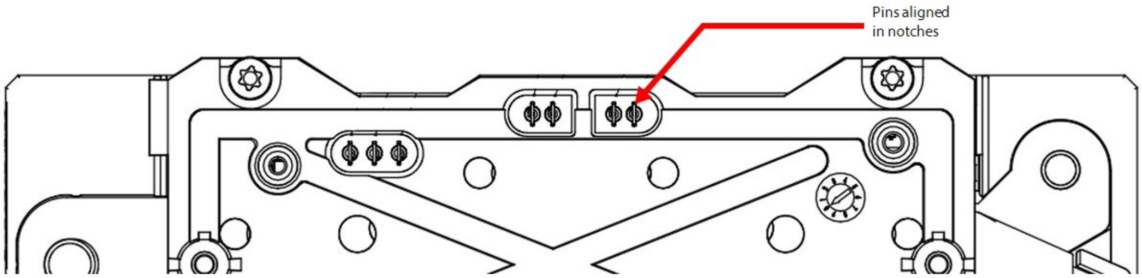
• • • CAUTION • • •
Do not move or touch any spring pins unless they are not in proper alignment. Damage or misalignment of spring pins can cause failure of the entire Inverter module.

4.22.7.2 Inverter Control Card Installation

ESD protection must be worn when handling the driver board.

1. Verify that all spring pins are present (total of 13 pins) and that they are in proper alignment. Refer to Figure 4-212 Seated Spring Pins on page 190.

Figure 4-212 Seated Spring Pins



2. There are two (2) different length spring pins, if any are replaced, be sure to replace with the same length spring pin. Refer to Figure 4-213 Spring Locations and Table 4-35 Spring Identification for the locations of the long and short spring pins. For an example of the difference between the two (2) different spring pin lengths, refer to Figure 4-214 Spring Pin Identification on page 191.

Figure 4-213 Spring Locations

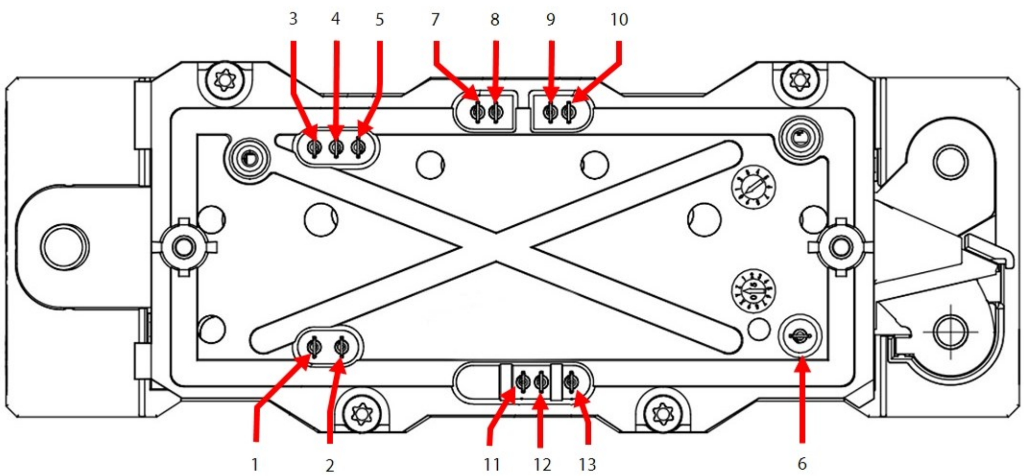
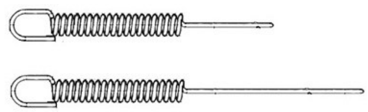


Table 4-35 Spring Identification

Spring Numbers	Length
Springs 1-6	Short
Springs 7-13	Long

Figure 4-214 Spring Pin Identification



3. 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 spring pins. The defective pins must be replaced.

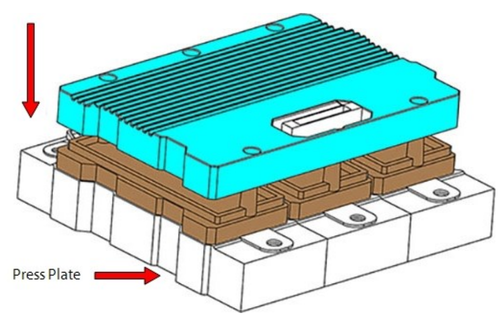
4. Discard the defective spring pins and inspect the Inverter for any foreign objects.
5. Insert the new spring pins carefully and verify they line up in the notches. Refer to Figure 4-212 Seated Spring Pins on page 190.
6. Retrieve the new Driver Board from the packaging.

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.

7. For proper alignment, insert two (2) of the fasteners in opposite corners of the Driver Board.
8. Align the new Driver Board over the Inverter module with the connector towards the motor output bus bar (the shape of Driver Board must be aligned with Inverter Press Plate shape). Refer to Figure 4-215 Driver Board Placement for the next two (2) steps.
9. Lower the Driver Board down on the Inverter module, do not allow for any lateral movement. Be sure the bottom of the Driver Board is parallel with the Press Plate.

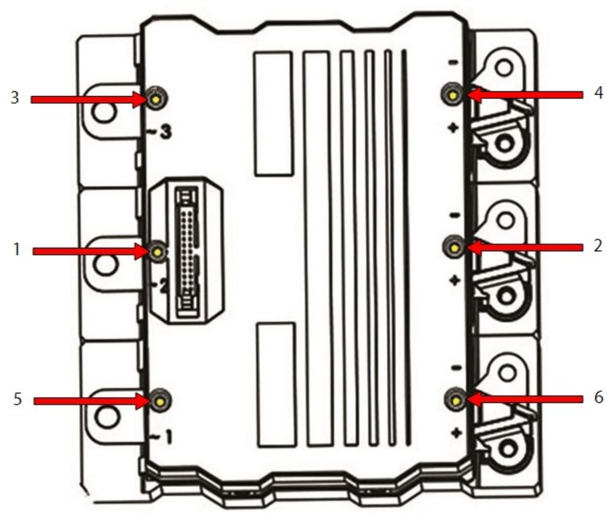
• • • CAUTION • • •
Any lateral movement may damage the spring pins.

Figure 4-215 Driver Board Placement



10. Insert the remaining fasteners and tighten from center outward according to Figure 4-216 Initial Tightening Pass Sequence on page 192. This will be the first pass and the fasteners should only be snug and not torqued at this step.

Figure 4-216 Initial Tightening Pass Sequence



11. Using an appropriately-rated torque wrench, tighten the fasteners from center outward (same sequence as previous step) to 1.5 Nm (13.2 in. lb.).

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

12. Install the Copper Tubes that connect the motor bus bars to the Inverter.
13. Connect the ribbon cable to the Inverter.
14. Install the DC Capacitor and Bus Assembly. Refer to Section 4.21.3 DC Capacitor Bus Bar Assembly Removal and Installation on page 168.
15. Install the Soft Start. Refer to Section 4.14 Soft Start on page 113.
16. Connect all remaining cable harnesses.
17. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
18. Return the compressor to normal operation.

4.22.8 Inverter Torque Specifications

Table 4-36 Inverter Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
Soft Start DC+ DC- to DC Bus Bolt/nut (TTS300/TGS230 only)	10	7	89
DC Capacitor Bus Bar to SCR Bus Bar Bolt (TTS300/TGS230 only)	10	7	89
DC Bus Bars to SCR fastener, M6x16 (TTS300/TGS230 only)	5	-	44
AC Bus Bar to SCR fastener, M6x16 (TTS300/TGS230 only)	5	-	44
AC Bus Bar to SCR fastener, M8x20 (Excludes TTS300/TGS230 compressors)	9	-	80
Fuse to Terminal Block fastener (TTS300/TGS230 only)	4	-	35
Terminal Block Mounting fastener, M5x45 (Excludes TTS300/TGS230 compressors)	4	-	35

Description	Nm	Ft.Lb.	In.Lb.
Terminal Block fastener, M5x15 (TTS300/TGS230 only)	3	-	27
DC Bus Bars to SCR fastener, M6x16 (TTS300/TGS230 only)	5	-	44
SCR Cooling Manifold to Inverter Cooling Manifold fastener, M6x20 (TTS300/TGS230 only)	7	-	62
SCR Cooling Manifold to Inverter Cooling Manifold fastener, M6x35 (Excludes TTS300/TGS23 compressors)	8.5	-	75
AC Bus Bar to SCR fastener, M8x20 (Excludes TTS300/TGS230 compressors)	9	-	80
Terminal Block Mounting fastener, M5x45 (Excludes TTS300/TGS230 compressors)	4	-	35
DC Bus to SCR fastener, M8x20 (TTS300/TGS230 only)	9	-	80
Capacitor DC Bus Bar to SCR fastener, M8x20 (excludes TTS300/TGS230 compressors)	9	-	80
Mains Input Pressure Screw, 11/16" - 16 UNC (TTS300/TGS230 compressors only)	20	15	177
Mains Input Nut, 3/8" - 16 UNC (excludes TTS300/TGS230 compressors)	21	15	186
Snubber Capacitor fastener, M6x16	7	-	62
Nylon Capacitor Nut	7	-	62
Soft Start Mounting fastener, M5X15	5	-	44
Inverter to Motor Bus Bar fastener, M8x70	14	10	124
Inverter Assembly Mounting fastener, M6x30	8.5	-	75
DC-DC Mounting fastener, M3x10	0.6	-	5
Backplane Ground fastener, M5x10	3	-	27
IGV Feedthrough Retainer Clip fastener, M5x16	25	18	221
Ground Post Top Nut, 5/16" - 18 UNC	7	-	62
Ground Post Second (Jam) Nut, 5/16" - 18 UNC	7	-	62
Cover Fastener, M5x15	1.5	-	13
Cover Fastener, M5x20 (#3 on Capacitor Cover)	1.5	-	13

4.23 Motor Components

4.23.1 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.

4.23.1.1 Stator

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

4.23.1.2 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.

4.23.2 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.

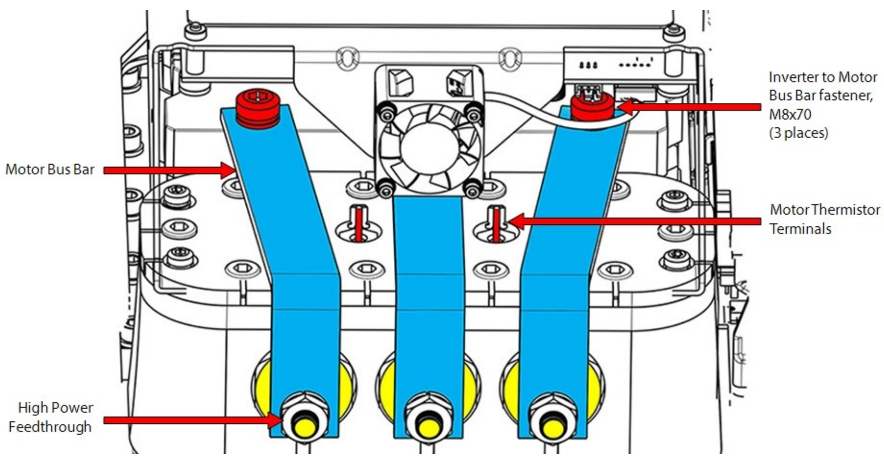
Motor currents and voltages displayed in the SMT cannot be directly compared or correlated to incoming 3-phase AC values.

All Stators employ overheat cutout protection utilizing thermistors in each winding.

4.23.3 Motor Connections

Refer to Figure 4-217 Connection to Stator for details on the connections and serviceable components.

Figure 4-217 Connection to Stator



4.23.4 Motor 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.

4.23.4.1 Stator Insulation Verification

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Remove the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
3. Remove the Copper Tubes that connect the motor bus bars to the Inverter.

• • • 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 (2) motor bus bars to ensure all windings are intact.

4.23.4.2 Stator Resistance Verification

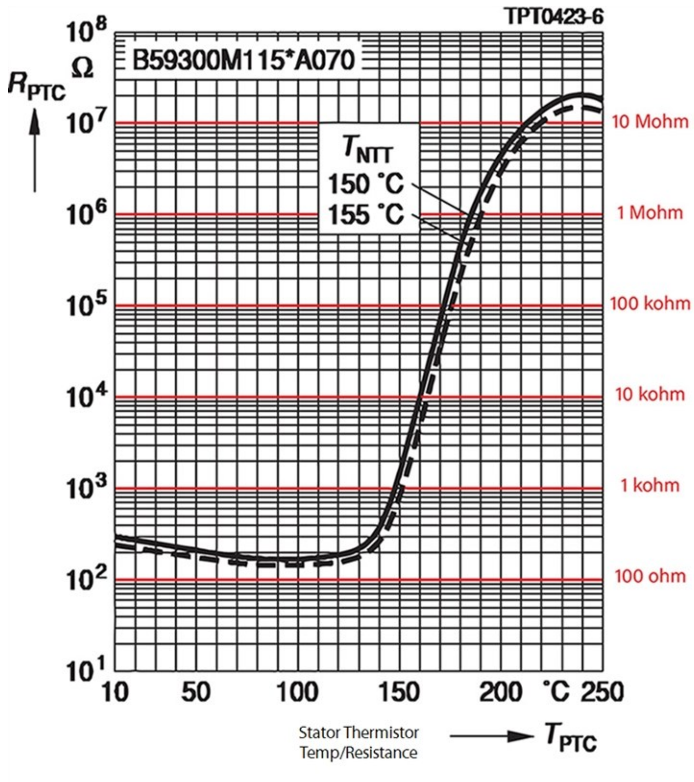
To verify the Stator resistance, complete the following steps:

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Remove the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
3. Remove the Copper Tubes that connect the motor bus bars to the Inverter.
4. Using a multimeter set for resistance measurements, place the red (+) multimeter lead on one of the three (3) 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.

4.23.4.3 Stator Thermistor Resistance Verification

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Disconnect the DC supply cable harness from the motor thermistor terminals. Refer to Figure 4-217 Connection to Stator on page 194.
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 (150-300Ω at 70°F (21°C) outlined in Figure 4-218 Stator Thermistor R/T Curve on page 196. If the measured value does not correspond to the expected resistance, then the Stator thermistor is faulty and the compressor must be replaced.

Figure 4-218 Stator Thermistor R/T Curve



4.23.5 Motor Components Removal and Installation

This section contains steps that explain the removal and replacement of the Motor Bus Bars, Copper Tubes, Cover Plate, and the High-Power Feedthroughs. The following steps apply to all TTS/TGS/TTH/TGH compressors.

The TTS/TGS/TTH/TGH compressors utilize two different styles of High-Power Feedthroughs. There is a clear physical distinction between the two styles. The Polyphenylene Sulfide (PPS) style has threaded female ends while the stainless-steel style has threaded male ends that require brass nuts. When necessary, the two (2) different types will be identified.

4.23.5.1 Motor Bus Bar Removal

1. Isolate compressor power as described in Section Section 1.8 Electrical Isolation on page 22.
2. Remove the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
3. Remove the Motor Bus Bars. If the feedthrough is a PPS style, hold the High-Power Feedthrough with a wrench while removing the motor bus bar fastener in order to prevent the feedthrough from rotating. If the feedthrough is stainless-steel style, hold the inner nut with a wrench while loosening the outer nut. Refer to Figure 4-219 Motor Bus Bar Removal - PPS Feedthroughs on page 197 and Figure 4-220 Motor Bus Bar Removal - Stainless-Steel Feedthroughs on page 197.

• • • CAUTION • • •

While removing the M10 nuts for the Stainless-Steel High-Power Feedthrough, it is important to hold the inner nut with a wrench. Failure to do so could place an excessive load on the feedthrough causing internal damage. Also, the feedthrough itself could move which could allow it to loosen or be over torqued.

Figure 4-219 Motor Bus Bar Removal - PPS Feedthroughs

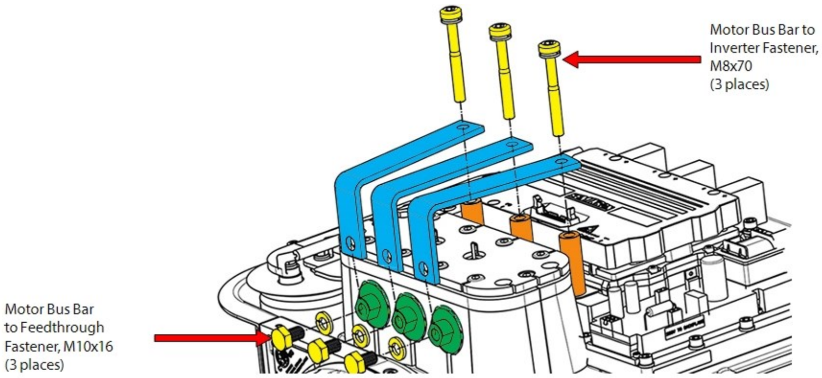
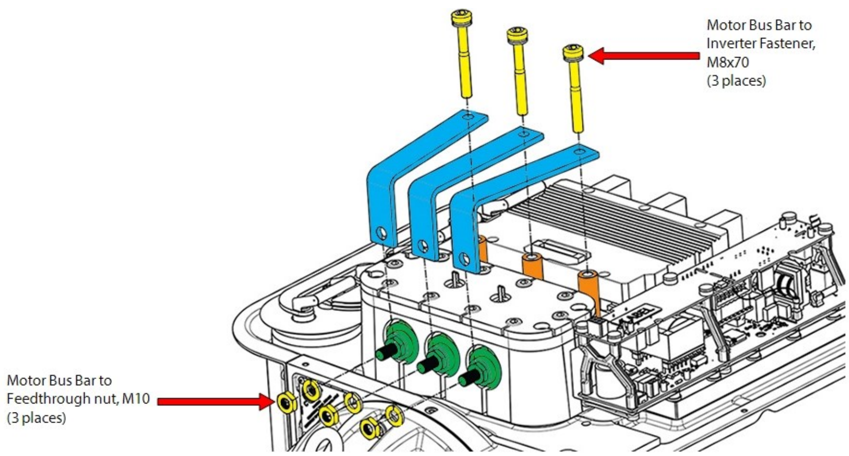


Figure 4-220 Motor Bus Bar Removal - Stainless-Steel Feedthroughs



4.23.5.2 Motor Bus Bar Installation

1. Place the motor bus bars in their correct locations; they are designed to align to individual bolt patterns and should not be forced.
2. Loosely install the three (3) M8x70 fasteners that secure the motor bus bars to the inverter output through the Copper Tubes. Continue to Step 3 if the compressor contains PPS High-Power Feedthroughs. Continue to Step 4 if the compressor contains Stainless-Steel High-Power Feedthroughs.
3. Install the three (3) M10x16 fasteners and lockwashers that secure the motor bus bars to the PPS High-Power Feedthroughs and torque to14 Nm (10 ft.lb.). Be careful not to over tighten the bolts to the power feedthroughs. Continue to Step 5.
4. Install the three (3) M10 nuts and lockwashers that secure the motor bus bars to the Stainless-Steel High-Power Feedthroughs and torque to 15.5 Nm (11.5 ft.lb.). Be careful not to over tighten the bolts to the power feedthroughs. Continue to Step 5.

• • • CAUTION • • •

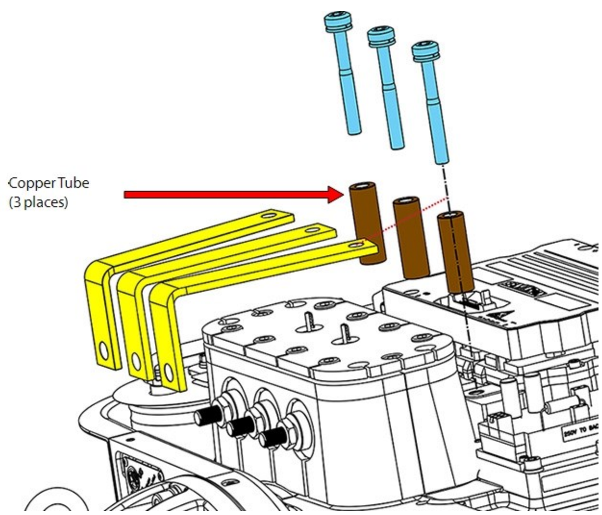
While torqueing the High-Power Feedthrough Nuts, it is important to hold the inner nut with a wrench. Failure to do so could place an excessive load on the feedthrough causing internal damage. Also, the feedthrough itself could move which could allow it to loosen or be over torqued.

5. Torque the three (3) M8x70 fasteners that secure the motor bus bars to the inverter output to 14 Nm (10 ft.lb.).
6. Install the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
7. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
8. Return the compressor to normal operation.

4.23.5.3 Copper Tube Removal

1. Isolate compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Remove the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
3. Remove the three (3) Motor Bus Bars. Refer to Section 4.23.5 Motor Components Removal and Installation on page 196.
4. Remove the three (3) Copper Tubes. Refer to Figure 4-221 Copper Tube Removal.

Figure 4-221 Copper Tube Removal



4.23.5.4 Copper Tube Installation

1. Install the three (3) Copper Tubes and torque the M8x70 Motor Bus Bar fasteners to 14 Nm (10 in.lb.).
2. Install the three (3) Motor Bus Bars. Refer to Section 4.23.5 Motor Components Removal and Installation on page 196.
3. Install the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
4. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
5. Return the compressor to normal operation.

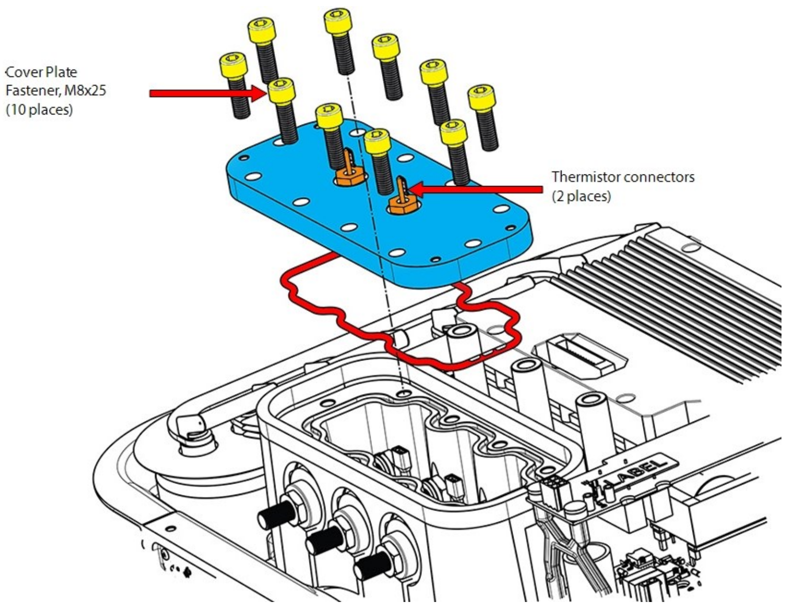
4.23.5.5 Motor Cover Plate Removal

• • • CAUTION • • •
Use extreme care not to drop any parts or tools into the motor cavity when removing the motor cover plate. Doing so could result in compressor damage or failure.

1. Isolate compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Isolate the compressor and recover the refrigerant according to industry standards. Refer to Section 3.1 Refrigerant Containment on page 41.
3. Remove the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.

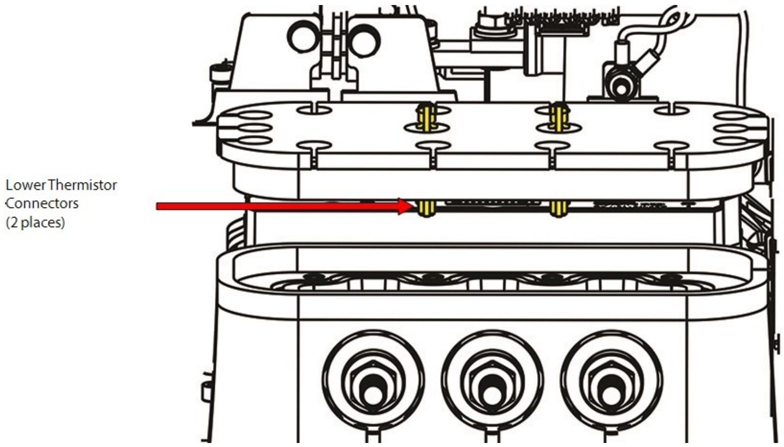
4. Remove the Motor Bus Bars. Refer to Section 4.23.5 Motor Components Removal and Installation on page 196.
5. Disconnect the two (2) connectors from thermistor sensor feedthrough. Refer to Figure 4-222 Motor Cover Plate Removal.

Figure 4-222 Motor Cover Plate Removal



6. Remove the 10 M8x25 fasteners that secure the Cover Plate to the Main housing. Refer to Figure 4-222 Motor Cover Plate Removal.
7. Cut the insulation (if necessary) in order to remove the Cover Plate.
8. Lift the Cover Plate slightly to prevent breaking the connections and carefully unplug the lower thermistor connectors. Refer to Figure 4-223 Thermistor Connector Removal.

Figure 4-223 Thermistor Connector Removal



9. Remove and discard the O-ring from the compressor housing.

4.23.5.6 Motor Cover Plate Installation

1. Clean the mating surfaces with a lint-free cloth. Inspect the sealing area for any damage.
2. Lubricate and install the preformed O-ring into the groove located in the Main housing.

3. Install the wires on the inner thermistor terminals while holding the Cover Plate. Refer to Figure 4-223 Thermistor Connector Removal on page 199.

NOTE

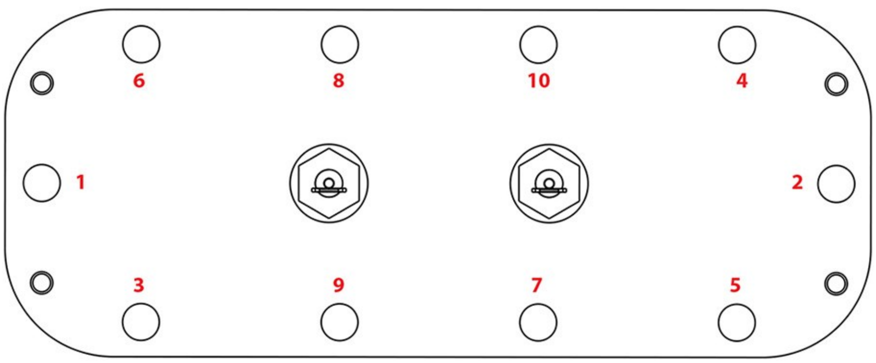
Polarity of the thermistor wires is not required.

• • • CAUTION • • •

Care must be taken while plugging in the thermistor sensor connectors. Ensure no damage occurs to the mounted O-ring during this action. The O-ring must be replaced if any damage occurs.

4. Lower the Cover Plate onto the Main housing.
5. Using the 10 M8x25 fasteners, install the Cover Plate. Finger-tighten and then, according to Figure 4-224 Cover Plate Torque Sequence, tighten in a crisscross pattern in two (2) stages.
   - Stage 1: Tighten to 10 Nm (7 ft.lb.)
   - Stage 2: Tighten to a final torque of 18 Nm (13 ft.lb.)

Figure 4-224 Cover Plate Torque Sequence



6. Leak test and evacuate in accordance with standard industry practices.
7. Connect the two (2) connectors to the thermistor sensor feedthrough.
8. Install the Motor Bus Bars. Refer to Section 4.23.5.2 Motor Bus Bar Installation on page 197.
9. Install the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
10. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
11. Return the compressor to normal operation.

4.23.5.7 High Power Feedthrough Removal

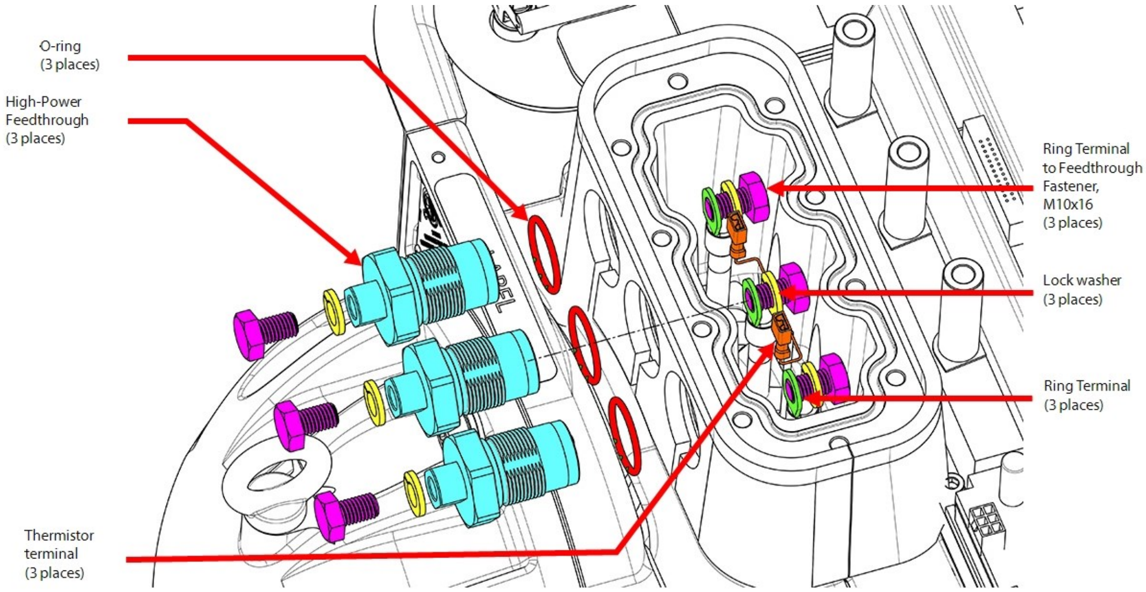
• • • CAUTION • • •

Use extreme care not to drop any parts or tools into the motor cavity when removing the high power feedthroughs. Doing so could result in compressor damage or failure.

1. Isolate compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Recover the refrigerant from the compressor according to industry standards. Refer to Section 3.1 Refrigerant Containment on page 41.
3. Remove the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.

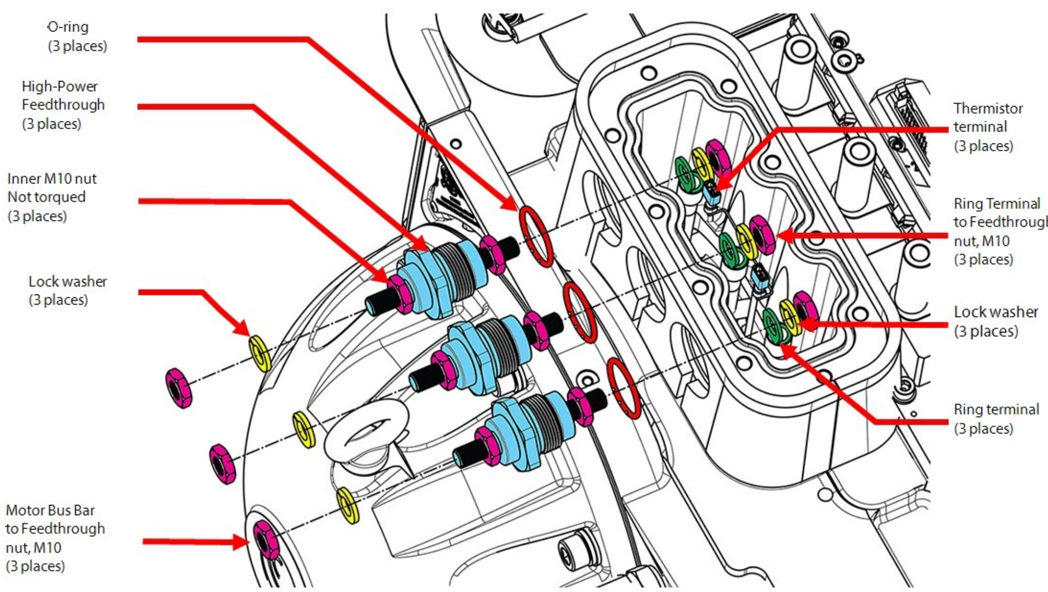
4. Remove the Motor Bus Bars. Refer to Section 4.23.5 Motor Components Removal and Installation on page 196.
5. Remove the Cover Plate. Refer to Section 4.23.5.5 Motor Cover Plate Removal on page 198.
6. For the PPS feedthrough, continue to Step 7. For the stainless-steel style, continue to Step 8.
7. Remove the three (3) M10x16 fasteners and ring terminal connections from the feedthrough in order to be able to release feedthrough assembly. Refer to Figure 4-225 High-Power Feedthrough Removal (PPS).

Figure 4-225 High-Power Feedthrough Removal (PPS)



8. Remove the three (3) M10 nuts, lock washers, and ring terminal connections from the feedthrough in order to be able to release feedthrough assembly. Refer to Figure 4-226 High-Power Feedthrough Removal (stainless steel).

Figure 4-226 High-Power Feedthrough Removal (stainless steel)



9. Remove the three (3) high-power feedthroughs using a 36mm wrench.
10. Remove the three (3) high-power feedthrough O-rings from the Main housing if they did not come out with the old feedthroughs.
11. Inspect the sealing area for any residue or debris and clean the threads with a lint-free cloth if needed.

4.23.5.8 High-Power Feedthrough Installation

1. Clean the feedthrough mating surfaces with a lint-free cloth. Inspect the sealing area for any damage.
2. Verify that the old high-power feedthrough O-rings have been removed.
3. Lubricate and install new O-rings onto the High-Power Feedthroughs.

• • • CAUTION • • •
Be sure to fully seat the O-ring into the grove in the feedthrough. Failure to do this can result in damage to the O-ring while tightening.

4. Finger-tighten the High-Power Feedthroughs into the Main housing and then torque to specification. Continue to Step 5 for the PPS High-Power Feedthroughs. Continue to Step 7 for the Stainless-Steel High-Power Feedthroughs.
5. Secure the ring terminals to the PPS High-Power Feedthroughs using the M10x16 fasteners from the inside.
6. Once the M10x16 fasteners are finger tight, torque them to 14 Nm (10 ft.lb). Continue to Step 9.

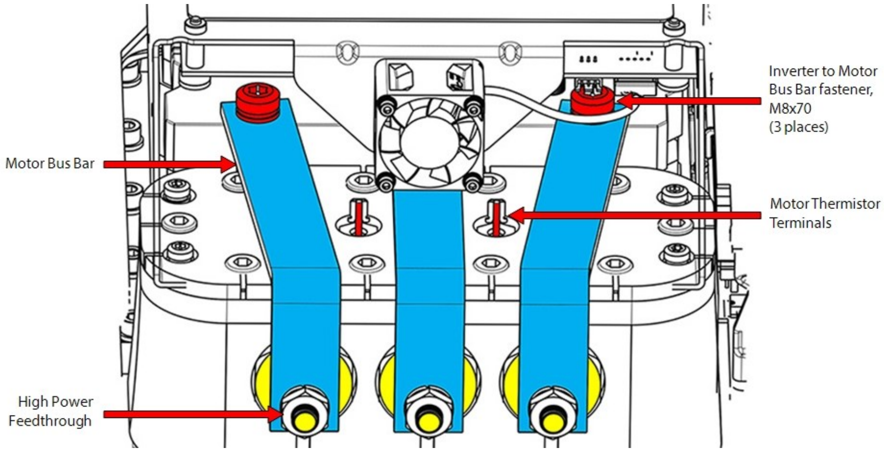
• • • CAUTION • • •
Hold the high-power feedthrough using a 36mm wrench while applying torque to the M10 fasteners to prevent loosening or over torqueing the feedthrough assembly.

7. Secure the ring terminals to the Stainless-Steel High-Power Feedthroughs using the M10 nuts and washers from the inside.
8. Once the nuts are finger tight, torque them to 15.5 Nm (11.5 ft.lb). Continue to Step 9.

• • • CAUTION • • •
While torqueing the High-Power Feedthrough Nuts, it is important to hold the inner nut with a wrench. Failure to do so could place an excessive load on the feedthrough causing internal damage. Also, the feedthrough itself could move which could allow it to loosen or be over torqued.

9. Install wires on the inner thermistor terminals and then install the Cover Plate. Refer to 4.23.5.6 Motor Cover Plate Installation on page 199.
10. Leak test and evacuate in accordance with standard industry practices.
11. Connect the two (2) connectors to the thermistor sensor feedthrough. Refer to Figure 4-227 Connection to Stator on page 203.

Figure 4-227 Connection to Stator



12. Install the Motor Bus Bars. Refer to Section 4.23.5 Motor Components Removal and Installation on page 196.
13. Install the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
14. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
15. Return the compressor to normal operation.

4.23.5.9 Motor Assembly Torque Specifications

Table 4-37 Motor Assembly Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
Soft Start Mounting fastener, M5X15	5	-	44
Cover Plate fastener, M8x25	18	13	159
High-Power Feedthrough (both styles)	22	16	195
Inverter to Motor Bus Bar fastener, M8x70	14	10	124
Motor Bus Bar to Feedthrough Fastener (PPS Feedthrough)	14	10	124
Motor Bus Bar to Feedthrough Nut (Stainless-Steel Feedthrough)	15.5	11.5	137
High-Power Feedthrough Screw to Ring Terminal (PPS Feedthrough)	14	10	124
High-Power Feedthrough Nut to Ring Terminal (Stainless-Steel Feedthrough)	15.5	11.5	137
Cover Fastener	1.5	-	13

4.24 High Voltage DC-DC Converter

There are two (2) variants of the DC-DC Converter mentioned in this manual. There is an epoxy, potted style which was in production since compressor inception and there is the open frame DC-DC converter that was released to production as replacement of the potted style in April 2019. The removal and installation of the two (2) variants are very similar. The open frame style utilizes six (6) mounting fasteners while the potted style uses eight (8). The open-frame style utilizes three (3) connectors whereas the potted style uses four (4). The open frame design no longer uses the 15VAC trigger signal from the Soft Start, thus eliminating the need for 15VAC on the DC-DC.

The open frame DC-DC Converter is fully backwards compatible, and it works with all of the voltage applications. The potted DC-DC Converter is specific to a given voltage.

4.24.1 DC-DC Converter Function

The 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 Potted DC-DC converter through the Closed-Top Soft Start Board F1 fuse. DC bus voltage (460-900VDC) is supplied to the Open Frame DC-DC converter directly through the AC/DC harness.

The Closed-Top Soft Start Board also powers the potted-style DC-DC Converter with 15VAC when the DC bus has reached minimum level.

Refer to Figure 4-229 Potted DC-DC on page 206 andFigure 4-230 Open Frame DC-DC on page 206 for the DC-DC Converter input-output (I/O) connections:

Inputs:

- J1 Bus Input
- J4 15VAC (potted version only)

Outputs:

- J2 250VDC
- J3 24VDC (potted) J4 24VDC (open frame)

4.24.2 DC-DC Converter Verification

4.24.2.1 Input Voltage Verification

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Install the DC bus test harness. Refer to Section 1.10.1 General Verification and Installation of the DC Bus Test Harness on page 26.
3. Turn on the mains power to the compressor.
4. Using the DC bus test harness, verify the expected voltages are present. Refer to Table 4-18 Expected AC Voltage Range on page 102.

4.24.2.2 Output Voltage Verification

1. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
2. Provided the Input Voltage is correct, with mains power on, using a multimeter set for DC voltage measurements, place the multimeter leads in the HV+ and HV- test points on the Backplane. Refer to Figure 4-239 Backplane Test Points on page 213 for this and the following step. The result should be 220 – 280 VDC.
3. Place the multimeter leads in the +24 and 0V test points on the Backplane. The result should be 22 – 26 VDC.

4.24.2.3 Input Resistance Measurement

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Unplug all connectors to the DC-DC Converter.
3. Using a multimeter set for resistance measurements, place the multimeter leads in the J1, HV DC input plug terminals. Refer to Figure 4-229 Potted DC-DC on page 206 and Figure 4-230 Open Frame DC-DC on page 206. The result should not be 0.0Ω. The result can be open (infinity) or >150kΩ depending on the polarity of the test leads.
4. Reverse the multimeter leads on the J1 plug terminals. The result should not be 0.0Ω. The result can be open (infinity) or >150kΩ.
5. In the Potted DC-DC, Place the multimeter leads in J4, 15VAC input terminals. The result should be >1MΩ.

NOTE

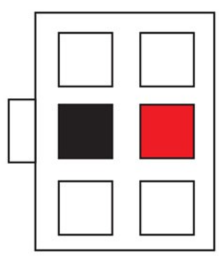
- J4 (15VAC input) is only for the Potted DC-DC Converter
- If resistance is low, allow time for it to rise

6. Reverse the multimeter leads on the J4 terminals. The result should be >1MΩ.

4.24.2.4 Output Resistance Measurement

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Unplug all connectors to the DC-DC Converter.
3. Using a multimeter set for resistance measurements, place the multimeter leads on the J2, 250VDC output terminals. Refer to Figure 4-229 Potted DC-DC on page 206 and Figure 4-230 Open Frame DC-DC on page 206. The result should be a rising or falling value, not static, zero, or infinity.
4. Reverse the multimeter leads on the J2 (250VDC output) terminals. The result should be a rising or falling value, not static, zero, or infinity.
5. Place the multimeter leads in the middle row of the J3, 24VDC output terminals for the potted DC-DC Converter or J4 for the open frame DC-DC Converter. Refer to Figure 4-228 J3/J4 - 24VDC Output Connector. The result should be a rising or falling value, not static, zero, or infinity.

Figure 4-228 J3/J4 - 24VDC Output Connector



6. Reverse the multimeter leads on the 24VDC output terminals and measure the resistance. The result should be a rising or falling value, not static, zero, or infinity.

NOTE

Should the output resistances show unexpected values, re-verify each output more than once. The best verification is identifying the correct Output Voltages are present when Input Voltage is correct.

4.24.3 DC-DC Removal and Installation

Removal

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Remove the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
3. Remove the connectors from the DC-DC.
   - Potted style - Four (4) connectors (DC Bus Input (J1), 250VDC (J2), 24VDC (J3), and 15VAC (J4)) from the DC-DC Converter. Refer to Figure 4-229 Potted DC-DC on page 206.
   - Open frame style - Three (3) connectors (DC Bus Input (J1), 250VDC Output (J2), and 24VDC output (J4)) from the DC-DC Converter. Refer to Figure 4-230 Open Frame DC-DC on page 206.

Figure 4-229 Potted DC-DC

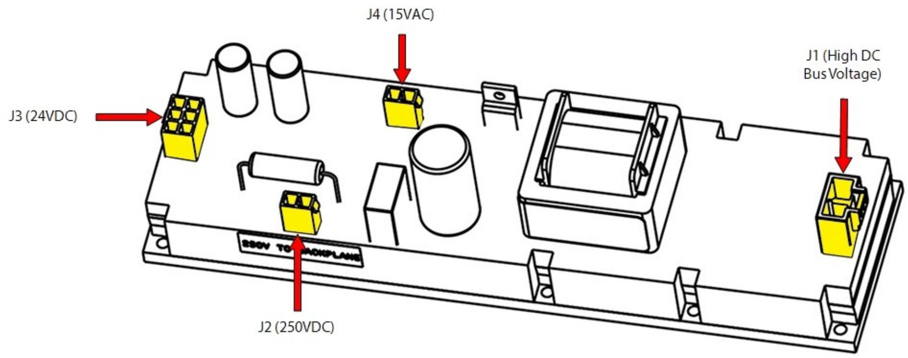
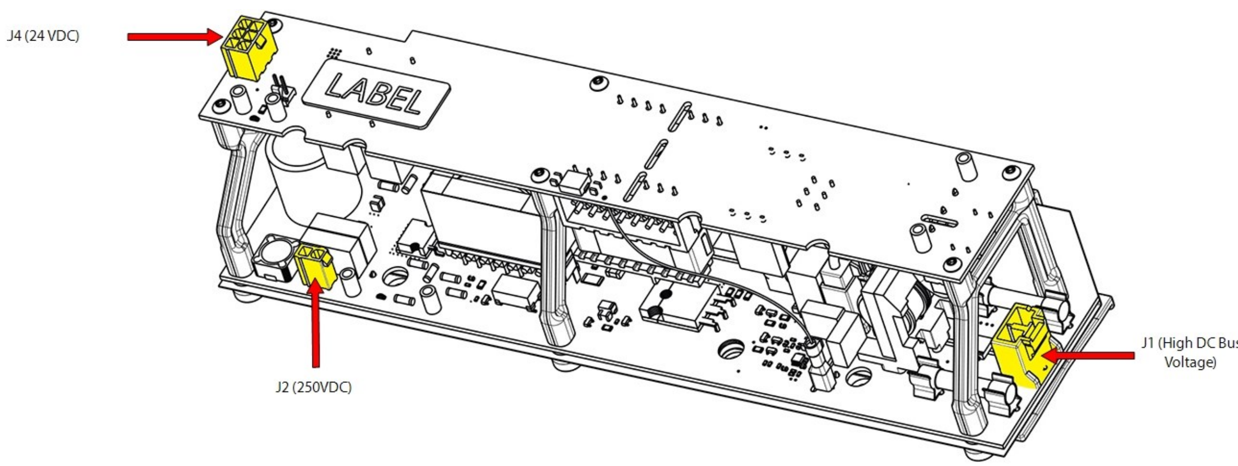
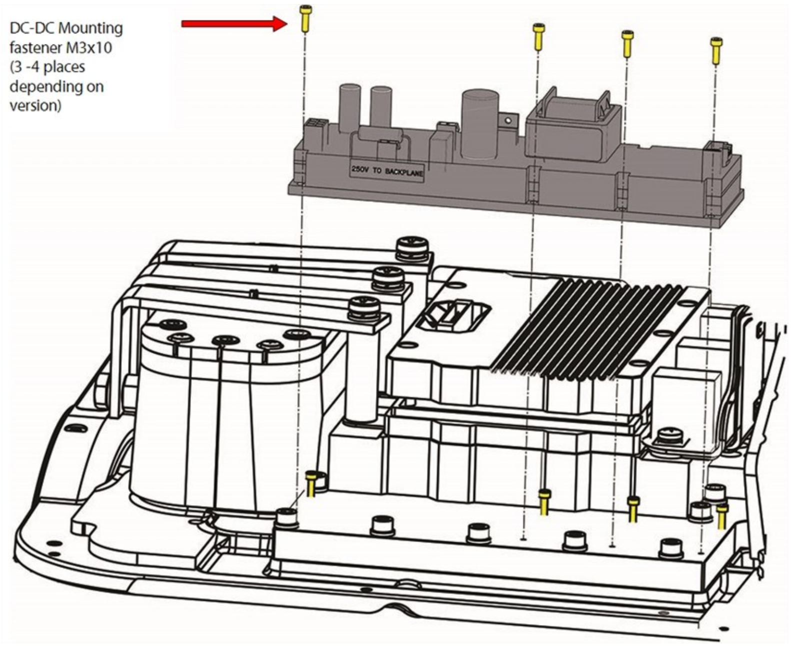


Figure 4-230 Open Frame DC-DC



4. Loosen the M3x10 fasteners that are located next to the Inverter. Refer to Figure 4-231 DC-DC Converter Removal on page 207 for this and the next two (2) steps.
5. Remove the M3x10 fasteners that are located on the front side of the DC-DC Converter.
6. Lift the DC-DC Converter on the front side and slide it clear of the rear fasteners. If reusing, store the DC-DC Converter in an anti-static bag.
7. After the removal of the DC-DC Converter, completely remove the remainder of the M3x10 fasteners.

Figure 4-231 DC-DC Converter Removal



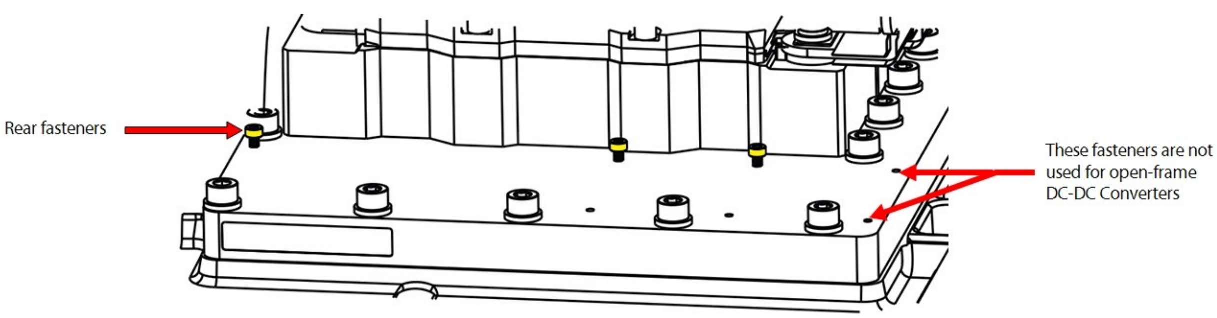
Installation

1. Clean the Inverter Heat Sink Plate where the DC-DC was mounted, and clean the mating surface of the DC-DC if it is to be reused. Isopropyl alcohol is recommended to best remove the heatsink paste.
2. Spread a thin and uniform coat of Dow Corning Silicone Heat Sink paste (or equivalent) entirely over the bottom of the Potted DC-DC.

NOTE
Open Frame DC-DC Converters do not require heat sink paste.

3. Install the rear M3x10 fasteners that secure the DC-DC Converter to the Inverter Heat Sink Plate. Do not tighten at this time; leave enough space under the fasteners to allow the DC-DC Converter to slide under. Refer to Figure 4-232 DC-DC Rear Fastener Install.

Figure 4-232 DC-DC Rear Fastener Install



4. Align the DC-DC Converter with the mounting holes on the Inverter Heat Sink Plate by sliding the DC-DC Converter under the partially-installed rear fasteners.
5. Install the new front M3x10 fasteners that secure the DC-DC Converter to the Inverter Heat Sink Plate. Torque all fasteners to 0.5 Nm (4 in.lb.). Refer to Figure 4-233 Potted DC-DC - Top View on page 208 and Figure 4-234 Open Frame DC-DC - Top View on page 208 for the fastener locations.

Figure 4-233 Potted DC-DC - Top View

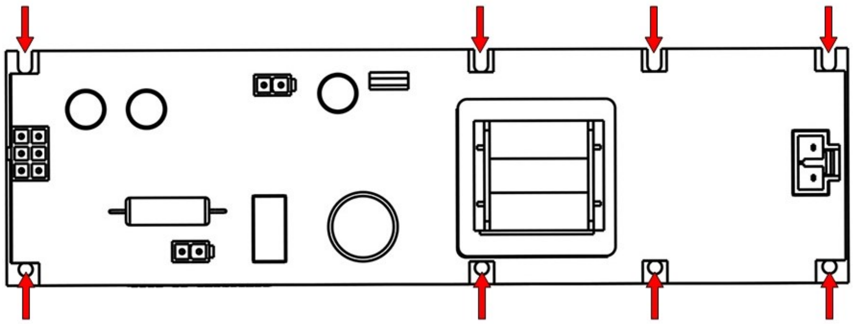
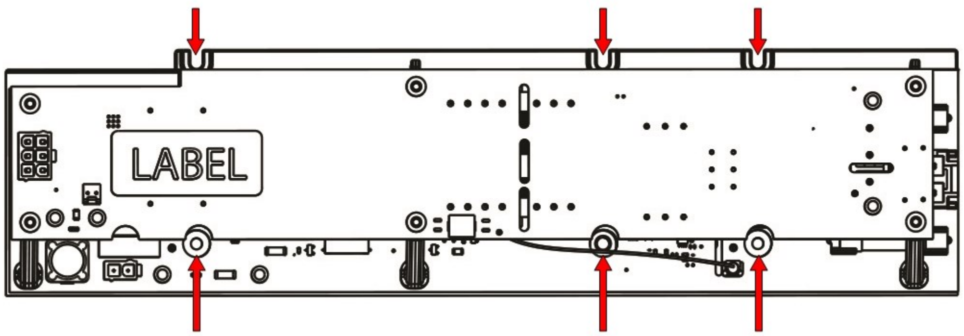


Figure 4-234 Open Frame DC-DC - Top View



6. Connect the DC-DC cables.
7. Install the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.
8. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
9. Return the compressor to normal operation.

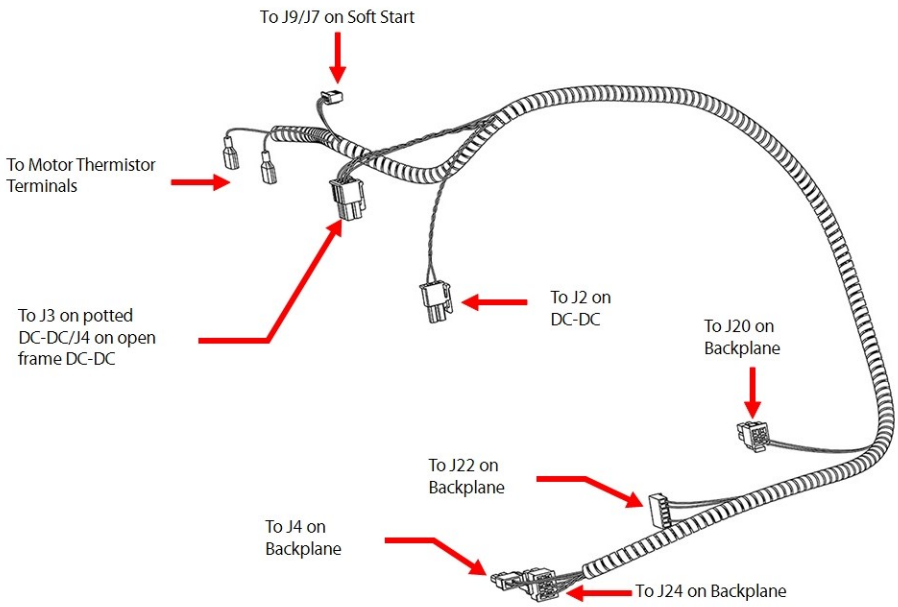
4.24.3.1 DC-DC Torque Specifications

Table 4-38 Table 4-39 DC-DC Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
Soft Start Mounting fastener, M5X15	5	-	44
DC-DC Mounting fastener, M3x10	0.5	-	4
Cover Fastener	1.5	-	13

4.24.4 DC-DC Supply Cable Harness

Figure 4-235 DC-DC Harness



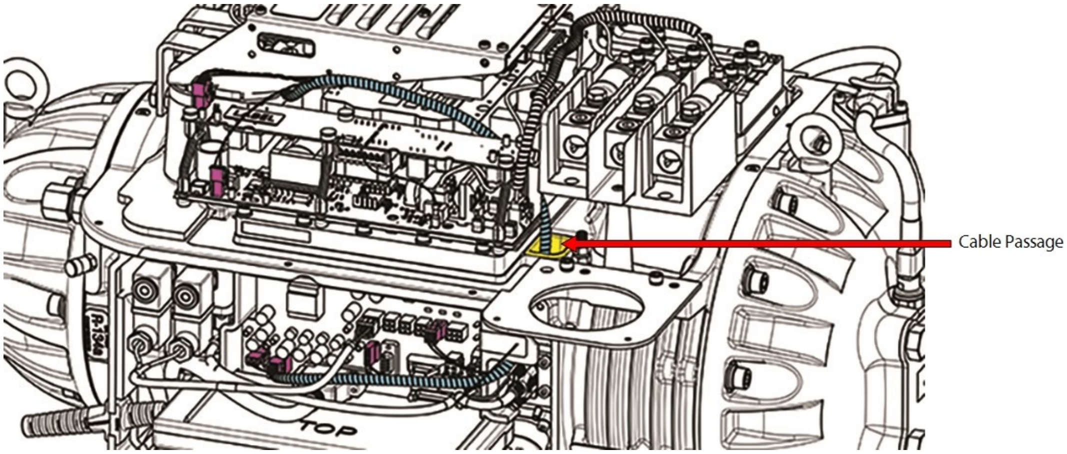
NOTE
J4 for the Potted DC-DC is not shown.

4.24.5 DC-DC Harness Removal and Installation

4.24.5.1 DC-DC Harness Removal

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
3. Disconnect the two (2) motor thermistor connections from the Motor Top Plate.
4. Disconnect the 24 and 250VDC output from the DC-DC. Refer to Figure 4-229 Potted DC-DC on page 206 and Figure 4-230 Open Frame DC-DC on page 206 for further details.
5. Remove the Soft Start Temperature Harness Connector. The two (2) different Soft Start variants have a change in these connectors. Both are approximately in the same location.
   a. For Closed-Top Soft Starts, disconnect the J9 connector. Refer to Figure 4-99 Closed-Top Soft Start J9 Connector on page 118.
   b. For Open-Top Soft Starts, disconnect the J7 connector. Refer to Figure 4-104 Open-Top Soft Start J7 Connector on page 120.
6. Carefully cut any cable ties that may be securing the cable harness in place both at the top side and service side.
7. Disconnect J4, J20, J22, and J24 from the Backplane. Refer to Figure 4-238 Backplane Connections on page 212.
8. Carefully pull the harness down through the cable passage on the Service Side and remove. Refer to Figure 4-236 DC-DC Harness Routing on page 210.

Figure 4-236 DC-DC Harness Routing

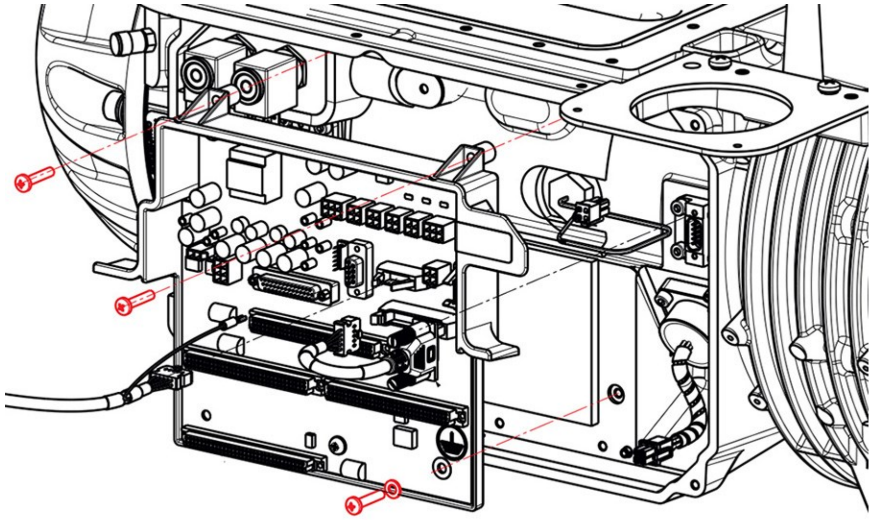


4.24.5.2 DC-DC Harness Installation

1. Carefully pull the harness down through the cable passage.
2. Connect J4, J20, J22, and J24 to the Backplane. Refer to Figure 4-238 Backplane Connections on page 212.
3. Connect the Soft Start Temperature Harness Connector to the J9 or J7 on the Soft Start.
4. Connect the 24VDC and 250VDC output from the DC-DC. Refer to Figure 4-229 Potted DC-DC on page 206 andFigure 4-230 Open Frame DC-DC on page 206 for further details.
5. Connect the two (2) motor thermistor connections to the Motor Top Plate.
6. Install any cable ties as necessary.
7. Install the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
8. Install the top covers. Refer to Section 4.1.2 Top Cover on page 53.
9. Return the compressor to normal operation.

4.25 Backplane

Figure 4-237 Backplane



4.25.1 Backplane Function

The Backplane is powered by +24VDC (with respect to 0V) from the DC-DC Converter. The DC-DC Converter also provides the Backplane with HV+ (+250VDC with respect to HV-) for the Bearing PWM Amplifier. The Backplane connects the on-board plug-in modules with communication from 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 on-board, 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 LEDs. All LEDs are amber in color except for the alarm LED (D12) which is green or red, depending on alarm status.

4.25.2 Backplane Connections and Test Points

The Backplane connections and test points are indicated in Figure 4-238 Backplane Connections on page 212 and Figure 4-239 Backplane Test Points on page 213.

Figure 4-238 Backplane Connections

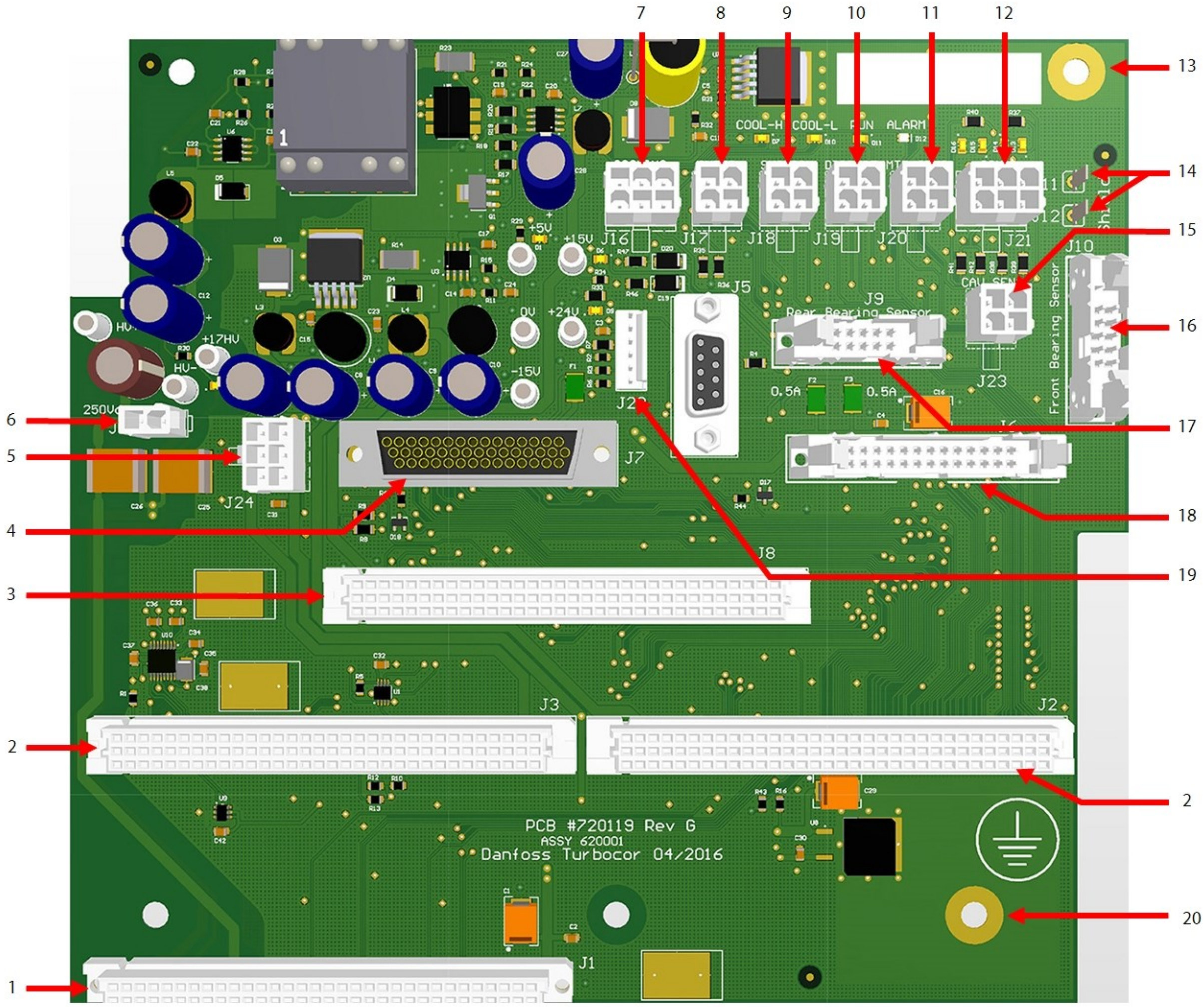


Table 4-39 Backplane Connections

No.	Component	No.	Component
1	J1: PWM Connection Port	11	J20: Motor-Winding Sensor Port
2	J2 and J3: BMCC Connection Port	12	J21: IGV Motor Control Port
3	J8: Serial Driver Connection Port	13	Inverter Ground Screw
4	J7: I/O Cable Connection	14	J11 and J12: Rear Bearing Sensor Cable to Ground (either may be used)
5	J24: Input of +24VDC from DC-DC	15	J23: Cavity Temperature Sensor Input
6	J4: Input of +250VDC From DC-DC	16	J10: Front Bearing Sensor Input
7	J16: Motor-Cooling Solenoids Control Port	17	J9: Rear Bearing Sensor Input
8	J17: SCR Temperature (TTH/TGH Interstage Temperature/Pressure Sensor) Sensor Port	18	J6: Inverter Connection Port
9	J18: Suction Temperature/Pressure Sensor Port	19	J22: Soft Start Temperature Sensor
10	J19: Discharge Temperature/Pressure Sensor Port	20	Backplane Ground Screw

Figure 4-239 Backplane Test Points

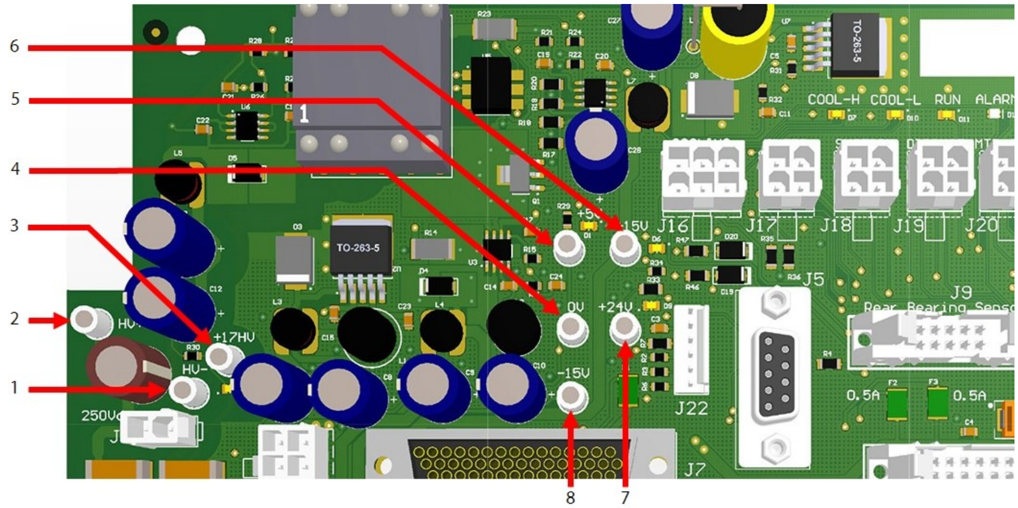


Table 4-40 Backplane Test Points

No.	Component	No.	Component
1	HV- Test Point	5	+5V Test Point
2	HV+ Test Point	6	+15V Test Point
3	+17HV Test Point	7	+24V Test Point
4	0V Test Point	8	-15V Test Point

4.25.2.1 LED Locations

The Backplane LEDs are indicated in Figure 4-240 Backplane LED Locations - Left Side and Figure 4-241 Backplane LED Locations - Right Side on page 214.

Figure 4-240 Backplane LED Locations - Left Side

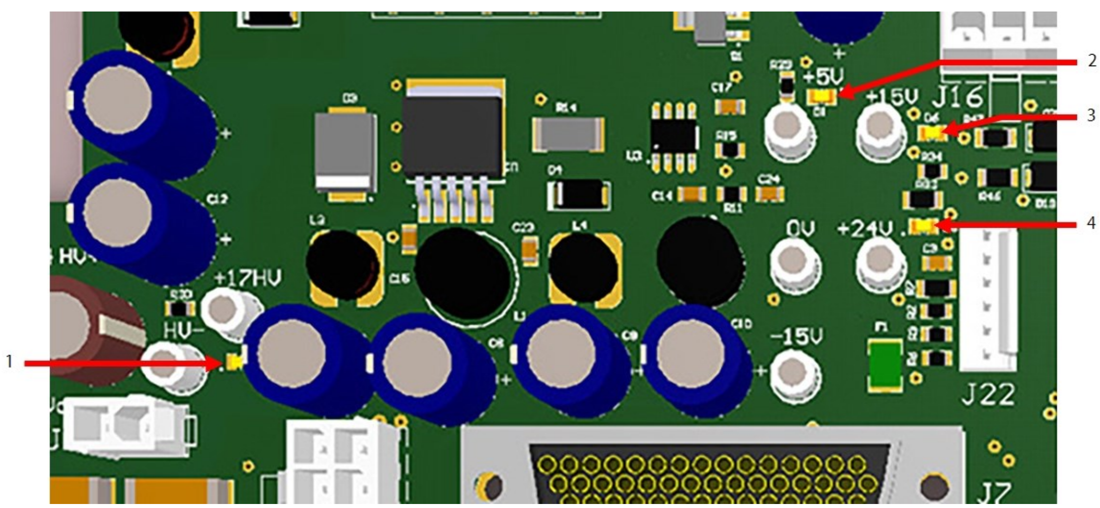


Figure 4-241 Backplane LED Locations - Right Side

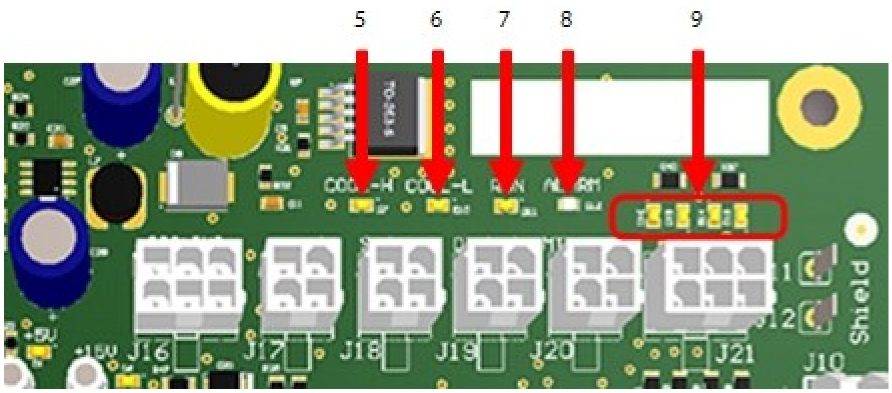


Table 4-41 Backplane LED Locations

No.	Component	No.	Component
1	D2: +17 VDC	6	D10: Cool-L power to solenoid
2	D1: +5VDC	7	D11: Run contact is closed when on
3	D6: + 15 VDC	8	D12: Compressor Status: Red indicates alarm or reset, Green indicates normal
4	D9: + 24 VDC	9	D13-D16: IGV Stepper Motor Indicator; flicker when operating
5	D7: Cool-H power to solenoid		

4.25.2.2 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. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
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 Figure 4-239 Backplane Test Points on page 213.Table 4-42 Backplane Test Point Values on page 215.
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 Figure 4-239 Backplane Test Points on page 213. The results should be greater than the resistance specified in Table 4-42 Backplane Test Point Values on page 215.
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.
8. Repeat Step 2. If the voltages are as expected, the Backplane is functioning correctly and not the cause of the energy drain.

Table 4-42 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

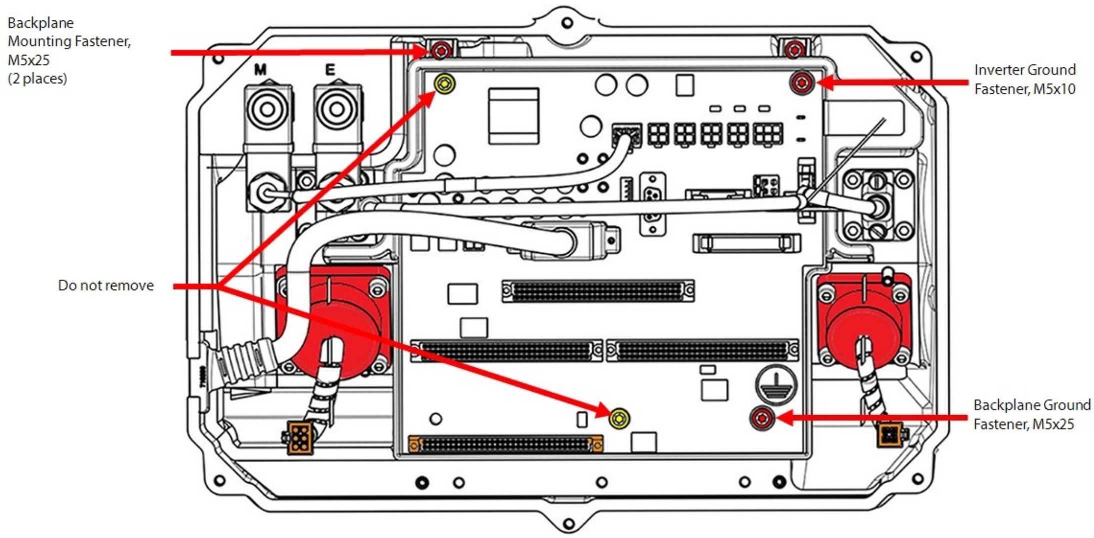
9. Install any components that may have been removed while testing.
10. Install the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
11. Return the compressor to normal operation.

4.25.3 Backplane Removal and Installation

4.25.3.1 Backplane Removal

1. Isolate compressor power.
2. Wait for the Backplane LEDs to turn off.
3. Remove the Serial Driver. Refer to Section 4.26.4 Serial Driver Removal and Installation on page 218.
4. Remove the BMCC. Refer to Section 4.27 BMCC on page 220.
5. Remove the PWM. Refer to Section 4.28.4 PWM Removal and Installation on page 228.
6. Disconnect and remove all remaining connectors from the Backplane. Refer to Figure 4-238 Backplane Connections on page 212.
7. Remove the Inverter Ground fastener from the top right of the Backplane to release the Inverter cable ground ring.
8. Replace the Inverter ground fastener.
9. Remove the three (3) fasteners that secure the Backplane Frame to the housing. Do not remove the fastener at the top left or bottom center of the Backplane so the circuit board remains in the frame. Refer to Figure 4-242 Removing the Backplane on page 216.

Figure 4-242 Removing the Backplane



10. Remove the Backplane Frame from the compressor housing.

4.25.3.2 Backplane Installation

1. Align the Backplane with the mounting holes, ensuring the cavity temperature sensor connector is available.
2. Insert and torque the fasteners at the top of the Backplane Frame to 3 Nm (27 in.lb.).
3. Insert and torque the Backplane Ground fastener at the bottom right of the Backplane to 3 Nm (27 in.lb.).
4. Install all connectors to their appropriate locations.
5. Remove the Inverter Ground fastener from top right of the Backplane.
6. Connect the Inverter ground ring to the Inverter Ground Screw and torque the fastener at top right of the Backplane to 3 Nm (27 in.lb.).
7. Install the Bearing PWM Amplifier, BMCC, and Serial Driver.
8. Install the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
9. Return the compressor to normal operation.

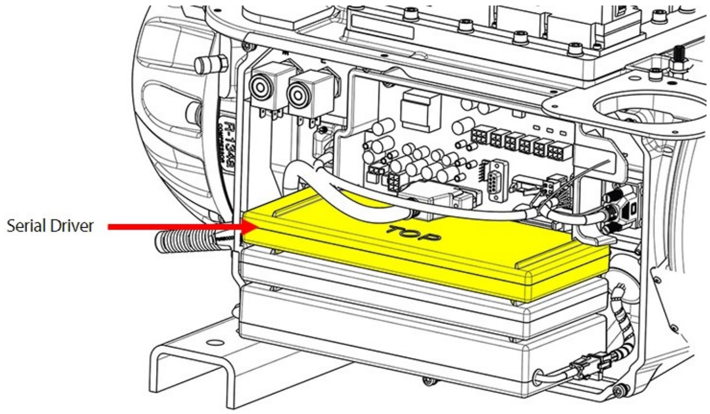
4.25.3.3 Backplane Torque Specifications

Table 4-43 Backplane Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
Backplane Mounting/Ground fastener, M5x10	3	-	27
Inverter Ground fastener, M5x25	3	-	27
PWM Mounting/heatsink fastener, M5x10	4.5	-	40
Cover fastener, M5x15	1.5	-	13

4.26 Serial Driver

Figure 4-243 Serial Driver



4.26.1 Serial Driver 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.

4.26.2 Serial Driver Connections

The Serial Driver is connected to J8 of the Backplane. All components that communicate with the Serial Driver are connected to the Backplane. Refer to Figure 4-238 Backplane Connections on page 212.

4.26.3 Serial Driver Verification

4.26.3.1 Serial Driver Input Voltage

1. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
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 4-40 Backplane Test Points on page 213 for the locations of the test points. The results should be within the voltage range specified in Table 4-42 Backplane Test Point Values on page 215.
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 4.25.2.1 LED Locations on page 213. The results should be greater than the resistance specified in Table 4-42 Backplane Test Point Values on page 215.
6. Install the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
7. Return the compressor to normal operation.

4.26.3.2 Serial Driver Output Voltage Verification

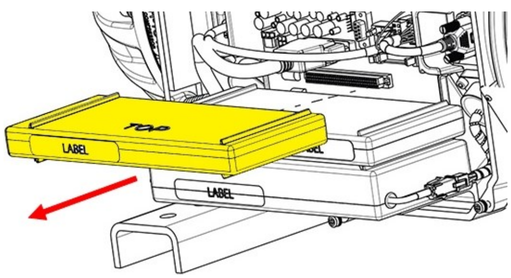
1. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
2. Isolate compressor power and wait for the Backplane LEDs to go out.
3. Wait a minimum of one (1) minute.
4. Reapply compressor power.
   - The Alarm LED will illuminate green and the Cool-H, Cool-L and Run LEDs will illuminate amber, all for about five (5) seconds. The Alarm LED will then switch to red and the others will turn off.
   - 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.
5. Install the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.

4.26.4 Serial Driver Removal and Installation

4.26.4.1 Serial Driver Removal

1. Isolate compressor power.
2. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
3. Wait for the LEDs on the Backplane to turn off.
4. Carefully disconnect the Serial Driver from the Backplane and slide it slowly away from the compressor. Refer to Figure 4-244 Serial Driver Removal.

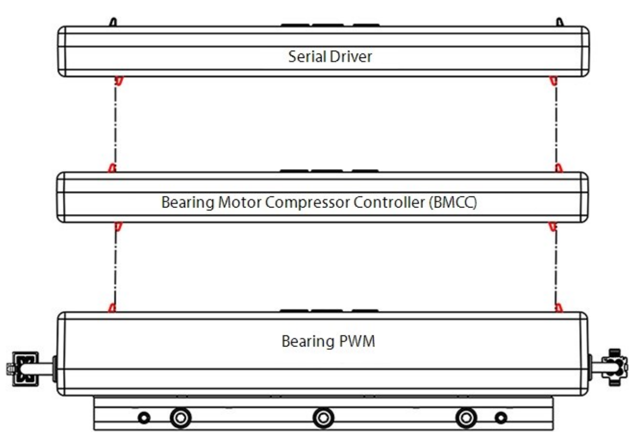
Figure 4-244 Serial Driver Removal



4.26.4.2 Serial Driver Installation

1. Carefully align the Serial Driver on top of the BMCC. Refer to Figure 4-245 Insertion Guides.

Figure 4-245 Insertion Guides



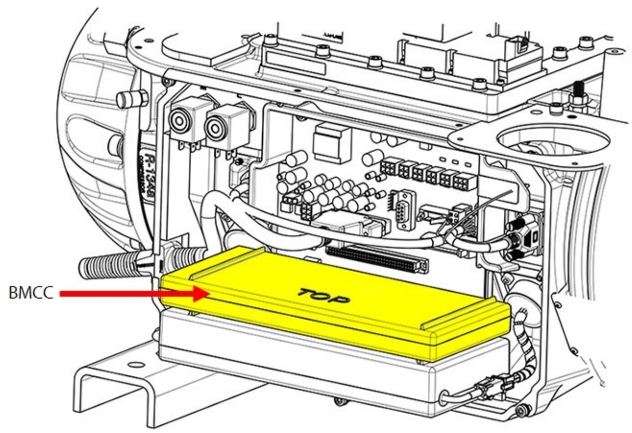
2. Slide the Serial Driver onto the J8 connector on the Backplane.
3. Install the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
4. Return the compressor to normal operation.

4.27 BMCC

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

Figure 4-246 BMCC



4.27.1 BMCC Connections

The BMCC is connected to J2 and J3 on the Backplane. Refer to Figure 4-238 Backplane Connections on page 212.

4.27.2 BMCC Verification

4.27.2.1 BMCC Power Verification

1. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
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. 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.

4.27.2.2 BMCC Communication Verification

This section requires the use of the SMT. Refer to the Service Monitoring Tools User Manual for guidance.

1. Using the SMT installed on your computer, connect to the compressor using the Compressor Connection Manager tool over RS-485 & RS-232.
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.

4.27.3 BMCC Battery and Verification

All BMCC printed circuit boards (PCBs) include a real-time clock integrated circuit (RTC-IC) for the purpose of maintaining the time and date of compressor events. While power is applied to the compressor, the BMCC receives a 5V supply via the Backplane to power the RTC-IC. The battery becomes the RTC-IC power supply and maintains the date and time only in the event of a power loss, if the BMCC is installed on a compressor that is not powered on, or if the BMCC was never installed on a compressor at all.

The Backup Battery does not affect the operation of the compressor in any way, nor does it have any adverse effects on the software within the BMCC. In fact, the only way to know if the battery may be defective is to verify the correct time was kept after the BMCC lost its 5V supply for any reason.

4.27.3.1 BMCC Battery Safety

The battery used in the BMCC is a coin type lithium style. The part number is BR1225. This battery is not sold by Danfoss LLC but can be locally sourced at most stores that sell coin-type batteries.

• • • DANGER! • • •
Please follow the safety warnings listed in this section.

Please observe the following safety warnings:

- Verify the battery is properly installed ("+" side facing up, away from the PCB)
- Do not attempt to charge the battery
- Do not deform, short, or heat up the battery
- Keep the battery away from small children and pets. A physician should be contacted immediately if the battery is swallowed
- Wrap insulating tape, such as electrical tape, around the battery prior to disposal
- Always refer to local requirements in your area to ensure the battery is properly disposed

4.27.3.2 BMCC Battery Verification

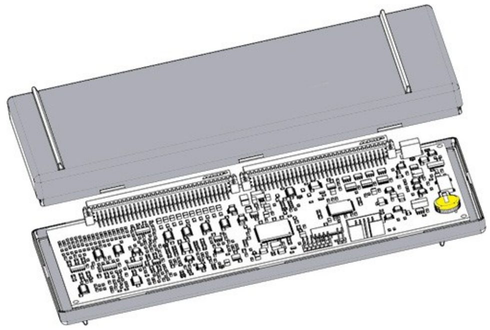
To verify the integrity of the battery, the BMCC case must be separated.

• • • CAUTION • • •
The BMCC is sensitive to ESD, which can render the BMCC software useless. When attempting to verify the condition of the backup battery, refer to Section 1.9 Handling Static Sensitive Devices on page 24 in this manual.

NOTE
This should only be performed when warranty has expired.

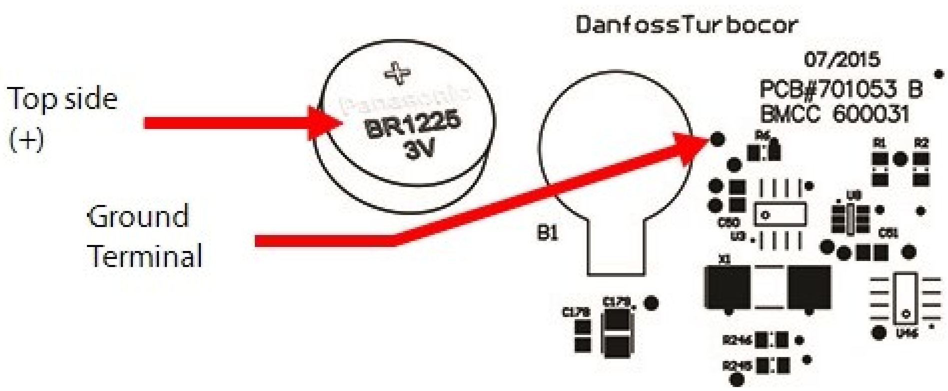
1. Remove the BMCC. Refer to Section 4.27.4.1 BMCC Removal on page 222.
2. Separate the BMCC case by removing or cutting the stickers that are applied to the seam of the case halves.

Figure 4-247 BMCC Case Separation



3. Set the multimeter for voltage measurements and place the red (+) probe on the battery itself (top)and the black (-) probe on the ground terminal shown below.
   - The measurement should be between 2.85V and 3.15V

Figure 4-248 BMCC Battery Measurement

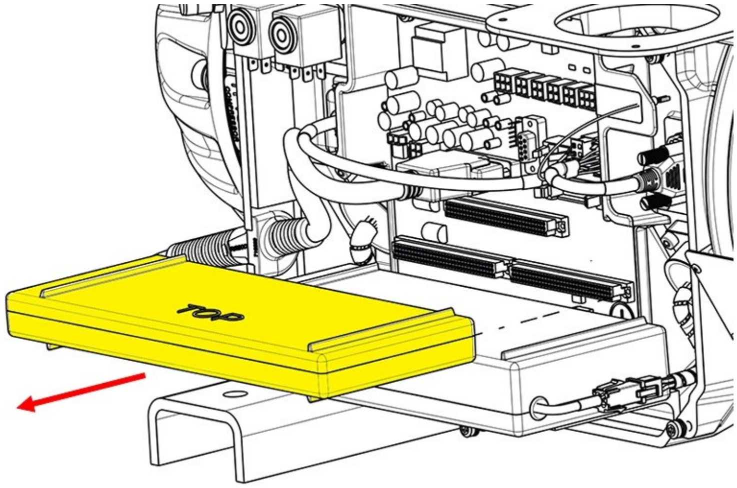


4.27.4 BMCC Removal and Installation

4.27.4.1 BMCC Removal

1. Isolate compressor power.
2. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
3. Verify the LEDs on the Backplane have turned off.
4. Carefully disconnect the Serial Driver from the Backplane and slide it slowly away from the compressor. Refer to Section 4.26.4 Serial Driver Removal and Installation on page 218.
5. Carefully disconnect the BMCC from the Backplane and slide it slowly away from the compressor. Refer to Figure 4-249 BMCC Removal on page 223.

Figure 4-249 BMCC Removal



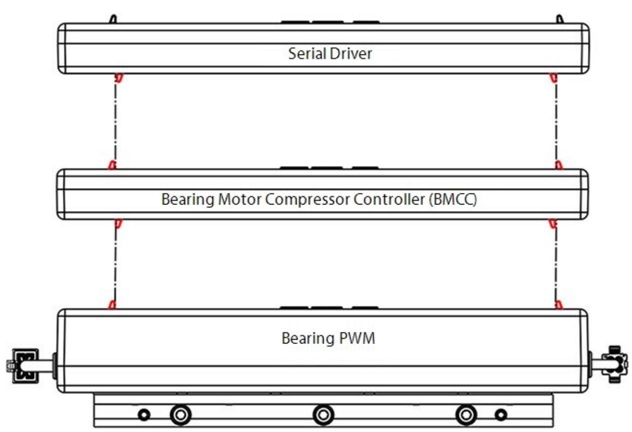
4.27.4.2 BMCC Installation

• • • CAUTION • • •

When installing a new BMCC or moving one from a different compressor, a bearing calibration must be performed and saved to electrically erasable programmable read-only memory (EEPROM). 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 unexpected behavior. Additionally, new compressors and BMCCs by default, are set to the lowest amperage limits and must be configured to meet the system requirements.

1. Align the two (2) lower insertion guides of the BMCC so that they are on the inside of the two (2) upper insertion guides on the Bearing PWM Amplifier. Refer to Figure 4-250 BMCC Insertion Guides.

Figure 4-250 BMCC Insertion Guides

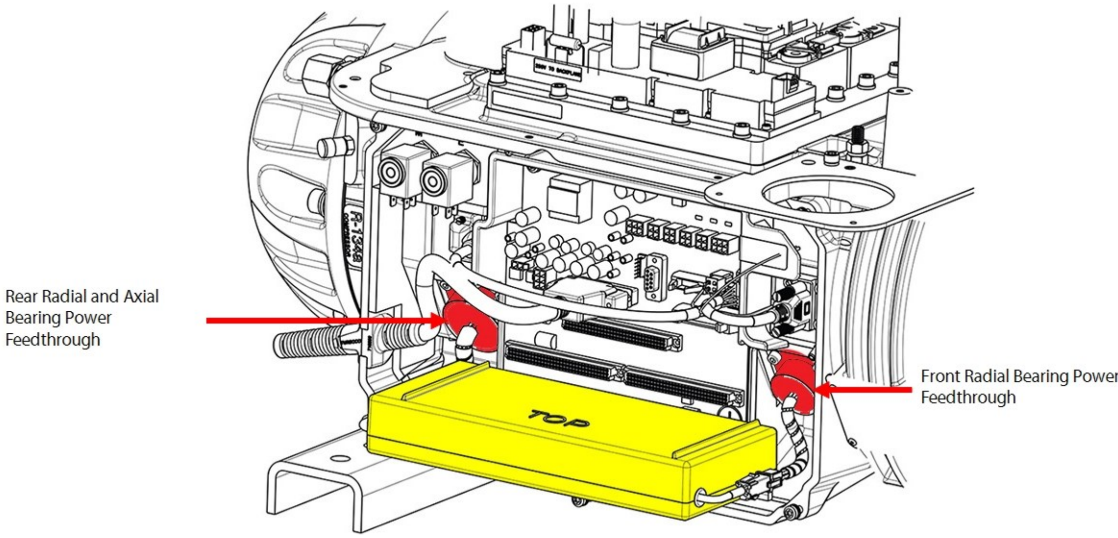


2. Slide the BMCC straight into the connector until firmly seated in the Backplane connector.
3. Install the Serial Driver. Refer to Section 4.26.4 Serial Driver Removal and Installation on page 218.
4. Install Service Side Cover. Refer to Section 4.1.3 Service Side Cover on page 54.
5. Return the compressor to normal operation.

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. Refer to Section 5.3 Bearing Calibration on page 263.

4.28 Bearing Pulse Width Modulator Amplifier

Figure 4-251 PWM

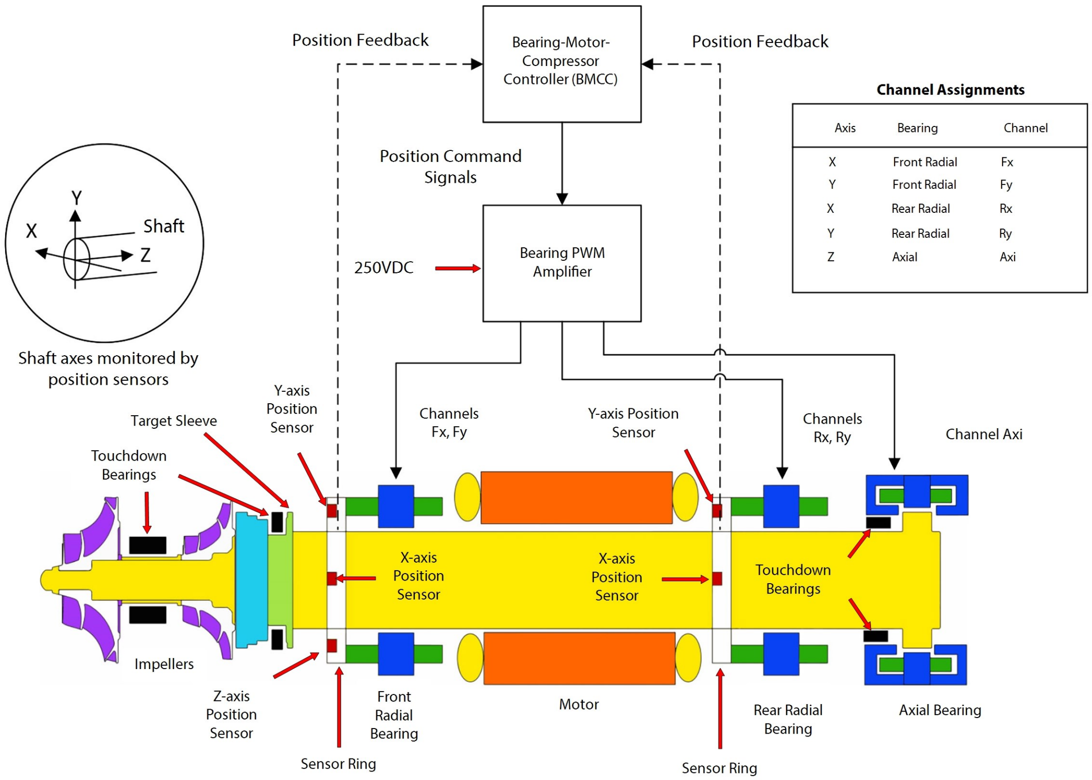


4.28.1 PWM Function

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. Refer to Figure 4-252 Bearing Control Signal Flow on page 226.

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

Figure 4-252 Bearing Control Signal Flow



4.28.2 PWM Connections

J1 on the Backplane is the PWM connection port. The PWM heat sink is secured with fasteners to the compressor housing below the Backplane.

The 6-pin/wire connects to the rear (left) bearing power feedthrough. The 4-pin/wire connects to the front (right) bearing power feedthrough. Refer to Figure 4-251 PWM on page 225 for an illustration of a Major Revision "F" and later compressor.

4.28.3 PWM Verification

NOTE

- A faulty PWM Amplifier may be the result of a bearing failure and may cause a failure of the Potted DC-DC resulting in a blown F1 fuse on the Closed-Top 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 (5) output channels
- Verify functionality of the five (5) diode sets

4.28.3.1 Verify if the Bearing PWM Amplifier is Draining Energy

1. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
2. Disable compressor operation while keeping the compressor energized.
3. Measure and record the voltage at the HV+, +17HV, and +5V test points on the Backplane.
4. Isolate compressor power.
5. Wait for the LEDs on the Backplane to turn off.
6. Disconnect the rear/axial bearing current output cable and the front bearing current output cable.
7. Apply power to the compressor.
8. Measure and record the voltage at the HV+, +17HV, and +5V test points.
9. Isolate compressor power.
10. Wait for the LEDs on the Backplane to turn off.
11. Remove the PWM from the Backplane. Refer to Section 4.28.4 PWM Removal and Installation on page 228.
12. Apply power to the compressor.
13. Measure and record the voltage at the HV+, +17HV, and +5V test points.
14. If the voltages do not change, the PWM is not the source (or not the only source) of energy drain.

4.28.3.2 Verify Functionality of the Five Output Channels

1. Verify the bearing coil resistances are within specification. Refer to Section 4.29.3 Bearing Verification on page 230.
2. Verify the bearing sensor resistances are within specification. Refer to Section 4.29.3 Bearing Verification on page 230.
3. Verify the voltages at the HV+, +17HV, and +5V Backplane test points are within the expected voltage ranges shown in Table 4-42 Backplane Test Point Values on page 215.
4. Perform a bearing calibration using the SMT.
5. Watch the bearing forces while the compressor is going through its calibration steps. The software should display both a positive and negative bearing amperage for each bearing position (Front Radial X, Front Radial Y, etc.). If you do not see bearing amperage at all, or in only one direction (+/-), its possible the PWM is faulty on that channel assuming the bearing coil verified in Step 1 was good.

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.

6. 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 could be faulty.

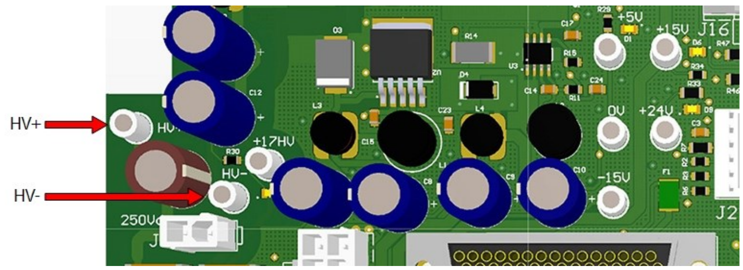
4.28.3.3 Verify Functionality of the Five Diode Sets

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

1. Isolate compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
3. Verify the LEDs on the Backplane have turned off.
4. Unplug the 250VDC input (J4) from the Backplane. Refer to Figure 4-238 Backplane Connections on page 212.

5. Disconnect the PWM connectors from the compressor housing bearing feedthroughs, keeping the PWM attached to the Backplane. Refer to Figure 4-251 PWM on page 225.
6. 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. Refer to Figure 4-253 Connecting Leads to PWM Connector and HV- and HV+ Test Points. The measured voltage drop should be 0.39-0.46VDC.
7. Repeat Step 6 for all 10-pin holes on both left and right PWM connectors.

Figure 4-253 Connecting Leads to PWM Connector and HV- and HV+ Test Points



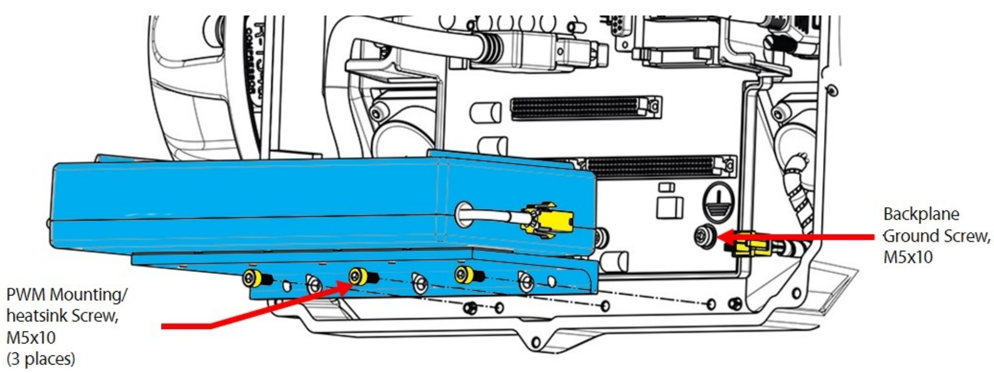
8. Still set on diode measurement, place the black (-) multimeter lead on the HV+ test point of the Backplane and the red (+) multimeter lead in the first pin hole of the PWM connector, ensure the lead makes contact with the clip in the pin hole. Refer to Figure 4-253 Connecting Leads to PWM Connector and HV- and HV+ Test Points. The measured voltage drop should be 0.39-0.46VDC.
9. Repeat for all 10-pin holes of both PWM connectors.
10. If any of the test results are out of the 0.39 - 0.46 VDC range, the PWM is defective and should be replaced.

4.28.4 PWM Removal and Installation

4.28.4.1 PWM Amplifier Removal

1. Isolate compressor power.
2. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
3. Wait for the LEDs on the Backplane to turn off.
4. Remove the Serial Driver. Refer to Section 4.26.4 Serial Driver Removal and Installation on page 218.
5. Remove the BMCC. Refer to Section 4.27 BMCC on page 220.
6. Disconnect the two (2) connectors for the PWM and bearing power feedthroughs.
7. Remove the fasteners below the PWM that secure the heat sink to the main compressor housing. Refer to Figure 4-254 Removing the PWM Amplifier.

Figure 4-254 Removing the PWM Amplifier



8. Remove the bearing PWM amplifier from J1 of the Backplane.

4.28.4.2 PWM Amplifier Installation

NOTE
Prior to replacing a PWM, verify the bearing coils. Refer to Section 4.29.3.1 Bearing Coil Verification on page 230.

1. Clean the surface of the compressor where the heat sink plate contacts the housing and clean the mating surface of the PWM if it is to be reused.
2. Spread a thin and uniform coat of Dow Corning Silicone Heat Sink paste (or equivalent) entirely over the PWM mounting surface where it contacts the compressor housing.
3. Check that the M5x10 ground fastener at the lower right of the Backplane is tight before replacing the PWM. Torque to 3 Nm (27 in.lb).
4. Align the heat sink of the PWM with the two (2) guide pins in the main compressor housing.
5. Insert the PWM into the J1 connector of the Backplane.
6. Secure the heat sink of the PWM to the main compressor housing with three M5x10 fasteners. Torque to 4.5 Nm (40 in.lb.).
7. Ensure the heat sink of the PWM is firmly seated against the main compressor housing.
8. Connect the two (2) connectors for the PWM and bearing power feedthroughs.
9. Install the BMCC. Refer to Section 4.27 BMCC on page 220.
10. Install the Serial Driver. Refer to Section 4.26.4 Serial Driver Removal and Installation on page 218.

NOTE
Perform a bearing calibration after replacing the PWM to verify functionality. Refer to Section 5.3 Bearing Calibration on page 263.

11. Install Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
12. Install top covers. Refer to Section 4.1 Compressor Covers on page 52.
13. Return the compressor to normal operation.

4.28.4.3 PWM Torque Specifications

Table 4-44 PWM Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
Backplane Mounting/Ground fastener, M5x10	3	-	27
PWM Mounting/heatsink fastener, M5x10	4.5	-	40
Cover fastener, M5x15	1.5	-	13

4.29 Magnetic Bearings

4.29.1 Magnetic Bearings Function

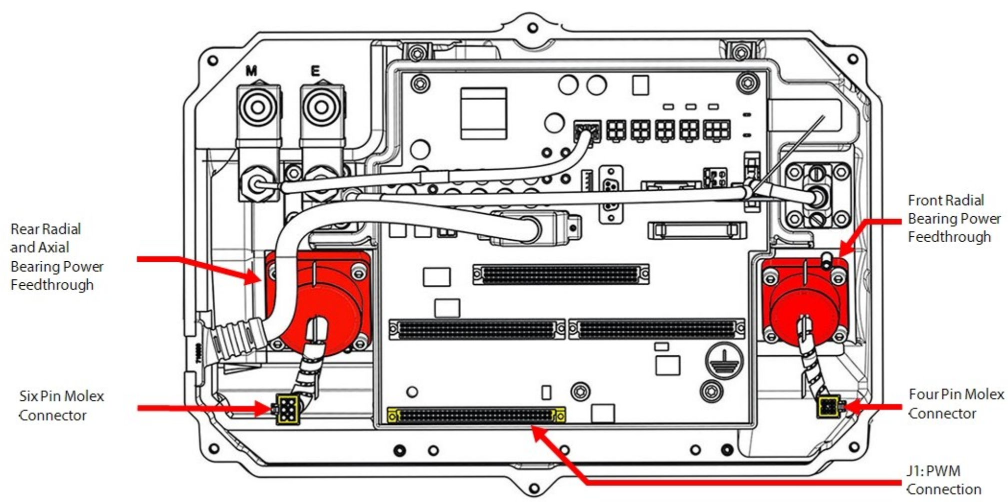
The compressor shaft and impellers levitate during operation and float on a magnetic cushion created by the magnetic bearings. Permanent magnets do most of the work and electromagnets are used for trimming the shaft position within 0.0003” (7 microns). One axial (Z axis) and two radial (X & Y axis) magnetic bearings are used to maintain shaft position. Centered rotation is instantaneously self-corrected and maintained by the bearing control loop. Refer to Figure 4-252 Bearing Control Signal Flow on page 226.

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

4.29.2 Magnetic Bearings Connections

PWM connectors supply power at the bearing power feedthroughs. Refer to Figure 4-255 Bearing Connections.

Figure 4-255 Bearing Connections



4.29.3 Bearing Verification

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

1. Isolate compressor power.
2. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
3. Wait for the LEDs on the Backplane to turn off.
4. Remove the Serial Driver, BMCC, and PWM.
5. Set multimeter for resistance checks.
6. Test resistance on bearing power feedthrough pins defined in Table 4-45 Magnetic Bearing Coil Resistance Values. Refer to Figure 4-256 Front and Rear Bearing Feedthrough Connectors for pin locations.

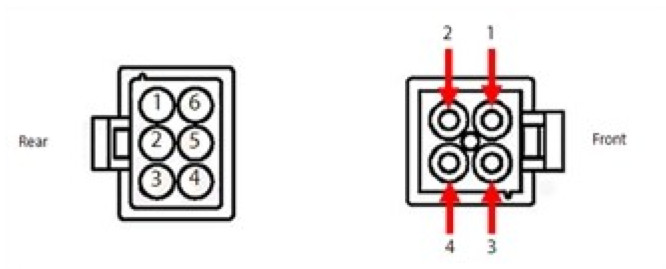
• • • CAUTION • • •
Use care not to damage the pins when inserting test leads into the connectors.

7. Compare the resistance values to those defined in Table 4-45 Magnetic Bearing Coil Resistance Values.
8. Test insulation of each pin to ground and between coils.
9. If the integrity of the bearing power feedthrough is in question, isolate the compressor, recover the refrigerant according to industry standards, remove the feedthrough and repeat the above steps directly at the internal bearing cluster block.

Table 4-45 Magnetic Bearing Coil Resistance Values

Compressor Model & Design Sequence				
Connector Location	**Bearing Identification**	**Feedthrough Pin Identification**	**TTS300, TTS400, TGS230, & TGS390**	**TTS350, TTS450, TTS500, TTS700, TGS310, TGS380, TGH490, TGS520, TTH375, & TGH285**
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 (TTS300/TGS230 only) 6.00 - 6.70Ω (TTS400/TGS390 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	Refer to Figure 4-256 Front and Rear Bearing Feedthrough Connectors for pin locations		All resistance values are in ohms. Resistance to ground and between coils should be >100MΩ @1KV	

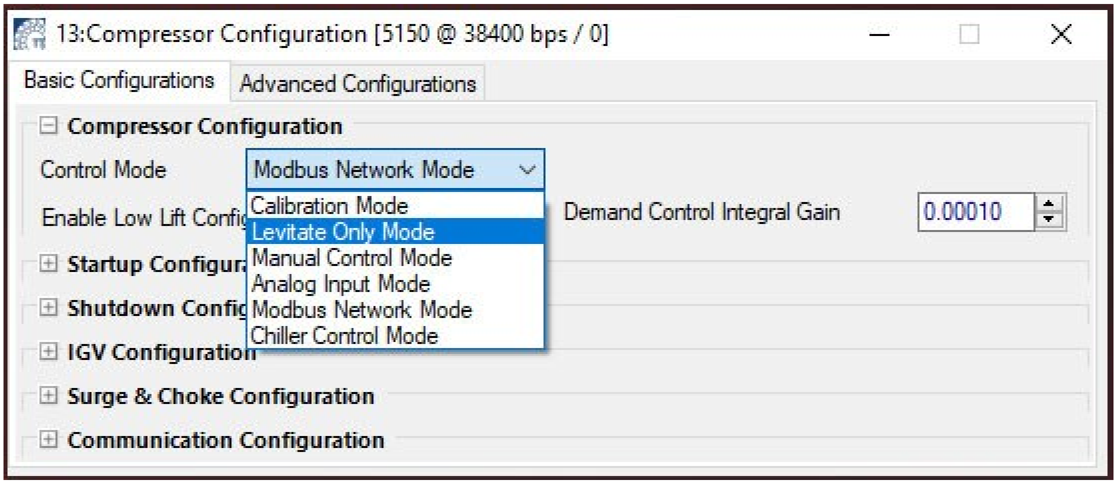
Figure 4-256 Front and Rear Bearing Feedthrough Connectors



4.29.3.2 Bearing Current Verification

1. Connect to the compressor using the SMT.
2. Open the Compressor Configuration Tool.
3. Change the Control Mode to "Levitate Only Mode".

Figure 4-257 Compressor Configuration Tool



4. Open the Compressor Monitor tool. Refer to Figure 4-258 Compressor Monitor Tool on page 233.
5. Click on the "Shaft Levitation Status" icon to levitate the shaft.
6. Look at the "Bearing Advanced" section and verify that the bearing amperages displayed are within the range as defined in Table 4-46 Bearing Amperage Nominal Ranges on page 233.
7. Click on the "Shaft Levitation Status" icon to de-levitate the shaft.
8. In the Compressor Configuration Tool, return the Control Mode to the original setting.

Figure 4-258 Compressor Monitor Tool

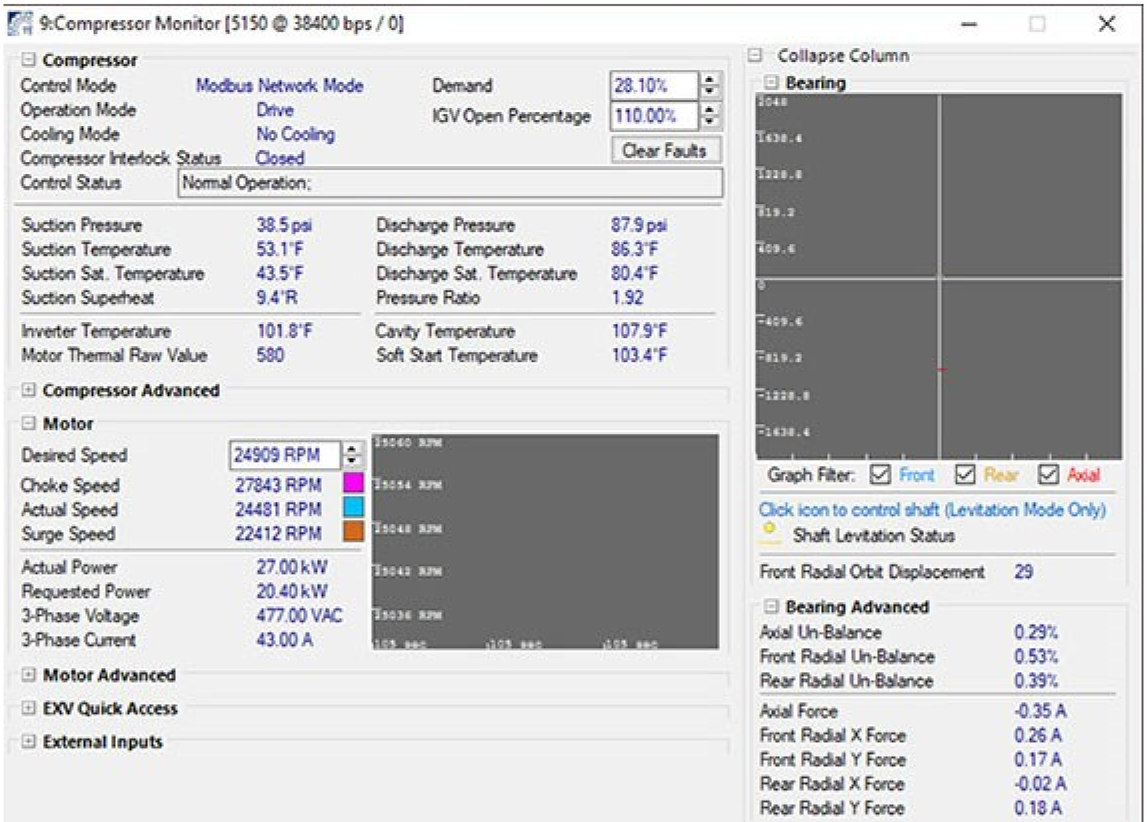


Table 4-46 Bearing Amperage Nominal Ranges

Bearing Position	Force Range
Axial Force	-1.5 to 1.5 Amp (TTS300 & TGS230 = -2 to 0 Amp)
Front X Force	-1.5 to 1.5 Amp
Front Y Force	-1.5 to 1.5 Amp
Rear X Force	-1.5 to 1.5 Amp
Rear Y Force	-1.5 to 1.5 Amp

4.29.4 Bearing Power Feedthrough Removal and Installation

The steps depicted in this section will apply to either the front or rear feedthrough.

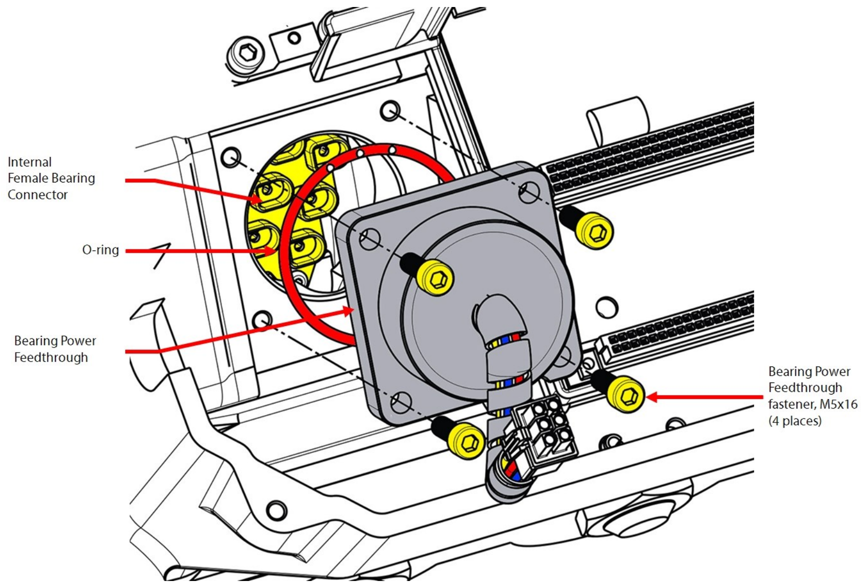
4.29.4.1 Bearing Power Feedthrough Removal

1. Isolate compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Isolate the compressor and recover the refrigerant according to industry standards. Refer to Section 3.1 Refrigerant Containment on page 41.
3. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
4. Pull the Serial Driver Module out of its slot. Make sure you do not damage the connector pins. Keep the module in a safe place. Refer to Section 4.26.4 Serial Driver Removal and Installation on page 218.

NOTE
Refer to 1.9 Handling Static Sensitive Devices for proper ESD handling of electronic components.

5. Pull the BMCC out of its slot. Make sure you do not damage the connector pins. Keep the BMCC in a safe place. Refer to Section 4.27 BMCC on page 220.
6. Unplug the cable harness from the 4-pin feedthrough and the 6-pin feedthrough.
7. Remove the three (3) M5x10 fasteners and pull the Bearing PWM out of its slot. Make sure you do not damage the connector pins. Keep the PWM in a safe place. Refer to Section 4.28.4 PWM Removal and Installation on page 228.
8. Remove the four (4) M5x16 fasteners that secure the feedthrough.

Figure 4-259 Rear Bearing Power Feedthrough Assembly



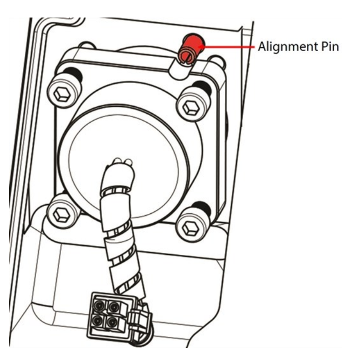
9. Remove the Feedthrough.

NOTE
Small pliers such as needle-nose, may be required to remove the feedthrough.

4.29.4.2 Bearing Power Feedthrough Installation

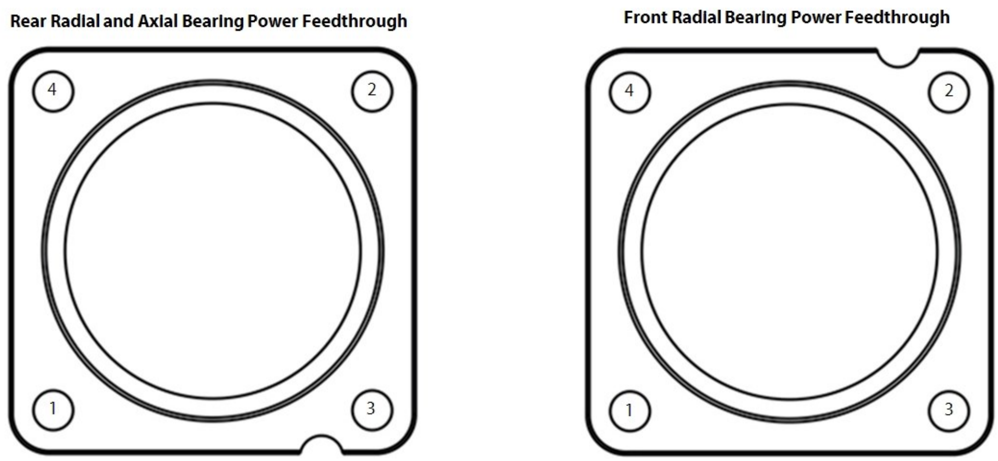
1. If necessary, clean both mating surfaces with a lint-free cloth.
2. Apply Super-O-Lube on the new O-ring.
3. Install the lubricated O-ring onto the new feedthrough.
4. Install the new feedthrough into the compressor housing. Check connector orientation with the Alignment Pin as well as the internal female connector of the bearing.

Figure 4-260 Bearing Power Feedthrough Alignment Pin



5. Finger-tighten the four (4) M5x16 fasteners and then torque in a crisscross pattern to 3 Nm (27 in. lb.) and then to a final torque of 5 Nm (44 in.lb.). Refer to Figure 4-261 Bearing Power Feedthrough Torque Sequence.

Figure 4-261 Bearing Power Feedthrough Torque Sequence



6. Leak test and evacuate in accordance with standard industry practices.
7. Carefully install the PWM. Refer to Section 4.28.4 PWM Removal and Installation on page 228.
8. Plug the cable harnesses back into the 4-pin feedthrough and 6-pin feedthrough.
9. Carefully, install the BMCC. Refer to Section 4.27 BMCC on page 220.
10. Carefully, install the Serial Driver. Refer to Section 4.26.4 Serial Driver Removal and Installation on page 218.
11. Install the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
12. Return the compressor to normal operation.

4.29.4.3 Magnetic Bearing Torque Specifications

Table 4-47 Magnetic Bearing Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
Inverter and Backplane Ground fastener, M5x25	3	-	27
Backplane Mounting/Ground fastener, M5x10	3	-	27
PWM Mounting/heatsink fastener, M5x10	4.5	-	40
Bearing Power Feedthrough fastener, M5x16	5	-	44
Cover fastener, M5x15	1.5	-	13

4.30 Bearing Sensors

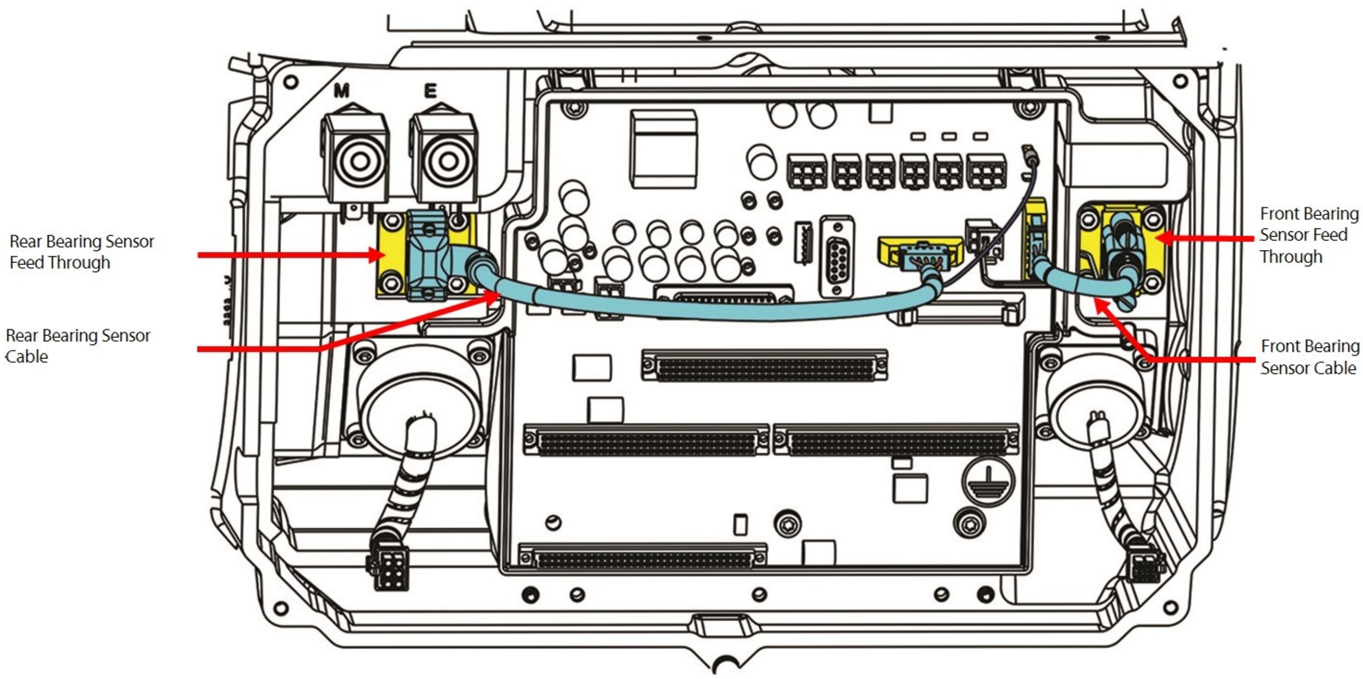
4.30.1 Bearing Sensor Function

Bearing sensors feed back real-time shaft orbit information to the bearing control loop. Refer to Figure 4-252 Bearing Control Signal Flow on page 226.

4.30.2 Bearing Sensor Connection

The Bearing Sensors are connected internally to the Bearing Sensor feedthroughs located above the front and rear bearing power feedthroughs. The bearing sensor feedthroughs are connected to the bearing sensor cables which connect to J9 and J10 on the Backplane. Refer to Figure 4-262 Bearing Sensor Feedthroughs.

Figure 4-262 Bearing Sensor Feedthroughs



4.30.3 Bearing Sensor Verification

4.30.3.1 Bearing Sensor Resistance Verification

1. Isolate compressor power.
2. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
3. Wait for the LEDs on the Backplane to turn off.
4. Place meter leads on bearing sensor feedthrough pins outlined in Table 4-48 Bearing Sensor Coil Resistance on page 237. Refer to Figure 4-263 Bearing Sensor Pin Locations on page 237 for pin locations.

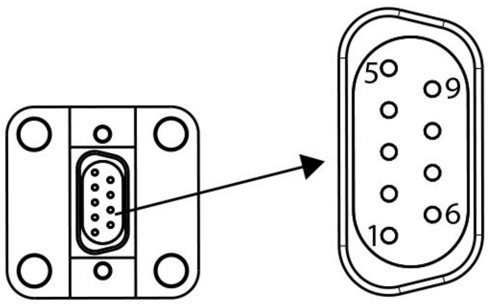
NOTE
There are no connections on Pins 1 & 4 and 1 & 9 on the Rear Bearing Sensor Feedthrough.

5. Test each pin to ground; reading should be open or infinite.
6. If the integrity of the bearing sensor feedthrough is in question, isolate the compressor, recover the refrigerant according to industry standards, remove the feedthrough and repeat the above steps directly at the internal sensor connector.

Table 4-48 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 4-263 Bearing Sensor Pin Locations



4.30.3.2 Bearing Sensor Cable Verification

If any unexpected behavior exists, it could be the result of an intermittent connection. If not properly diagnosed, the issue may lead to unnecessarily replacing components in the bearing control loop, such as the BMCC, PWM, Bearing Power Feedthroughs, or Bearing Sensor Cables.

This section provides verification details should a compressor experience a bearing fault type where other verification, testing, and troubleshooting processes have not been able to identify the cause.

1. Remove the Modbus and Interlock connections from the compressor I/O Board.
2. Connect to the compressor using the SMT software and open the Calibration Tool.
3. Perform a bearing calibration by clicking on "Start Calibration."
4. After calibration is complete, review the data. Do all orbits and gain values appear normal?
   a. Yes: Continue to Step 5.
   b. No: Continue to Step 7.
5. Perform a validation by clicking on "Validate."
6. After validation is complete, did the shaft levitate as expected?
   a. Yes: Continue to Step 21.
   b. No: Continue to Step 7.
7. Isolate compressor power.
8. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
9. Disconnect the Bearing Sensor Cables from J9 and J10 at the Backplane.

10. Remove the Bearing Sensor Cables from the front and rear 9-pin feedthroughs.
11. Inspect the Bearing Sensor Cables and associated connections for damage, debris, or corrosion.
12. Clean or replace as necessary.
13. Install the Bearing Sensor Cables to their respective locations.
14. Apply a thin coating of dielectric grease on the exterior of the Bearing Sensor Feedthrough Connectors where the Bearing Sensor Cables contact the feedthroughs.

NOTE

Do not apply dielectric grease directly to the Bearing Sensor Feedthrough pins.

15. Re-install the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
16. Re-apply power to the compressor.
17. Repeat the calibration and validation procedures, Steps 2 through 6.
18. If the calibration and/or validation results improve, the bearing control loop is functioning normally. Continue to Step 21.
19. If calibration and/or validation results continue to show an issue, replace the Bearing Sensor Cables, then verify other components in the bearing control loop as instructed in the Service Manual.
20. Repeat the validation process in Steps 2 through 6 to ensure proper functionality.
21. Return the compressor to normal operation.

4.30.4 Bearing Sensor Cable Removal and Installation

Refer to Figure 4-238 Backplane Connections on page 212 for connector locations in this section.

Bearing Sensor Cable Removal:

1. Isolate compressor power.
2. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
3. Wait for the LEDs on the Backplane to turn off.
4. For the Front Bearing Sensor Cable, refer to Steps 4 and 5; for the Rear Bearing Sensor Cable, refer to Steps 6 through 8.
5. Remove the cable from J10 on the Backplane by spreading the clips out and away from the cable connector.
6. Remove the cable from the 9-pin connector at the Front Bearing Sensor Feedthrough by removing the two (2) retaining screws that secure the connector to the Bearing Sensor Feedthrough.
7. Remove the cable from J9 on the Backplane by spreading the clips out and away from the cable connector.
8. Remove the cable from the 9-pin connector at the Rear Bearing Sensor Feedthrough by removing the two (2) retaining screws that secure the connector to the Bearing Sensor Feedthrough.
9. Remove the ground wire from J11 on the Backplane.

NOTE

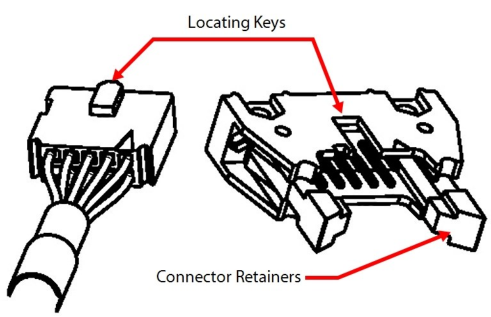
The ground wire may be installed on either J11 or J12.

10. Pull the cable from the feedthrough.

Bearing Sensor Cable Installation:

1. Ensure that all connectors are clean and free of grease and silicone gel.
2. For the Front Bearing Sensor Cable, refer to Steps 3-5; for the Rear Bearing Sensor Cable, refer to Steps 6-8.
3. Install the 9-pin connector at the Front Bearing Sensor Feedthrough and torque the fasteners to 0.5 Nm (0.4 ft.lb.; 4.4 in.lb.).
4. Apply a thin coating of dielectric grease to the exterior of the bearing sensor 9-pin connector where it meets the feedthrough to seal from moisture ingress.
5. Install the cable to J10 on the Backplane. Ensure that plug is inserted in correct polarity. Refer to the locating keys on the plug and slots in the connector (The Front locating key should be at the left of the J10 Backplane clip.). Gently squeeze the connector retainers to snap the connectors in place.
6. Install the 9-pin connector at the Rear Bearing Sensor Feedthrough and torque the fasteners to 0.5 Nm (0.4 ft.lb.; 4.4 in.lb.).
7. Install the ground wire to J11 or J12 on the Backplane.
8. Install the cable to J9 on the Backplane. Ensure that plug is inserted in correct polarity. Refer to the locating keys on the plug and slots in the connector (The Rear locating key should be at the top of the J9 Backplane clip.). Gently squeeze the connector retainers to snap the connectors in place. Refer to Section 4.30.3 Bearing Sensor Verification.

Figure 4-264 Bearing Cable Orientation



9. Install the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
10. Return the compressor to normal operation.
11. Verify sensor cable functionality by performing a bearing calibration. Refer to Section 5.3 Bearing Calibration on page 263.

4.30.5 Bearing Sensor Feedthrough Removal and Installation

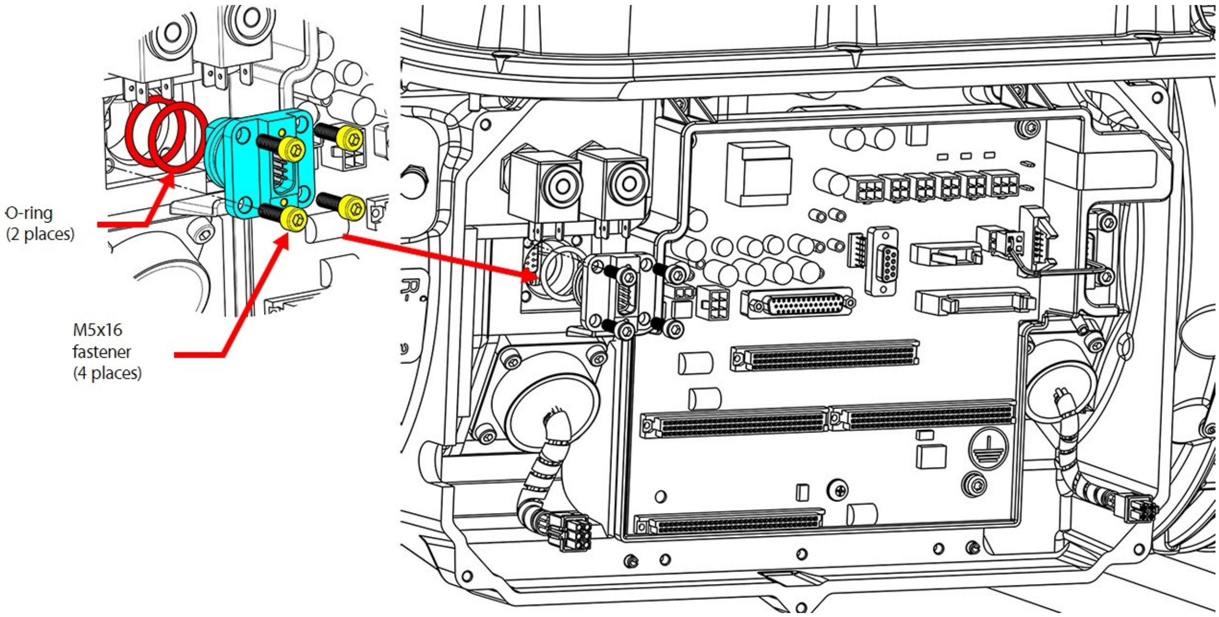
The following procedure will contain the same steps for either the Front or Rear Bearing Sensor Feedthrough.

4.30.5.1 Bearing Sensor Feedthrough Removal

1. Isolate compressor power.
2. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
3. Wait for the LEDs on the Backplane to turn off.
4. Isolate the compressor and recover the refrigerant according to industry standards. Refer to Section 3.1 Refrigerant Containment on page 41.
5. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.

6. Remove the bearing sensor cable from the 9-pin feedthrough. Refer to Figure 4-265 Bearing Sensor Feedthrough Removal (Rear (Left) Shown).
7. Using a hex socket, remove the four (4) M5x16 fasteners that secure the 9-pin feedthrough. Refer to Refer to Figure 4-265 Bearing Sensor Feedthrough Removal (Rear (Left) Shown).
8. Carefully remove the 9-pin feedthrough. It may be necessary to use needle-nose pliers to grasp the feedthrough. Do not pry the feedthrough out of the housing.

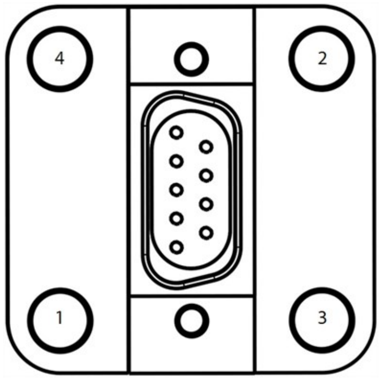
Figure 4-265 Bearing Sensor Feedthrough Removal (Rear (Left) Shown)



4.30.5.2 Bearing Sensor Feedthrough Installation

1. Using a lint-free cloth, clean the mating surface on the compressor housing.
2. Verify that the new O-rings and 9-pin feedthrough are clean. If not, wipe off any contaminants with a lint-free cloth.
3. Apply O-lube on each of the new O-rings.
4. Install the new O-rings onto the new 9-pin feedthrough.
5. Install the new 9-pin feedthrough.
6. Secure the feedthrough with the four (4) M5x16 fasteners. Finger-tighten and then follow the torque sequence shown in Figure 4-266 Bearing Sensor 9-Pin Feedthrough Connector Torque Sequence on page 241 and torque to 3 Nm (2.2 ft.lb.). Torque the fasteners a final time to 5 Nm (3.7 ft.lb.).

Figure 4-266 Bearing Sensor 9-Pin Feedthrough Connector Torque Sequence



7. Leak test and evacuate compressor in accordance with standard industry practices.
8. Install the bearing sensor cable onto the new 9-pin feedthrough. (Refer to the Bearing Sensor Cable install section above).
9. Install the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
10. Return the compressor to normal operation.

4.30.5.3 Bearing Sensor Torque Specifications

Table 4-49 Bearing Sensor Torque Specifications

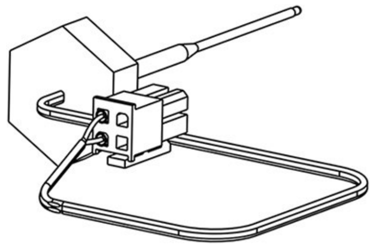
Description	Nm	Ft.Lb.	In.Lb.
Bearing Sensor Feedthrough fastener, M5x16	5	3.7	44
Bearing Sensor Cable integrated fasteners	0.5	0.4	4.4
Cover fastener, M5x15	1.5	-	13

4.31 Cavity Temperature Sensor

4.31.1 Cavity Temperature Sensor Function

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

Figure 4-267 Cavity Sensor



4.31.2 Cavity Temperature Sensor Connections

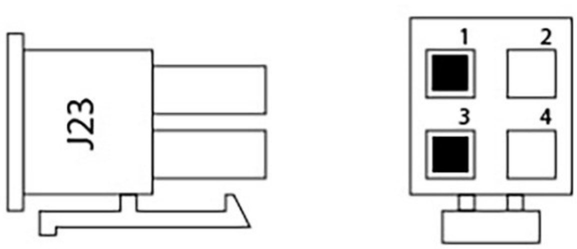
The Cavity Temperature sensor is located behind the Backplane. Refer to Figure 4-269 Cavity Temperature Sensor Removal on page 243.

The Cavity Temperature Sensor is connected to the J23 connector on the Backplane. Refer to Figure 4-238 Backplane Connections on page 212.

4.31.3 Cavity Temperature Sensor Verification

1. Isolate compressor power.
2. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
3. Wait for the LEDs on the Backplane to turn off.
4. Disconnect the Cavity Temperature Sensor Cable, J23, from the Backplane.
5. Set multimeter for resistance measurements.
6. Measure the resistance between the Cavity Temperature Sensor terminals 1 and 3. Refer to Figure 4-268 Cavity Temperature Sensor Terminal.
   - The Cavity Temperature Sensor is a 10KΩ @ 77°F (25°C) NTC thermistor. The resistance value should correspond to the chart in Figure 4-273 Temperature vs. Resistance on page 246.
7. Measure the resistance of the Cavity Temperature Sensor terminals 1 and 3 to ground.
   - The resistance value should be open or infinite.
8. Connect the Cavity Temperature Sensor Cable, J23, to the Backplane.
9. Install the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
10. Return the compressor to normal operation.

Figure 4-268 Cavity Temperature Sensor Terminal

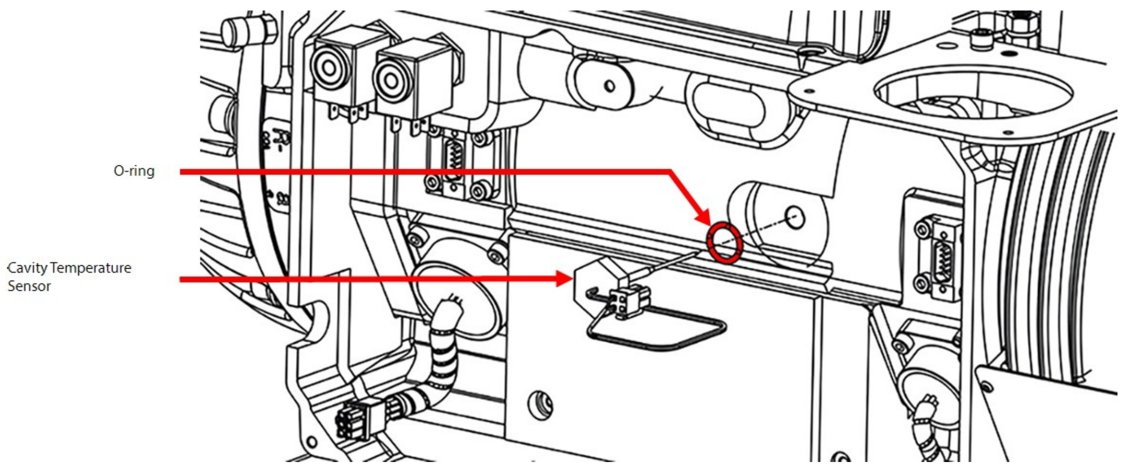


4.31.4 Cavity Temperature Sensor Removal and Installation

4.31.4.1 Cavity Temperature Sensor Removal

1. Isolate compressor power.
2. Wait for the LEDs on the Backplane to turn off.
3. Isolate the compressor and recover the refrigerant according to industry standards. Refer to Section 3.1 Refrigerant Containment on page 41.
4. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
5. Verify the LEDs on the Backplane have turned off.
6. Remove the Serial Driver. Refer to Section 4.26.4 Serial Driver Removal and Installation on page 218.
7. Remove the BMCC. Refer to 4.27 BMCC on page 220.
8. Remove the PWM. Refer to 4.28.4 PWM Removal and Installation on page 228.
9. Remove the Backplane. 4.25.3 Backplane Removal and Installation on page 215.
10. Using a 15/16” wrench or slotted socket, remove the Motor Cavity Sensor.

Figure 4-269 Cavity Temperature Sensor Removal



4.31.4.2 Cavity Temperature Sensor Installation

1. Clean the mating surface with a lint-free cloth. Inspect the sealing area for any damage.
2. Lubricate the O-ring and install onto the groove in the sensor head.
3. Insert the sensor and engage the first few threads by hand.
4. Tighten the sensor to 13 Nm (10 ft.lb.).
5. Leak test and evacuate in accordance with standard industry practices.
6. Install the Backplane. Refer to Section 4.25.3 Backplane Removal and Installation on page 215.
7. Install the PWM. Refer to Section 4.28.4 PWM Removal and Installation on page 228.
8. Install the BMCC. Refer to Section 4.27 BMCC on page 220.
9. Install the Serial Driver. Refer to 4.26.4 Serial Driver Removal and Installation on page 218.
10. Install the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.

11. Return the compressor to normal operation.
12. Check for proper cavity temperature indication.

4.31.4.3 Cavity Sensor Torque Specifications

Table 4-50 Cavity Sensor Torque Specifications

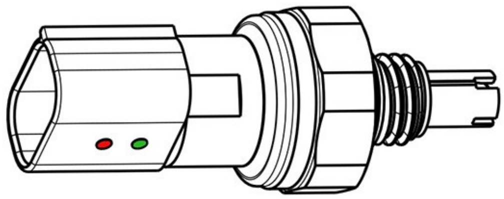
Description	Nm	Ft.Lb.	In.Lb.
Inverter and Backplane Ground fastener, M5x25	3	-	27
Backplane Mounting fastener, M5x25	3	-	27
PWM Mounting/heatsink fastener, M5x10	4.5	-	40
Cavity Temperature Sensor	13	10	115
Cover fastener, M5x15	1.5	-	13

4.32 Pressure/Temperature Sensor

4.32.1 Pressure/Temperature Sensor Function

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

Figure 4-270 Pressure/Temperature Sensor



4.32.2 Pressure/Temperature Sensor 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.

The interstage pressure/temperature sensor is secured to the Interstage Pipe.

Refer to Figure 4-271 Pressure/Temperature Sensor Connections (All TTS/TGS Compressors) and Figure 4-272 Pressure/Temperature Sensor Locations (TTH/TGH) on page 246 for the location of the sensors.

Figure 4-271 Pressure/Temperature Sensor Connections (All TTS/TGS Compressors)

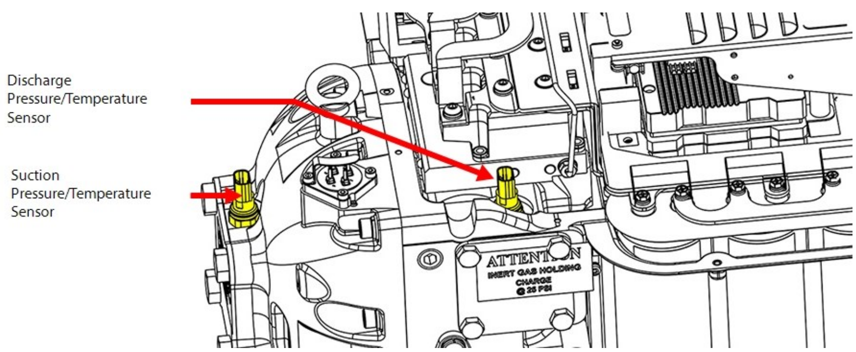
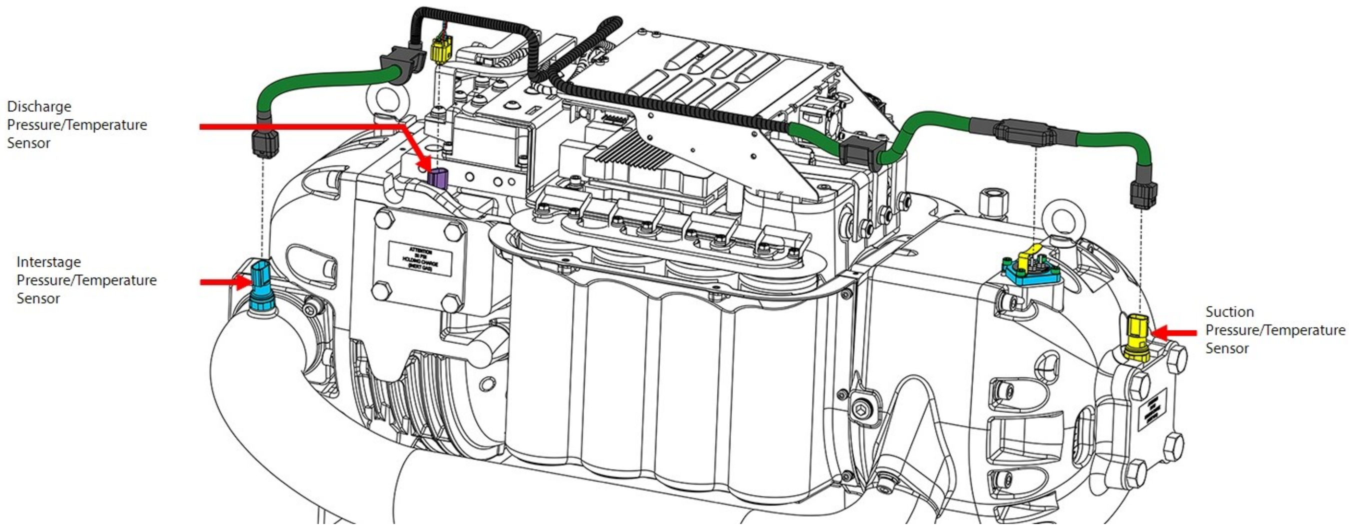


Figure 4-272 Pressure/Temperature Sensor Locations (TTH/TGH)



The sensor connector clips link to the compressor control cable which then connect to the Backplane at J18 and J19 (and J17 for TTH/TGH only).

4.32.3 Pressure/Temperature Sensor Verification

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
3. Disconnect the pressure/temperature cable clip (SUCTION – J18 or DISCHGE – J19 or INTER - J17) from the Backplane board. Refer to Figure 4-274 Pressure/Temperature Cable Terminals on page 247 for this and the following step.
4. Using a multimeter set for resistance measurements, place leads on Terminal 1 and Terminal 2 of the pressure/temperature cable clip.
    - The temperature sensor is a 10KΩ @ 77°F (25°C) NTC thermistor. The resistance value should correspond to Figure 4-273 Temperature vs. Resistance.

Figure 4-273 Temperature vs. Resistance

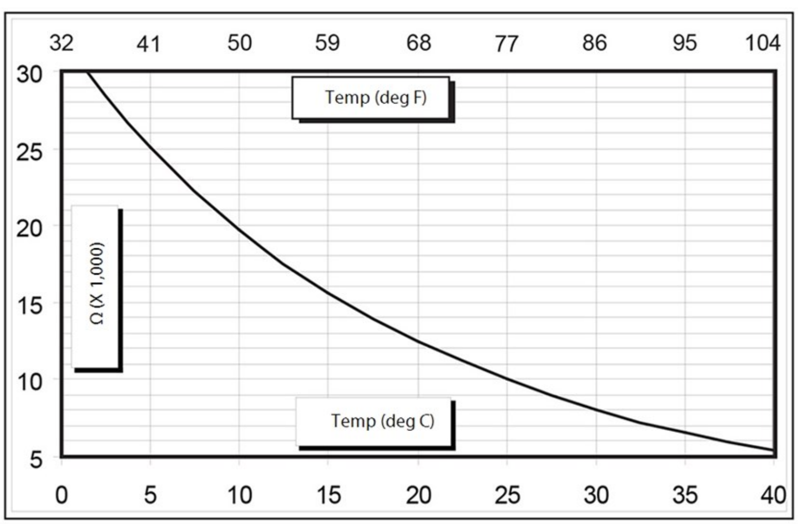
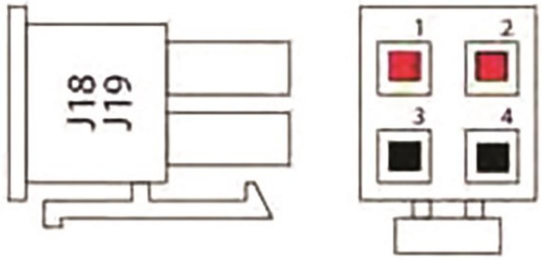


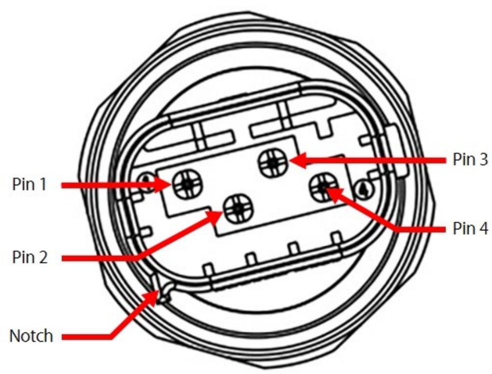
Figure 4-274 Pressure/Temperature Cable Terminals



5. If the integrity of the cable is in question, disconnect the compressor controller cable from the pressure/temperature sensor and proceed to the next step.
6. Place the leads on Terminal 1 & 3 of the pressure/temperature sensor. Refer to Figure 4-275 Pressure/Temperature Sensor Pin Locations.
   - The temperature sensor is a 10KΩ @ 77°F (25°C) NTC thermistor. The resistance value should correspond to Figure 4-273 Temperature vs. Resistance on page 246

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

Figure 4-275 Pressure/Temperature Sensor Pin Locations



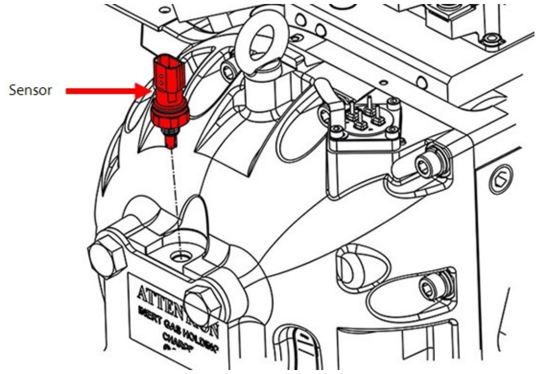
7. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
8. Return the compressor to normal operation.

4.32.4 Pressure/Temperature Sensor Removal and Installation

4.32.4.1 Suction Pressure/Temperature Sensor Removal

1. Isolate the compressor power.
2. Isolate the compressor and recover the refrigerant according to industry standards. Refer to Section 3.1 Refrigerant Containment on page 41.
3. Disconnect the sensor connector.
4. Using a deep 15/16" socket, remove the sensor from the IGV Housing Assembly.

Figure 4-276 Suction Pressure/Temperature Sensor Removal



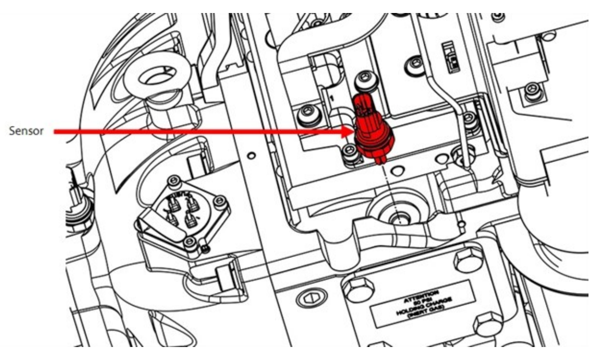
4.32.4.2 Suction Pressure/Temperature Sensor Installation

1. Check and clean the O-ring, housing thread, and O-ring sealing surface in the IGV Housing.
2. Apply lube to O-ring.
3. Insert the sensor and engage the first few threads by hand.
4. Using a deep 15/16" socket, tighten the sensor to 10 Nm (7 ft.lb).
5. Reconnect the sensor connector.
6. Leak test and evacuate in accordance with standard industry practices.
7. Return the compressor to normal operation.

4.32.4.3 Discharge Pressure/Temperature Sensor Removal

1. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
2. Recover the refrigerant according to industry standards.
3. Disconnect the sensor connector.
4. Using a deep 15/16" socket, remove the sensor from the compressor housing.

Figure 4-277 Discharge Pressure/Temperature Sensor



4.32.4.4 Discharge Pressure/Temperature Sensor Installation

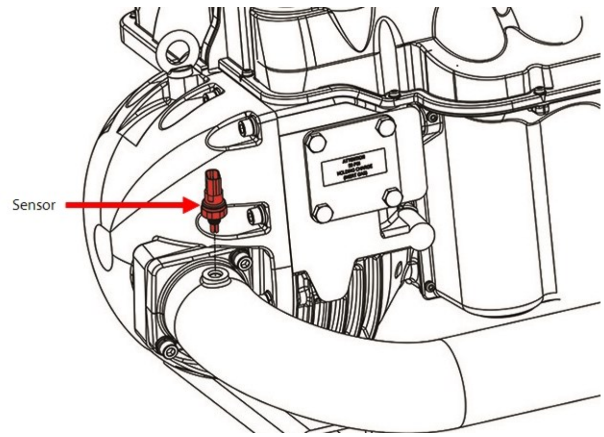
1. Check and clean O-ring, housing thread, and O-ring sealing surface in the compressor housing.
2. Apply lube to O-ring.
3. Insert the sensor and engage the first few threads by hand.
4. Using a deep 15/16" socket, tighten the sensor to 10 Nm (7 ft.lb).
5. Reconnect the sensor connector.
6. Leak test and evacuate in accordance with standard industry practices.

7. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
8. Return the compressor to normal operation.

4.32.4.5 Interstage Pressure/Temperature Sensor Removal (TTH/TGH Compressors Only)

1. Isolate the compressor power.
2. Isolate the compressor and recover the refrigerant according to industry standards. Refer to Section 3.1 Refrigerant Containment on page 41.
3. Disconnect the sensor connector.
4. Using a deep 15/16" socket, remove the sensor from the Interstage Pipe.

Figure 4-278 Interstage Pressure/Temperature Sensor Removal



4.32.4.6 Interstage Pressure/Temperature Sensor Installation (TTH/TGH Compressors Only)

1. Check and clean O-ring, housing thread, and O-ring sealing surface in the compressor housing.
2. Apply O-lube to O-ring.
3. Insert the sensor and engage the first few threads by hand.
4. Using a deep 15/16" socket, tighten the sensor to 10 Nm (7 ft.lb).
5. Reconnect the sensor connector.
6. Leak test and evacuate in accordance with standard industry practices.
7. Return the compressor to normal operation.

4.32.4.7 Pressure/Temperature Sensor Torque Specifications

Table 4-51 Pressure/Temperature Sensor Torque Specifications

Description	Nm	Ft.Lb.	In.Lb.
Pressure/ Temperature Sensor	10	7	89
Cover fastener, M5x15	1.5	-	13

THIS PAGE INTENTIONALLY LEFT BLANK

Chapter 5.0 lTroubleshooting

5.1 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.

5.1.1 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. Refer to Table 5-1 Alarm Types.

Table 5-1 Alarm Types

Compressor Status Alarm	Description
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.
Discharge Pressure	The measured discharge pressure has exceeded the alarm limit.
Discharge Temperature	The measured discharge temperature has exceeded the alarm limit. (Removed from CC 4.X.X software)
Inverter Cooling Control	The Measured Inverter Temperature has exceeded the Inverter Cooling Control Fault limit, starting the Fault Delay timer.
Inverter Temperature	The measured Inverter temperature has exceeded the alarm limit.
Leaving Fluid Temperature	The lowest acceptable measured leaving fluid temperature has exceeded the alarm limit. (Removed from CC 4.X.X software)
Motor Cooling Control	The Measured Cavity Temperature has exceeded the Motor Cooling Control Fault limit, starting the Fault Delay timer.
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. (Sensor removed from Rev. H compressors)(Fault and Alarm removed from CC 4.2.X and later software)
Suction Pressure	The measured suction pressure has exceeded the alarm limit.
Superheat	The calculated superheat temperature has exceeded the alarm limit. The superheat alarm is set 8°K below the fault limit.

5.1.2 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. Refer to the following tables:

- Table 5-2 Compressor Fault Types on page 252
- Table 5-3 Compressor Status 2 Faults on page 253
- Table 5-4 Motor Fault Types on page 253
- Table 5-5 Bearing Fault Types on page 254

Table 5-2 Compressor Fault Types

Compressor Status Fault	Description
Inverter Temperature	The measured Inverter temperature has exceeded the fault limit.
Discharge Temperature	The measured discharge temperature has exceeded the fault limit.
Soft Start Temperature	The measured Soft Start temperature has exceeded the fault limit.
Low 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, pre-CC4.0.0.
3-Phase Over-Current	The calculated 3 phase current has exceeded the fault limit. Instantaneous lock-out , pre-CC4.0.0.
Cavity Temperature	The measured cavity temperature has exceeded the fault limit.
Leaving Fluid Temperature	The lowest acceptable measured leaving fluid temperature has been exceeded. (Removed from CC 4.X.X software)
Pressure Ratio	The calculated pressure ratio of discharge/suction has exceeded the fault limit.
Bearing/Motor Fault Active	If a Motor Fault type or a Bearing Fault type is present, then the Bearing/ Motor Fault Active is triggered. This is not an actual fault, only an indication that a motor or bearing fault type 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 Fluid 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. (Fault and Alarm removed from CC 4.2.X and later software)
Lock Out Fault	Lock-Out faults require power cycle to reset. Instantaneous lock outs: Inverter Error - CC 4.X.X Discharge Pressure - pre CC4.0.0 3 Phase Over Current - pre CC4.0.0 If any (or a combination of) the faults listed below occurs more than 3 times within 30 minutes, a Lock-Out fault occurs: Discharge Pressure - CC 4.X.X 3-Phase Overcurrent - CC 4.X.X Inverter Temperature SCR Temperature Motor Overcurrent Inverter Error - pre CC4.0.0 Rotor Starting Torque Low Motor Back EMF
Winding Temperature	The measured motor winding temperature has exceeded the fault limit.
High Suction Superheat	The calculated Suction Superheat Temperature has exceeded the Fault limit.

Table 5-3 Compressor Status 2 Faults

Compressor Status 2 Fault	Description
Suction Pressure Sensor Fault	Sensor errors occur when the sensor is providing a reading that is outside the normal readable range and indicates an error in the reading, or a functional problem with the sensor. - only available in 4.X
Suction Temperature Sensor Fault	
Discharge Pressure Sensor Fault	
Discharge Temperature Sensor Fault	
Inverter Temperature Sensor Fault	
Cavity Temperature Sensor Fault	
Soft Start Temperature Sensor Fault	
Invalid Bearing Calibration Fault	A valid bearing calibration is not stored in the EEPROM.
Inverter Cooling Control Fault	The measured Inverter Temperature has exceeded the Cooling Control Fault limit after the Fault Delay timer has expired. If the temperature rises above the fault limit, the fault delay timer will begin, if the temperature falls below the fault limit, the timer will be reset, the compressor will stop if the timer expires.
Motor Cooling Control Fault	The measured Cavity Temperature has exceeded the Cooling Control Fault limit after the Fault Delay timer has expired. If the temperature rises above the fault limit, the fault delay timer will begin, if the temperature falls below the fault limit, the timer will be reset, the compressor will stop if the timer expires.

Table 5-4 Motor Fault Types

Motor/System Status	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 DC Bus Voltage limit, while RPM is >0
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 Status Fault type is present, then the Bearing Fault Active is triggered. This is not an actual fault, only an indication that a fault has occurred in the Bearing Status section.
Rotor Starting Torque Fault	Motor Current maximum has been 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 or higher than the DC Bus Under or Over Voltage Fault limits.
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 5-5 Bearing Fault Types

Bearing Status	Description
Startup Calibration Check Fault	A discrepancy between the Bearing Startup check and the stored calibration values has been detected.
Axial Displacement Fault	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.

5.2 Troubleshooting with the Service Monitoring Tools Software

The SMT software package can be used to view detailed compressor information for operational status indications and troubleshooting procedures. Please refer to the Service Monitoring Tools User Manual for the details on how to use the SMT software.

5.2.1 Compressor Fault Troubleshooting

When troubleshooting a compressor fault, detailed analysis of this data should be made (in conjunction with a 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.

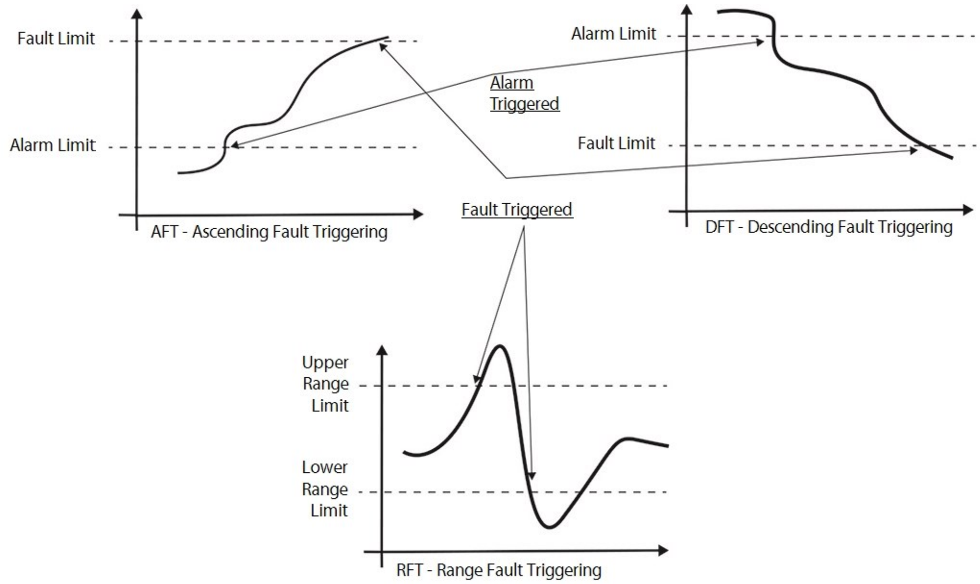
Compressor Alarm and Fault settings can be found in the Configure Alarms/Faults menu option of the Active Alarm/Fault Viewer tool.

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. Refer to Figure 5-1 Fault Trigger Methods on page 255 for explanations regarding faults and alarms and the trigger method terminology is used:

- Instant fault triggering (INS)
- Ascending Fault Triggering (AFT)
- Descending Fault Triggering (DFT)
- Range Fault Triggering (RFT)

Figure 5-1 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.

The Clear Faults button in the SMT Compressor Monitor can be used in software versions 4.0.0 and later. Also see the OEM Programming Guide for additional fault reset options.

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. Refer to the following tables:

- Table 5-6 Compressor Status
- Table 5-8 Motor/System Status on page 260
- Table 5-9 Bearing Status on page 263

Table 5-6 Compressor Status

Compressor Status Description	Trigger Method	Troubleshooting
High Inverter Temperature Fault	AFT	Consequence: • Indicates the Inverter cooling is insufficient. Repeated occurrences of this alarm can result in Inverter failure. • If this fault occurs three (3) times within a 30-minute period, a Lock-Out Fault will occur. • 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. Recommendation: • 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. ○ Low Lift operation requires additional considerations, refer to the Applications Manual • Verify the solenoids are operational and not blocked. Refer to Section 4.6.3 Solenoid

Compressor Status Description	Trigger Method	Troubleshooting
		Verification on page 73. • Verify the solenoid actuators. Refer to Section 4.6.3 Solenoid Verification on page 73. • Verify the Serial Driver. Refer to Section 4.26.3 Serial Driver Verification on page 217. • Review the fault log for actual Inverter temperature and other conditions that are recorded at the time of fault. • The Inverter requires replacement if the embedded temperature sensor is 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. Refer to Section 4.32.3 Pressure/Temperature Sensor Verification on page 246. • Review the fault log for actual discharge temperature 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 or flow. • Check the charge, system load and entering air/water conditions. • Review the fault log for actual suction pressure and other conditions that are recorded at the time of fault.
High Discharge Pressure Fault	AFT	Consequence: • Results in an Instantaneous Lock-Out Fault - pre-CC4.0.0 Recommendation: • Suggests the condenser may be faulty or insufficient air/water flow. • Check the condenser and air/water flow. • Review the fault log for actual discharge pressure and other conditions that are recorded at the time of fault.
3-Phase Over-Current Fault	AFT	Consequence: • 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 - pre-CC4.0.0. Requires a power cycle to reset. • Indicates the compressor is drawing current greater than the 3-Phase Current Fault Limit. Recommendation: • 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 , minimum pressure ratio set too high at start-up, power control integral (loop) gain set too high. Can also be related to sudden increase in load/demand or system changes.
High Cavity Temperature Fault	AFT	Consequence • Indicates the motor cooling is insufficient. **CAUTION:** Repeated occurrences of this fault can result in shaft demagnetization or Back EMF is low

Compressor Status Description	Trigger Method	Troubleshooting
		faults. Recommendation: • 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. ◦ Low Lift operation requires additional considerations, refer to Applications Manual • Verify the solenoids are operational and not blocked. Refer to Section 4.6.3 Solenoid Verification on page 73. • Verify the solenoid actuators. Refer to Section 4.6.3 Solenoid Verification on page 73. • Verify the Serial Driver. Refer to Section 4.26.3 Serial Driver Verification on page 217. • Verify cavity temperature sensor. Refer to Section 4.31.3 Cavity Temperature Sensor Verification on page 242.
Low Leaving Fluid Temperature Fault	DFT	• (Removed from CC 4.X.X software) • Suggests insufficient evaporator fluid flow or insufficient system load. • Check evaporator fluid 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 ressure is high, not enough load on the evaporator, or insufficient water/air flow in either condenser or evaporator. • Check the electronic expansion valve (EXV) operation, condenser, evaporator loads, and water/air 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 Bearing/Motor Fault is triggered. • This is not an actual fault, only an indication that a fault has occurred in the Motor or Bearing section. Refer to Table 5-8 Motor/System Status on page 260 and Table 5-5 Bearing Fault Types on page 254.
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: Refer to Section 4.31.3 Cavity Temperature Sensor Verification on page 242. • Suction Temperature: Verify suction pressure/temperature sensor. Refer to Section 4.32.3 Pressure/Temperature Sensor Verification on page 246. • Discharge Temperature: Verify discharge pressure/temperature sensor. Refer to Section 4.32.3 Pressure/Temperature Sensor Verification on page 246. • 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	Removed from CC 4.2.X and later software • Indicates the SCR cooling is insufficient. • If this fault occurs three times within a 30-minute period, a Lock-Out Fault will occur.

Compressor Status Description	Trigger Method	Troubleshooting
		• 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. Refer to Section 4.6.3 Solenoid Verification on page 73. • Verify the solenoid actuators. Refer to Section 4.6.3 Solenoid Verification on page 73. • Verify the Serial Driver. Refer to Section 4.26.3 Serial Driver Verification on page 217. • Verify SCR temperature sensor. Refer to Section 4.18.2.5 SCR Temperature Sensor Verification on page 144. • Verify SCRs. Refer to Section 4.18.2 SCR Verification on page 142. (Alarm and Fault removed from CC 4.2.X and later software)
Lock Out Fault	INS	Instantaneous Lock Out Fault: • Discharge Pressure Pre-CC 4.0.0 • 3-Phase Overcurrent Pre-CC 4.0.0 • Inverter Error CC 4.X.X If any (or a combination of) the faults listed below occurs more than three (3) times within 30 minutes, a Lock-Out fault will occur: • Discharge Pressure CC 4.X.X • Inverter Temperature • SCR Temperature • 3-Phase Overcurrent CC 4.X.X • Motor High Current • Inverter Error Pre-CC 4.0.0 • Rotor Starting Torque • Low Motor Back EMF • 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. Refer to Section 4.6 Solenoids and Coils on page 72. • Verify the solenoid actuators. Refer to Section 4.6.3 Solenoid Verification on page 73. • Verify the Serial Driver. Refer to Section 4.26.3 Serial Driver Verification on page 217. • Verify the motor thermistor. Refer to Section 4.23.4.3 Stator Thermistor Resistance Verification on page 195.
High Suction Superheat Fault	AFT	• Suction Superheat is calculated from 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.

Compressor Status Description	Trigger Method	Troubleshooting
		• 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. Refer to Section 4.32.3 Pressure/Temperature Sensor Verification on page 246.

Table 5-7 Compressor Status 2 Faults

Compressor Status 2 Description	Trigger Method	Troubleshooting
Suction Pressure Sensor Fault	RFT	• Sensor errors occur when the sensor is providing a reading that is outside the normal readable temperature range and therefore must have an error in the reading or functional problem with the sensor • Verify the associated sensor and related connections
Discharge Pressure Sensor Fault	RFT	• Sensor errors occur when the sensor is providing a reading that is outside the normal readable temperature range and therefore must have an error in the reading or functional problem with the sensor • Verify the associated sensor and related connections
Suction Temperature Sensor Fault	RFT	• Sensor errors occur when the sensor is providing a reading that is outside the normal readable temperature range and therefore must have an error in the reading or functional problem with the sensor • Verify the associated sensor and related connections
Discharge Temperature Sensor Fault	RFT	• Sensor errors occur when the sensor is providing a reading that is outside the normal readable temperature range and therefore must have an error in the reading or functional problem with the sensor • Verify the associated sensor and related connections
Inverter Temperature Sensor Fault	RFT	• Sensor errors occur when the sensor is providing a reading that is outside the normal readable temperature range and therefore must have an error in the reading or functional problem with the sensor • Verify the associated sensor and related connections
Cavity Temperature Sensor Fault	RFT	• Sensor errors occur when the sensor is providing a reading that is outside the normal readable temperature range and therefore must have an error in the reading or functional problem with the sensor. • Verify the associated sensor and related connections
Soft Start Temperature Sensor Fault	RFT	• Sensor errors occur when the sensor is providing a reading that is outside the normal readable temperature range and therefore must have an error in the reading or functional problem with the sensor. • Verify the associated sensor and related connections
Invalid Bearing Calibration Fault	INS	• If a bearing calibration is not saved in the EEPROM, this fault will be triggered, a valid calibration is required prior to the compressor accepting demand. • Calibrate the compressor bearings using the Calibration Tool and save to EEPROM. Cycle power and verify the calibration is retained in EEPROM.
Inverter Cooling Control Fault	AFT	• Refer to Table 5-6 Compressor Status on page 255 regarding High Inverter Temperature Fault Troubleshooting
Motor Cooling Control Fault	AFT	• Refer to Table 5-6 Compressor Status on page 255 regarding High Cavity Temperature Fault Troubleshooting

5.2.2 Motor/System Faults Troubleshooting

Table 5-8 Motor/System Status

Motor/System Status Description	Trigger Method	Troubleshooting
Motor Single Phase Overcurrent Fault	AFT	• One (1) 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. Refer to Inverter Error. • Verify the Stator. Refer to Section 4.23.4 Motor Verification on page 195. • Verify the Inverter and the Inverter cable connections. Refer to Section 4.22.2 Inverter Verification on page 176. • This fault can be related to BMCC Inverter switching control. Verify the BMCC. Refer to Section 4.27.2 BMCC Verification on page 220. 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. Refer to Section 4.21.2 DC Bus Voltage Verification on page 167. • 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. Refer to Section 4.14.2 Soft Start Verification on page 115. • 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. Refer to Section 4.22.2 Inverter Verification on page 176.
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. Refer to Section 4.22.2 Inverter Verification on page 176. • Verify the Stator. Refer to Section 4.23.4 Motor Verification on page 195.
Inverter Error	INS	• Indicates there is an error within the Inverter Control Board or no BMCC communication with the Inverter. • Pre-CC 4.0.0 - If this fault occurs three (3) times within a 30-minute period, a Lock-Out Fault will occur. • CC 4.X.X - Instantaneous Lockout Fault • Verify the Inverter and the Inverter cable connections. Refer to Section 4.22.2 Inverter Verification on page 176. 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 Overcurrent, Back EMF is Low or Rotor May Be Locked faults immediately following an Inverter Error fault most likely indicates a faulty Inverter.
Bearing Alarm Active	INS	• If a bearing fault type is present, the Bearing Alarm is triggered in the Motor/Status section. • This is not an actual fault, only an indication that a fault has occurred in the Bearing section. Refer to Section 5.1.2 Fault Types on page 251.

Motor/System Status Description	Trigger Method	Troubleshooting
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 Starting Torque fault after one Inverter Error, the Inverter should be verified and may require replacement. Refer to Inverter Error on page 260 or Motor Single Phase Overcurrent Fault on page 260. Shaft or bearings may be mechanically damaged and unable to turn. • Verify the bearing calibration and levitation. Refer to Section 5.3 Bearing Calibration on page 263. • Verify the Inverter. Refer to Section 4.22.2 Inverter Verification on page 176. • Verify the Stator. Refer to Section 4.23.4 Motor Verification on page 195. • 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 gas. Usually seen in open-air operation. • 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. Refer to Section 4.22.2 Inverter Verification on page 176. • Verify the Stator. Refer to Section 4.23.4 Motor Verification on page 195.
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 and compare the incoming main AC voltage to the compressor rated 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. Refer to Section 1.10.1 General Verification and Installation of the DC Bus Test Harness on page 26. • Verify the Soft Start. Refer to Section 4.14.2 Soft Start Verification on page 115. • Verify the SCRs. Refer to Section 4.18.2 SCR Verification on page 142. • Verify the connections to the Inverter. Refer to Section 4.22.2 Inverter Verification on page 176.
24VDC Under/Over Voltage Fault	RFT	• Suggests the measured 24VDC supply voltage is out of range. • Measure the 24VDC test points at the Backplane. Refer to Section 4.25.2.2 Backplane Verification on page 214. • Compare the measured voltages to the displayed readings in the Compressor Monitor Tool and Fault and Event • Review Fault Log details to determine conditions related to the fault. • If the measured voltage is incorrect, verify the DC-DC Converter. Refer to Section 4.24.2 DC-DC Converter Verification on page 204. • Determine that one of the modules is not draining energy. Refer to Section 5.5.2 Determining the Cause of an Energy Drain on page 271. • 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.

Motor/System Status Description	Trigger Method	Troubleshooting
		• 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 Starting Torque or Single phase Over-Current faults. Refer to Inverter Error on page 260. • Verify the Inverter. Refer to Section 4.22.2 Inverter Verification on page 176. • Verify the Stator. Refer to Section 4.23.4 Motor Verification on page 195.
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	• Suggests that a voltage or current imbalance may exist between the incoming AC phases to the SCRs. • Measure the difference in current and voltage between the AC 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 also be caused by a faulty SCR, SCR Gate, Gate control from the Soft Start Board, or a faulty power capacitor. • Verify the SCRs. Refer to Section 4.18.2 SCR Verification on page 142. • Verify the Soft Start Board. Refer to Section 4.14.2 Soft Start Verification on page 115.

5.2.3 Bearing Fault Troubleshooting

Table 5-9 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 (3) attempts, verify the PWM (refer to Section 4.28.3 PWM Verification on page 226), bearing sensors (refer to Section 4.30.3 Bearing Sensor Verification on page 236), and bearings (refer to Section 4.29.3 Bearing Verification on page 230).
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 (refer to Section 4.28.3 PWM Verification on page 226), bearing sensors (refer to Section 4.30.3 Bearing Sensor Verification on page 236) and bearings (refer to Section 4.29.3 Bearing Verification on page 230). • Review the calibration report to determine conditions related to the fault. Refer to Section 5.3.5 Calibration Report Analysis on page 266.
Bearing Overcurrent Fault	INS	• Indicates that the current drawn by the bearing exceeds the maximum amps in one of the five (5) 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 (3) attempts, verify the PWM (refer to Section 4.28.3 PWM Verification on page 226), bearing sensors (refer to Section 4.30.3 Bearing Sensor Verification on page 236) and bearings (refer to Section 4.29.3 Bearing Verification on page 230). • Review the calibration report to determine conditions related to the fault. Refer to Section 5.3.5 Calibration Report Analysis on page 266.

5.3 Bearing Calibration

5.3.1 When to Calibrate the Bearings

5.3.1.1 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.

5.3.1.2 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.

5.3.1.3 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.

5.3.1.4 BMCC Change

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

5.3.2 Performing a Calibration

Once Calibration is started , the SMT Bearing Calibration Tool will automatically change the Compressor Control Mode to Calibration Mode and send a delevitate shaft signal to the bearing control. After calibration is complete, the SMT will revert back to the original Compressor Control Mode. 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.

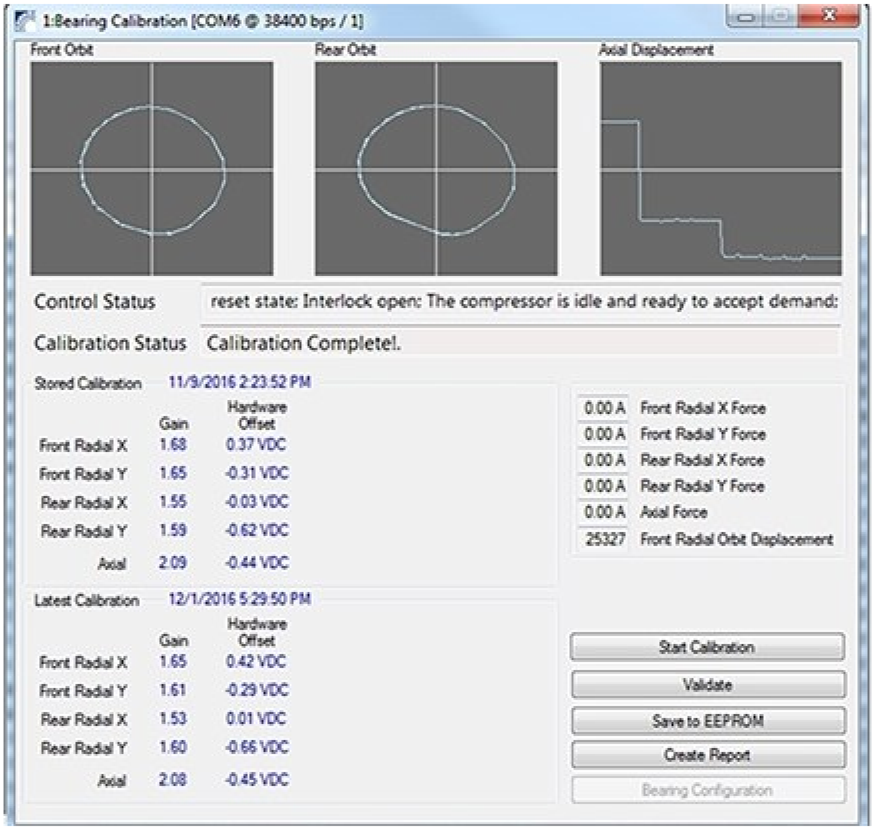
5.3.2.1 Before Performing a Calibration

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

5.3.2.2 Calibration

1. Open the SMT and connect to the compressor.
2. Open the Bearing Calibration tool. The Bearing Calibration tool displays. Refer to Figure 5-2 Bearing Calibration Tool on page 265.
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 5-2 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

5.3.3 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.

5.3.3.1 Validate

By validating the calibration, you are levitating the shaft using the 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 stored calibration data.

5.3.3.2 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.

5.3.4 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.

5.3.5 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

Refer to Figure 5-3 Bearing Calibration Flow on page 268.

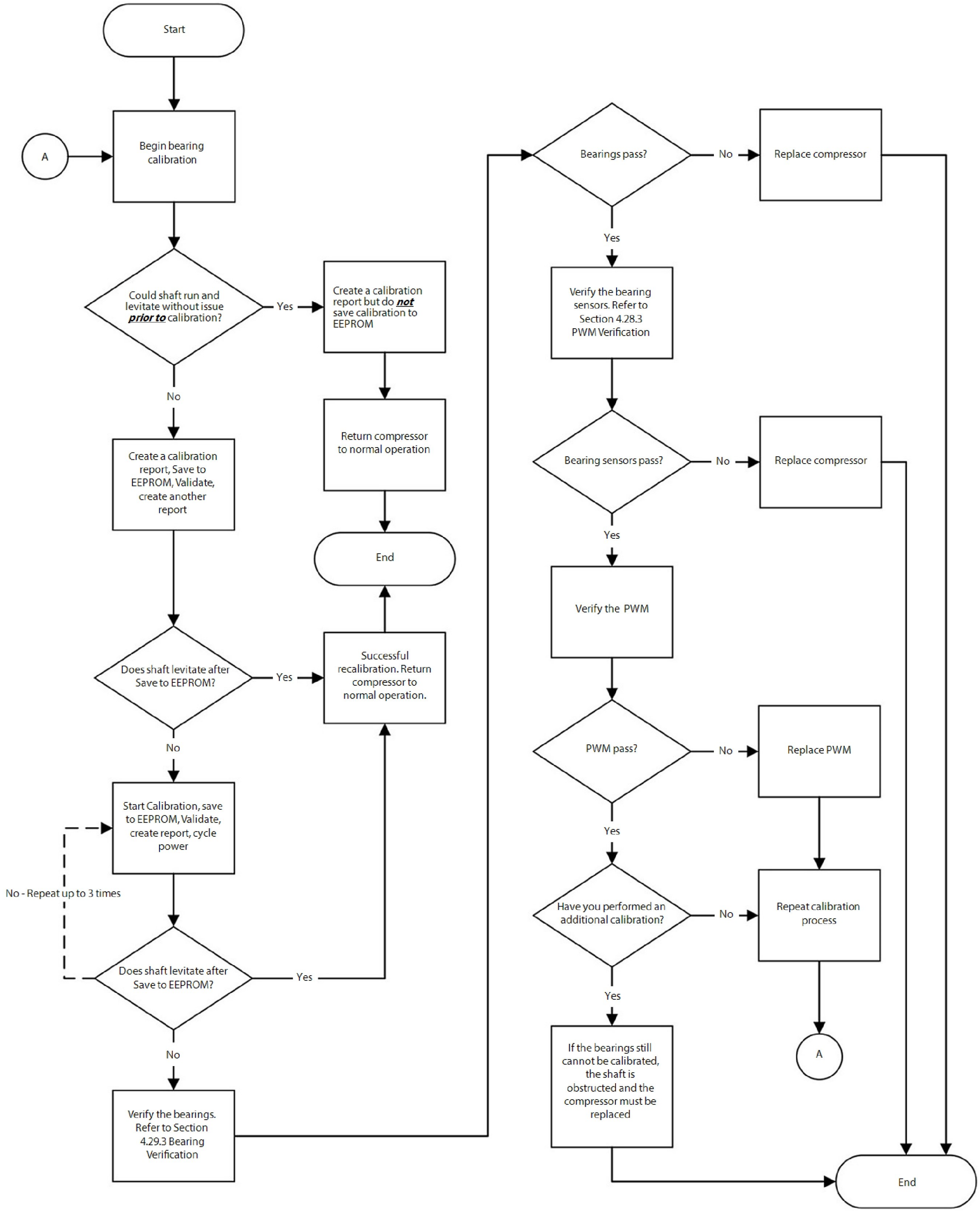
5. Data in Report: One or more of the bearing Force Current values exceeds 1.5A in Validation Results.
    - Interpretation: Bearing electrical fault or shaft is obstructed
    - Action: Verify the bearings
    - Action: Verify the bearing sensors

Refer to Figure 1-3 Bearing Calibration Flow on page 1.

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

Refer to Figure 5-3 Bearing Calibration Flow on page 268.

Figure 5-3 Bearing Calibration Flow



5.4 SMT 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 connection 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

5.5 System and Compressor Level Troubleshooting

5.5.1 Compressor Voltage Troubleshooting

1. Carefully, remove the Mains Input Cover.
2. Verify all three (3) phases of voltage before the mains fuses. Refer to Section 4.11.1.1 3-Phase AC input Verification on page 100.
    - If the nameplate 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 Section 1.8 Electrical Isolation on page 22.
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 (Closed Top only). Refer to Section 4.14.2.2 Verifying Soft Start Fuses on page 116.
    - If all of the fuses are okay, proceed to Step 7
    - If any of the fuses are blown, replace the fuse(s) and review the cause of the blown fuses - Refer to Section 5.5.2.6 Determining the Cause of Blown Soft Start Fuses (Closed-Top Soft Start Only) on page 272.
7. Verify the Inverter cable to the Inverter connector is installed correctly.
8. Verify the DC-DC Converter resistances. Refer to Section 4.24.2 DC-DC Converter Verification on page 204.
    - 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. Refer to Section 1.10.1 General Verification and Installation of the DC Bus Test Harness on page 26.
10. Disconnect the J2 (250VDC) and J3 (24VDC) (Potted DC-DC) or J4 (24VDC) Open Frame DC-DC) outputs from the DC-DC Converter.
11. Install the Top Cover then re-apply the compressor power.

12. Verify the DC Bus voltage through the test harness. Refer to Section 4.21.2 DC Bus Voltage Verification on page 167.
    - 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 12
    - If one or more of the SCRs test faulty, replace all three of the SCRs then repeat Step 12
    - If the 15VAC is present, proceed to Step 14
    - If the 15VAC is not present, replace the Soft Start then repeat Step 13
13. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
14. Remove the DC-Bus test harness and re-install the J2 (250VDC) and J3 (24VDC) (Potted DC-DC) or J4 (24VDC) (Open Frame DC-DC) outputs to the DC-DC Converter.
15. Install the top covers. Refer to Section 4.1 Compressor Covers on page 52.
16. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54. and remove the Service Side Cover.
17. 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 as described in the Section 1.8 Electrical Isolation on page 22.
20. Wait for the LEDs on the Backplane to turn off.
21. Remove all connectors from the Backplane, leaving only the J6 (Inverter cable), J4 (250VDC) and J24 (24VDC) inputs connected.
22. Remove the Serial Driver, BMCC, and PWM. Refer to the following sections:
    - 4.26.4 Serial Driver Removal and Installation on page 218
    - 4.27 BMCC on page 220
    - 4.28.4 PWM Removal and Installation on page 228
23. Apply compressor power.
24. Verify the HV+ and the +24 VDC test points on the Backplane.
    - If all voltages are within +/- 10%, proceed to Step 27
    - 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
25. Apply compressor power.
26. 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
27. Verify the +17V, +15, +5 and -15 VDC test points on the Backplane.
    - If all voltages are within +/- 10%, proceed to Step 28
    - If any voltages at the +17V, +15, +5 and -15 VDC test points are not within +/- 10%, replace the Backplane
28. Isolate the compressor power as described in the Section 1.8 Electrical Isolation on page 22.
29. Wait for the LEDs on the Backplane to turn off.
30. Install all connectors.
31. Install the PWM, BMCC, and Serial Driver to the Backplane. Refer to the following sections:

- 4.28.4 PWM Removal and Installation on page 228
- 4.27 BMCC on page 220
- 4.26.4 Serial Driver Removal and Installation on page 218

32. Apply the compressor power.
33. 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%, refer to Section 5.5.2 Determining the Cause of an Energy Drain.

5.5.2 Determining the Cause of an Energy Drain

5.5.2.1 Determining if Serial Driver is Draining Energy

1. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
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 as described in the Section 1.8 Electrical Isolation on page 22.
4. Wait for the LEDs on the Backplane to turn off.
5. Remove the Serial Driver.
6. Re-apply the compressor power.
7. 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

5.5.2.2 Determining if BMCC is Draining Energy

1. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
2. First, follow the procedure in Section 5.5.2.1 Determining if Serial Driver is Draining Energy.
3. Isolate the compressor power as described in the Section 1.8 Electrical Isolation on page 22.
4. Wait for the LEDs on the Backplane to turn off.
5. Remove the Serial Driver. Refer to Section 4.26.4 Serial Driver Removal and Installation on page 218.
6. 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
7. Isolate the compressor power as described in the Section 1.8 Electrical Isolation on page 22.
8. Wait for the LEDs on the Backplane to turn off.
9. Remove the BMCC (refer to Section 4.27 BMCC on page 220).
10. Re-apply the compressor power.
11. 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

5.5.2.3 Determine if PWM is Draining Energy

1. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
2. First, follow the procedures in Section 5.5.2.1 Determining if Serial Driver is Draining Energy and Section 5.5.2.2 Determining if BMCC is Draining Energy.
3. Isolate the compressor power as described in the 1.8 Electrical Isolation.
4. Wait for the LEDs on the Backplane to turn off.
5. Remove the Serial Driver (refer to Section 4.26.4 Serial Driver Removal and Installation on page 218) and BMCC (refer to Section 4.27 BMCC on page 220).
6. 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
7. Isolate the compressor power as described in Section 1.8 Electrical Isolation on page 22.
8. Wait for the LEDs on the Backplane to turn off.
9. Verify the PWM diodes. Refer to Section 4.28.3.3 Verify Functionality of the Five Diode Sets on page 227.
10. Remove the PWM (refer to Section 4.28.4.1 PWM Amplifier Removal on page 228) (keep the Inverter cable connected).
11. Verify the bearings. Refer to Section 4.29.3.1 Bearing Coil Verification on page 230.
12. Verify the bearing sensors. Refer to Section 4.30.3 Bearing Sensor Verification on page 236.
13. Re-apply the compressor power.
14. 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

5.5.2.4 Determining if Inverter is Draining Energy

1. Remove the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.
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

5.5.2.5 Determining if Compressor I/O Board is Draining Energy

Refer to Section 4.3.2.1 Determining if the Compressor Interface Module is Draining Energy on page 62.

5.5.2.6 Determining the Cause of Blown Soft Start Fuses (Closed-Top Soft Start Only)

NOTE
Refer to Section 4.14.2.2 Verifying Soft Start Fuses on page 116 for details on verifying Soft Start fuses.

1. Verify the Soft Start fuses. Refer to Section 4.14.2.2 Verifying Soft Start Fuses on page 116.
2. An open F1 fuse may indicate a problem with the DC-DC or a component connected to its outputs.
   - Using the DC Bus Test Harness, verify the DC-DC Converter high voltage input. Refer to Section 4.24.2.1 Input Voltage Verification on page 204.

- Verify the DC-DC Converter. Refer to Section 4.24.2 DC-DC Converter Verification on page 204.
- Verify the PWM. Refer to Section 4.28.3 PWM Verification on page 226.
- Verify the bearings. Refer to Section 4.29.3 Bearing Verification on page 230.

3. An open F2 fuse may indicate a problem with the Potted DC-DC Converter.
   - Verify the DC-DC Converter 15VAC input resistance (Potted DC-DC only). Refer to Section 4.24.2.3 Input Resistance Measurement on page 205.
4. An open F3 or F6 fuse may indicate a problem with the Soft Start Circuit Board.
   - Verify the SCRs and SCR gates. Refer to Section 4.18.2.1 Diodes Verification - Two-Hole Mount on page 142.
   - Replace the fuse.
   - Reapply power.
   - 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.
   - Verify the DC-DC 15VAC input resistance (Potted DC-DC only). Refer to Section 4.24.2.3 Input Resistance Measurement on page 205.
   - Verify the SCRs and SCR gates. Refer to Section 4.18.2.1 Diodes Verification - Two-Hole Mount on page 142.
   - If no faulty component is identified, replace the fuse and reapply power.
   - If the fuse fails again, replace the Soft Start. Refer to Section 4.14.3 Soft Start Removal and Installation on page 117.

5.5.3 Troubleshooting an Open Interlock

1. Verify the interlock. Refer to Section 4.3.2.3 Interlock Verification on page 63.
2. Ensure there is 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 (refer to Section 4.27 BMCC on page 220), replace the wire to the I/LOCK-(neg) at the J2 connector of the I/O board.

5.5.4 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” faults.
   - Presence of an “Inverter Error” fault indicates probable failure of the Inverter. Replace the Inverter.
   - If no “Inverter Error” fault is present, continue with the next step.
3. Verify the Inverter. Refer to Section 4.22.2 Inverter Verification on page 176.
4. If the Inverter verification passes, but he compressor will not run, refer to Section 4.23.4.1 Stator Insulation Verification on page 195 and Section 4.23.4.2 Stator Resistance Verification on page 195.

THIS PAGE INTENTIONALLY LEFT BLANK

Chapter 6.0 Maintenance

6.1 Preventative Maintenance Tasks

Table 6-1 Preventative Maintenance Tasks identifies tasks that should be performed on a regular basis to maintain optimal performance of the system.

Table 6-1 Preventative Maintenance Tasks

Item	Task	Frequency		
		6 Months	12 Months	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.		✓	
	Inspect the Capacitor Relief Membrane. Replace as necessary.	✓		
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 Bus Bar Assembly. (Refer to Section 4.21 DC Capacitor Bus Bar Assembly on page 165)			Energized: 10 years/Denergized: 5 years
	Check operation of all system safety devices and interlocks.		✓	
	Perform moisture-prevention measures.		✓	
	Replace Soft Start fan. (Refer to Section 4.14.8 Soft Start Fan Removal and Installation on page 123)			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 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 refrigerant charge.	✓		
	Check superheat/level control, if applicable.		✓	
	Check system and liquid line to ensure sufficient sub-cooled refrigerant is available at liquid line adapter.	✓		
	Verify discharge check valve operation. If there is backward gas flow immediately after stopping the compressor, replace the check valve.	✓		

Item	Task	Frequency		
		6 Months	12 Months	Other
	Check operating conditions external to the compressor.	✓		
	Inspect/clean liquid line adapter strainer (if service has taken place).			As required

6.2 Moisture Prevention Measures

6.2.1 Required Items

This section applies to all Rev F and later TTS/TGS/TTH/TGH compressors that have stainless-steel fasteners.

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
- Dielectric grease (Danfoss LLC part # 901982 or equivalent)
- Dielectric grease spray

NOTE

The Danfoss LLC 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

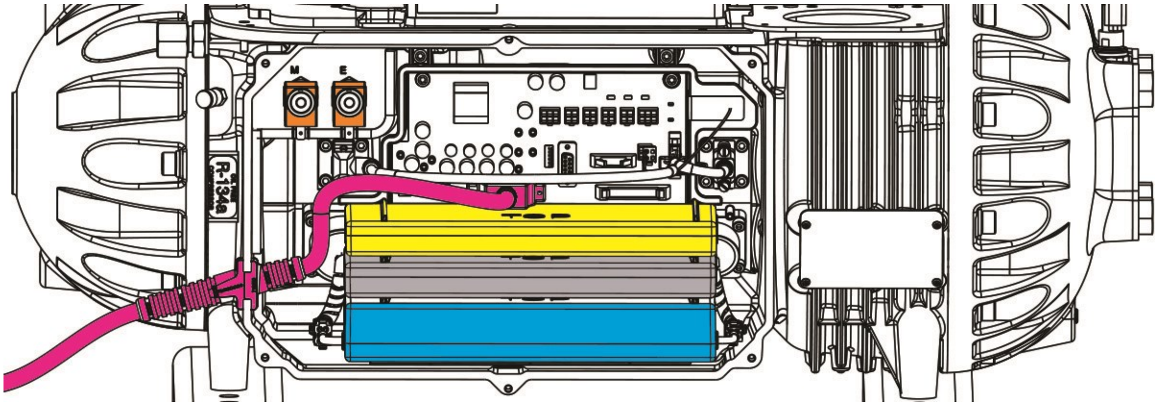
• • • DANGER! • • •

Be sure to follow the manufacturer's usage and safety recommendations when using the aforementioned chemicals.

6.2.1.1 Service Side Disassembly

1. Isolate compressor power.
2. Wait for the Backplane LEDs to turn off.
3. Allow time for the compressor to reach ambient temperature.
4. Remove the Service Side Cover from the compressor.

Figure 6-1 Module Removal

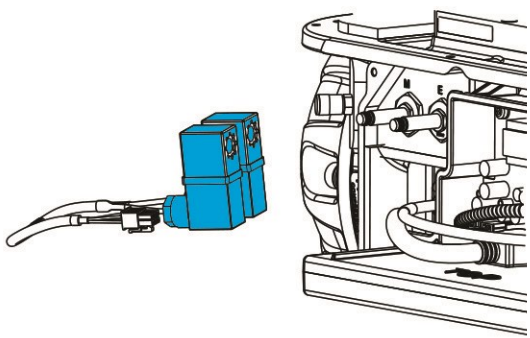


5. Remove the Motor-Cooling Valve Solenoid Coils by removing the retaining nut on each solenoid.

• • • CAUTION • • •
The solenoid actuators are dedicated on all models except TT300/TG230. Note actuator position before removal.

6. Dry off any condensate around the solenoids.

Figure 6-2 Motor Cooling Valve Solenoids

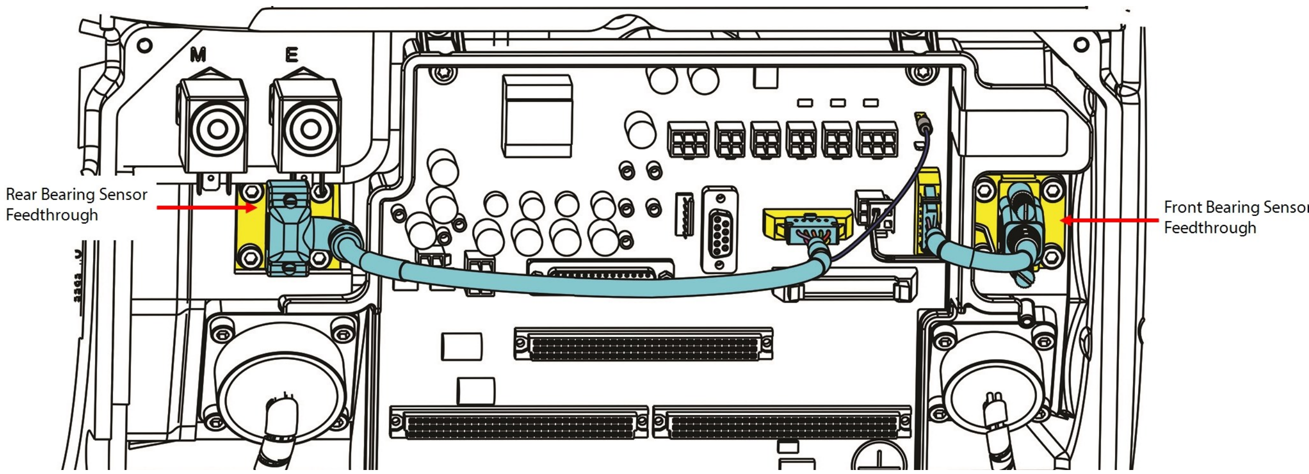


7. Remove any debris or dust from Backplane Board and solenoids using a soft-bristle brush.

6.2.1.2 Service Side Assembly

1. Apply a thin coating of dielectric grease to the exterior of the bearing sensor feedthrough connectors.

Figure 6-3 Bearing Sensor Feedthrough Dielectric Grease Application



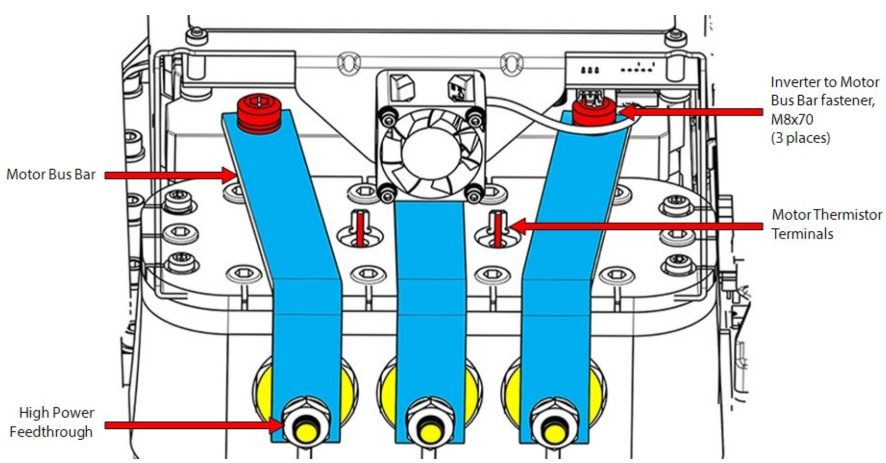
• • • CAUTION • • •
Do not apply any dielectric grease directly to bearing sensor feedthrough DB9 pins, only apply grease around bearing sensor feedthrough connectors after the cables are connected to prevent moisture from entering the pin area.

2. Install the Motor-Cooling Valve Solenoid Coils.
3. Connect the solenoid actuator and bearing sensor cables to the Backplane.
4. Install the Service Side Cover. Refer to Section 4.1.3.1 Service Side Cover Removal and Installation on page 54.

6.2.1.3 Top Side

1. Remove the top covers from the compressor. Refer to Section 4.1 Compressor Covers on page 52.
2. Dry off any condensate around the motor winding sensor terminals, high power feedthroughs and motor bus bars.
3. Using a soft-bristle brush, remove any debris or dust from the motor winding sensor terminals.
4. Spray or apply dielectric grease on the motor thermistor terminals. Refer to Figure 6-4 Motor Component Dielectric Grease Application.
5. Reinstall top covers. Refer to Section 4.1 Compressor Covers on page 52.
6. Return the compressor to normal operation.

Figure 6-4 Motor Component Dielectric Grease Application



Appendix A Acronyms/Terms

Table A-1 Acronyms/Terms

Acronym/Term	Definition
AC	Alternating Current
AFT	Ascending fault triggering
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).
Backplane	A PCB for the purpose of power and control signal transmission. Many other components connect to this board.
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.
Cavity Sensor	NTC temperature sensor located behind the Backplane for the purpose of sensing motor-cooling vapor temperature. Provides overheat protection to motor windings.
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.
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.
DC	Direct Current
DC-DC	DC to DC Converter
DFT	Descending fault triggering
DIN	German Institute for Standardization
EEPROM	Electrically Erasable Programmable Read-Only Memory
EMF	Electromotive Force
EPR	Evaporator pressure regulating
ESD	Electostatic Discharge
EXV	Electronic Expansion Valve
HV	High Voltage
IGV	Inlet guide vane
INS	Instant fault triggering
I/O	Input/output
k/V	Kilovolt
LED	Light Emitting Diode
LOTO	Lockout/Tagout
NTC	Negative Temperature Coefficient
OEM	Original Equipment Manufacturer
ORFS	O-ring face seal
PCB	Printed Circuit Board
PDF	Portable Document Format
PWM	Pulse width modulation
P/T	Pressure/Temperature
RFT	Range fault triggering

Acronym/Term	Definition
RTC	Real-Time Clock
SCR	Silicone-Controlled Rectifier
SMT	Service Monitoring Tools Software
VDC	Volts Direct Current or Volts DC
°C	Degrees Celsius
°F	Degrees Fahrenheit

Appendix B Compressor Troubleshooting Flowcharts

This appendix contains flowcharts for Compressor Operation Troubleshooting (Figure B-1 Compressor Operation Troubleshooting Flowchart (Sheet 1)) and Compressor Voltage Troubleshooting (Figure B-3 Compressor Voltage Troubleshooting Flowchart (Sheet 1)).

Figure B-1 Compressor Operation Troubleshooting Flowchart (Sheet 1)

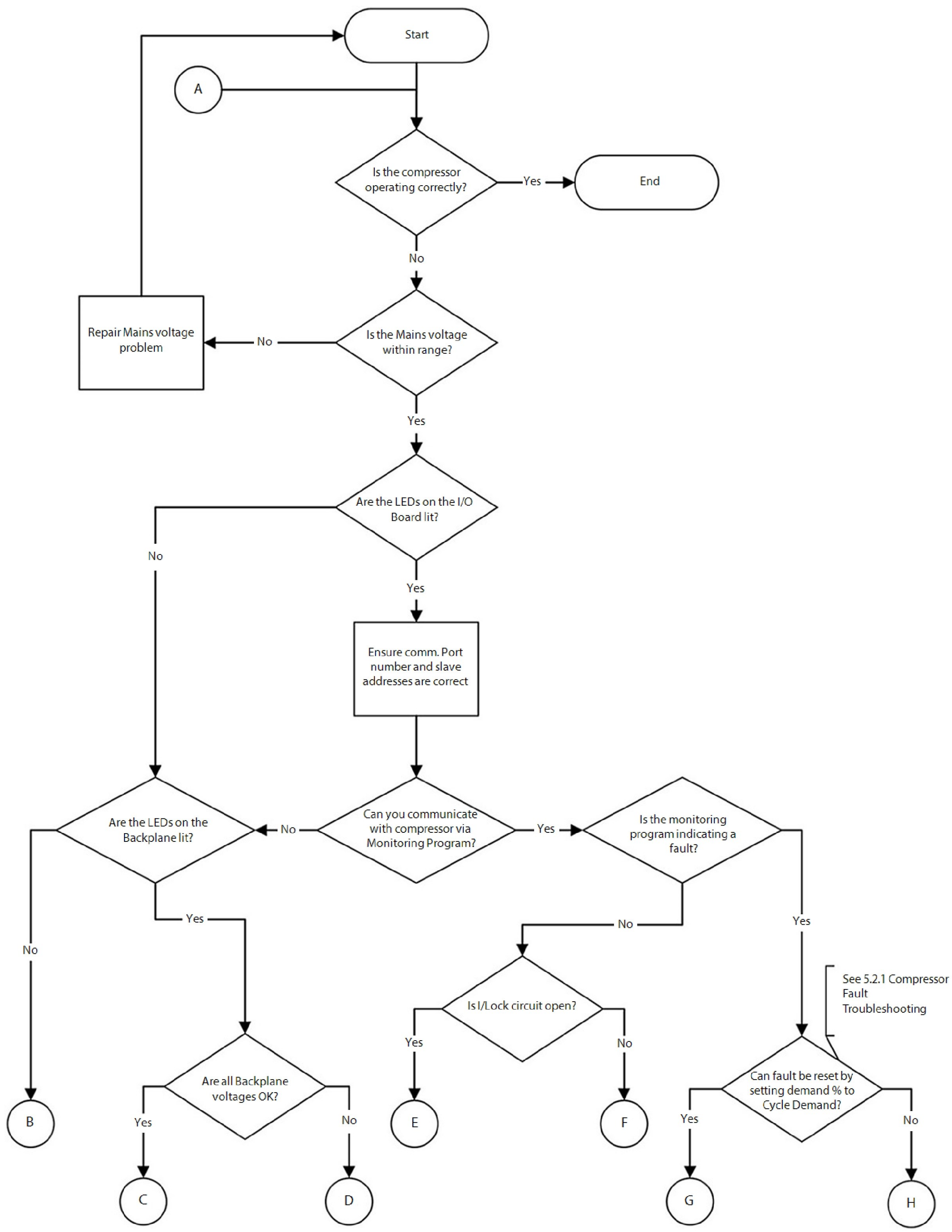


Figure B-2 Compressor Operation Troubleshooting Flowchart (Sheet 2)

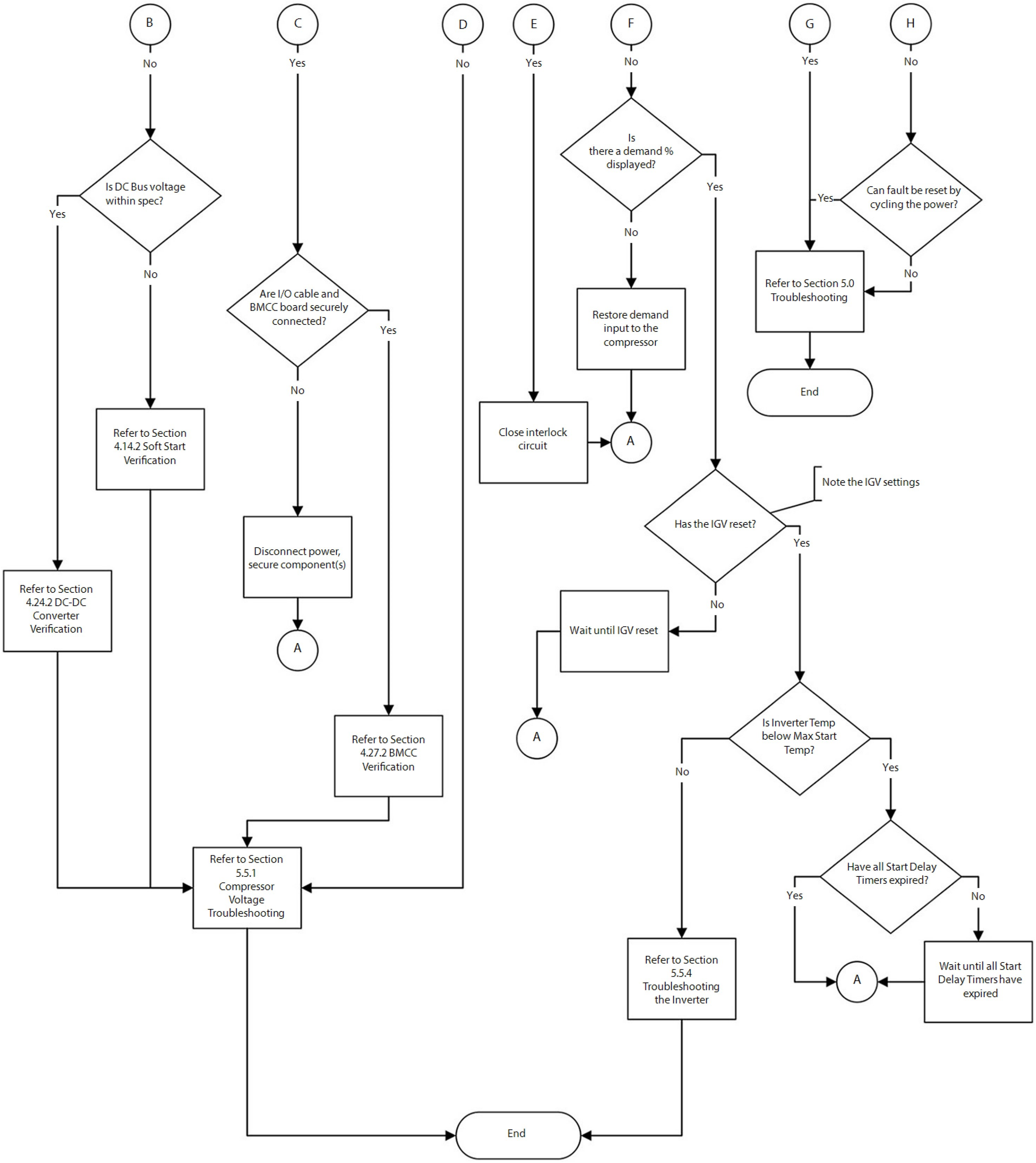


Figure B-3 Compressor Voltage Troubleshooting Flowchart (Sheet 1)

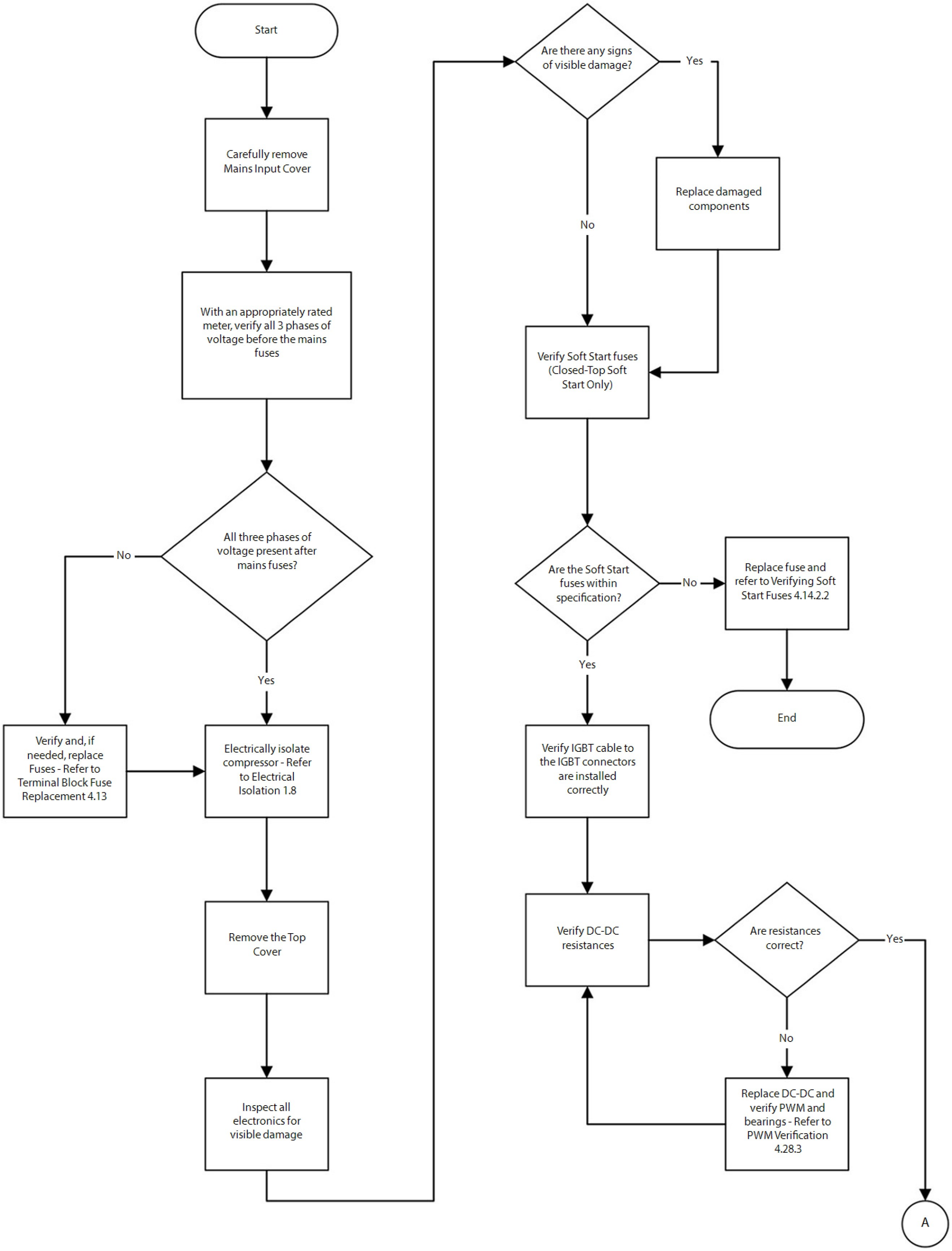


Figure B-4 Compressor Voltage Troubleshooting Flowchart (Sheet 2)

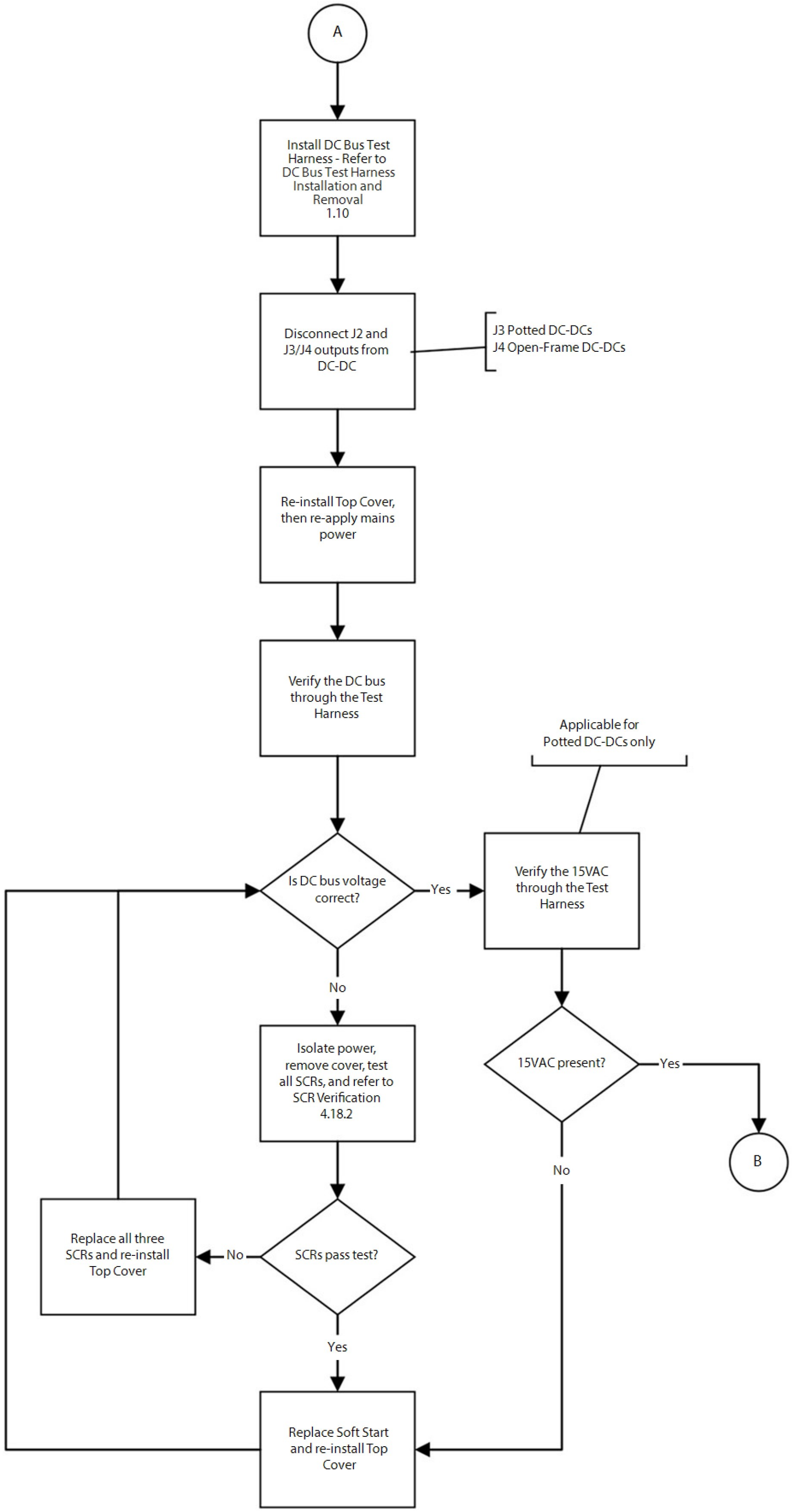
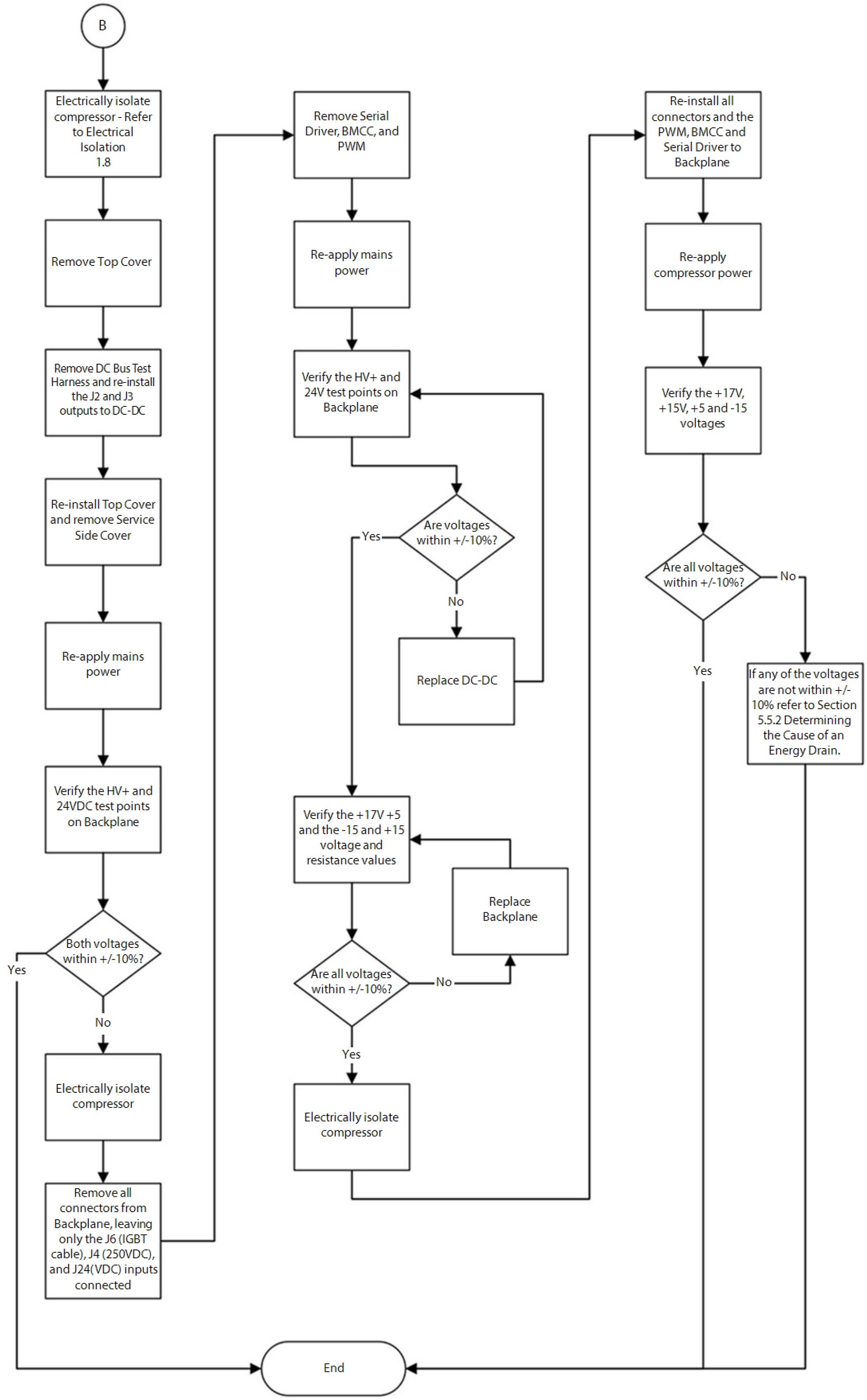


Figure B-5 Compressor Voltage Troubleshooting Flowchart (Sheet 3)



THIS PAGE INTENTIONALLY LEFT BLANK

Appendix C Compressor Test Sheet

Component	Test Point	Expected Value	Verification Section	Measured Value
Backplane DC Voltage	0V to 24V	22 to 26 VDC	4.25.2.2 Backplane Verification	
	0V to +15V	14.75 to 15.25 VDC	4.25.2.2 Backplane Verification	
	0V to -15V	-14.75 to -15.25 VDC	4.25.2.2 Backplane Verification	
	0V to +5V	4.75 to 5.25 VDC	4.25.2.2 Backplane Verification	
	HV- to HV+	220 to 280 VDC	4.25.2.2 Backplane Verification	
	HV- to +17V	16.5 to 17.85 VDC	4.25.2.2 Backplane Verification	
Cavity Temperature Sensor Resist	Positive to Negative	10KΩ @ 77°F (25°C)	4.31.3 Cavity Temperature Sensor Verification	
DC Bus Test Harness	DC Bus	462-853VDC	1.10 DC Bus Test Harness Installation and Removal	
	DC Bus F	462-853VDC	1.10 DC Bus Test Harness Installation and Removal	
	15VAC	12 – 25VAC	1.10 DC Bus Test Harness Installation and Removal	
DC-DC Resistance	J1	open or >150kΩ	4.24.2.3 Input Resistance Measurement	
	J2	Charging or discharging Ω	4.24.2.4 Output Resistance Measurement	
	J3 Potted (J4 Open-Frame)	Charging or discharging Ω	4.24.2.4 Output Resistance Measurement	
	J4 Potted	>1MΩ	4.24.2.4 Output Resistance Measurement	
Front Bearing Feedthrough Resistance	TTS300, TTS400 C, E, F, & G/ TGS230, & TGS390: 1 to 2	2.7 to 25Ω	4.29.3 Bearing Verification	
	TTS300, TTS400 C, E, F, & G/ TGS230, & TGS390: 3 to 4	2.7 to 25Ω	4.29.3 Bearing Verification	
	TTS350, TTS400 P, TTS500, TTS700, TGS310, & TGS520, TTH375, & TGH 285: 1 to 2	4.7 to 5.20 Ω	4.29.3 Bearing Verification	
	TTS350, TTS400 P, TTS500, TTS700, TGS310, & TGS520, TTH375, & TGH 285: 3 to 4	4.7 to 5.20 Ω	4.29.3 Bearing Verification	
Front Bearing Sensor Feedthrough Resistance	5 to 2	2.0Ω to 3.5Ω	4.30.3 Bearing Sensor Verification	
	5 to 3	2.0Ω to 3.5Ω	4.30.3 Bearing Sensor Verification	
	6 to 7	2.0Ω to 3.5Ω	4.30.3 Bearing Sensor Verification	
	6 to 8	2.0Ω to 3.5Ω	4.30.3 Bearing Sensor Verification	
	1 to 4	2.0Ω to 3.5Ω	4.30.3 Bearing Sensor Verification	
	1 to 9	2.0Ω to 3.5Ω	4.30.3 Bearing Sensor Verification	
Inverter Diode	Phase 1: + Lead on AC Output to - DC input	Open	4.22.2 Inverter Verification	

Component	Test Point	Expected Value	Verification Section	Measured Value
	Phase 1: + Lead on AC Output to + DC input	0.275v - 0.4v	4.22.2 Inverter Verification	
	Phase 2: + Lead on AC Output to - DC input	Open	4.22.2 Inverter Verification	
	Phase 2: + Lead on AC Output to + DC input	0.275v - 0.4v	4.22.2 Inverter Verification	
	Phase 3: + Lead on AC Output to - DC input	0.275v - 0.4v	4.22.2 Inverter Verification	
	Phase 3: + Lead on AC Output to + DC input	Open	4.22.2 Inverter Verification	
	Phase 1: - Lead on AC Output to - DC input	0.275v - 0.4v	4.22.2 Inverter Verification	
	Phase 1: - Lead on AC Output to + DC input	Open	4.22.2 Inverter Verification	
	Phase 2: - Lead on AC Output to - DC input	0.275v - 0.4v	4.22.2 Inverter Verification	
	Phase 2: - Lead on AC Output to + DC input	Open	4.22.2 Inverter Verification	
	Phase 3: - Lead on AC Output to - DC input	0.275v - 0.4v	4.22.2 Inverter Verification	
	Phase 3: - Lead on AC Output to + DC input	Open	4.22.2 Inverter Verification	
IGV Motor Resistance	1 to 2	46Ω to 59Ω	4.9.2 IGV Verification	
	3 to 4	46Ω to 59Ω	4.9.2 IGV Verification	
Interlock	Power On: I/Lock - to Ground	0VDC	4.3.2.3 Interlock Verification	
	Power On: J2 Removed I/Lock - to I/Lock +	2.2 to 3.7 VDC	4.3.2.3 Interlock Verification	
	Power Off: J2 Removed I/Lock - to I/Lock +	< 22 kΩ	4.3.2.3 Interlock Verification	
Pressure/Temperature Sensor Resistance	1 to 3 (1 to 2 of the plug)	10KΩ @ 77°F (25°C)	4.31.3 Cavity Temperature Sensor Verification	
PWM Diode	Lead in HV-; - lead in PWM connector	0.39-0.46VDC	4.28.3.3 Verify Functionality of the Five Diode Sets	
	- Lead in HV+; +C47 lead in PWM connector	0.39-0.46VDC	4.28.3.3 Verify Functionality of the Five Diode Sets	
Rear Bearing Feedthrough Resistance	All models 1 to 6	2.7 to 3.25Ω	4.29.3 Bearing Verification	
	All models 2 to 5	2.7 to 3.25Ω	4.29.3 Bearing Verification	
	TT300/TG230 3 to 4	5.7 to 6.2Ω	4.29.3 Bearing Verification	
	All models except TT300/TG230: 3 to 4	6.0 to 6.7Ω	4.29.3 Bearing Verification	
Rear Bearing Sensor Feedthrough Resistance	5 to 2	2.0Ω to 3.5Ω	4.30.3 Bearing Sensor Verification	
	5 to 3	2.0Ω to 3.5Ω	4.30.3 Bearing Sensor Verification	
	6 to 7	2.0Ω to 3.5Ω	4.30.3 Bearing Sensor Verification	
	6 to 8	2.0Ω to 3.5Ω	4.30.3 Bearing Sensor Verification	
SCR Diode	positive (+) on 1 negative (-) on 2	∞ or open	4.18.2 SCR Verification	
	positive (+) on 1 negative (-) on 3	∞ or open	4.18.2 SCR Verification	
	positive (+) on 2 negative (-) on 1	∞ or open	4.18.2 SCR Verification	
	positive (+) on 3 negative (-) on 1	0.3V to 0.45V	4.18.2 SCR Verification	
SCR Gate Resistance	Gate Terminals	>1Ω and <25Ω (all models)	4.18.2.3 Gates Verification	
SCR Temperature Sensor	J17 Sensor connector	10KΩ @ 70°F (21°C)	4.18.2.5 SCR Temperature Sensor Verification	
Soft Start Fuses (Closed-Top Soft Start only)	F1	<1Ω	4.14.2.2 Verifying Soft Start Fuses	
	F2	<1Ω	4.14.2.2 Verifying Soft Start Fuses	
	F3 & F6	<1Ω	4.14.2.2 Verifying Soft Start	

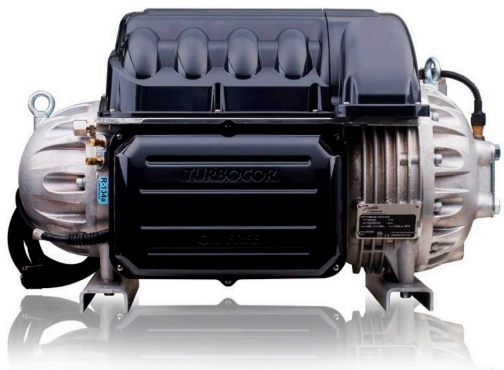
Component	Test Point	Expected Value	Verification Section	Measured Value
			Fuses	
	F4 & F5	30-38Ω	4.14.2.2 Verifying Soft Start Fuses	
Solenoid Actuators	4.8 W	108Ω – 132Ω	4.6.3 Solenoid Verification	
	9.3 W	56.25Ω – 68.75Ω	4.6.3 Solenoid Verification	
Stator Resistance	Phase 1:2	>0.0Ω and <1Ω	4.23.4.2 Stator Resistance Verification	
	Phase 1:3	>0.0Ω and <1Ω	4.23.4.2 Stator Resistance Verification	
	Phase 2:3	>0.0Ω and <1Ω	4.23.4.2 Stator Resistance Verification	
Stator Thermistor Resistance	+ to -	150-300Ω at 70° F (21°C)	4.23.4.2 Stator Resistance Verification	

THIS PAGE INTENTIONALLY LEFT BLANK


ENGINEERING TOMORROW
Danfoss
TurboTool®
Quick access to Danfoss Turbocor® compressor troubleshooting.
The new version of the Danfoss TurboTool® 2.0 app for all your full service Danfoss Turbocor® compressor needs.
24/7
Access to Danfoss Turbocor® compressor troubleshooting on site
The TurboTool® app makes it easy for technicians to troubleshoot issues on Danfoss Turbocor® compressors.
The user can select from a list of symptoms in the app that match the problems exhibited by the compressor being serviced. The app will then list potential causes, solutions to the problem, and service literature to reference for further information.
The app provides the correct operating parameters for key components: no need to keep reference documents on hand.
Troubleshoot
Documents & Video
Spare Parts
You no longer need to keep hundreds of pages of parts catalogs and training manuals. With the app, all of this information is at your fingertips on your smart device.
With the app, you can access videos made by Danfoss Turbocor® that demonstrate how to remove, install, and rebuild key components on Danfoss Turbocor® compressors.
TurboTool® helps you to quickly identify the required spare parts. A quick scan of the compressor serial # using your smartphone camera or by entering the part # or model #, and the app will display potential spare parts kits.
Download the 2.0 app today!
Scan to download app
www.turbocor.danfoss.com | TURBOCOR®

THIS PAGE INTENTIONALLY LEFT BLANK

ENGINEERING
TOMORROW



Boost your **Turbocor®** knowledge

The Danfoss Turbocor® Training Program - Service, Maintenance, and Troubleshooting

- Online and face-to-face training modules
- Discover the advantages of oil-free technology
- Go hands-on with a Turbocor compressor
- Master the Turbocor monitoring software
- Interact directly with Danfoss experts

Highly qualified and field-experienced instructors of the **Danfoss Turbocor® Learning Center** will provide you with a high level of training.

Attendees will be trained in three key areas of the Turbocor® program that includes:

- Practical classroom courses
- Hands-on compressor demonstrations
- Service Monitoring Tools software applications

78
years of combined service and applications knowledge

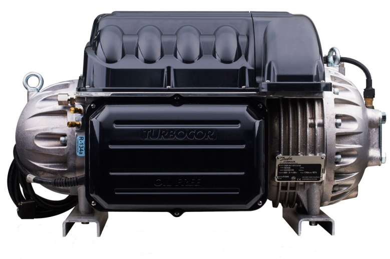
Join us for the next **Turbocor® Training** class. Scan the code to see our schedule and **register today!**

www.turbocor.danfoss.com | TURBOCOR®

Danfoss Commercial Compressors

is a worldwide manufacturer of compressors and condensing units for refrigeration and HVAC applications. With a wide range of high quality and innovative products, we help your company to find the bast possible energy efficient solution that respects the environment and reduces the total life cycle costs.

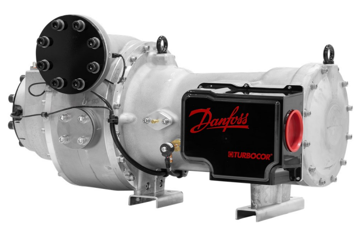
We have over 40 years within the development of hermetic compressors which has brought us amongst the global leaders in our business, and has positioned us as distinct variable speed technology specialists. Today we operate from engineering and manufacturing facilities spanning across three continents.



TTS Compressors

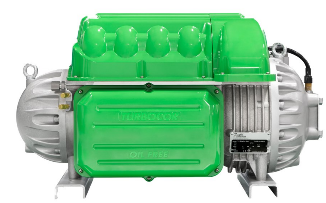
Highlift Compressors

Danfoss Turbocor Compressors



VTX1600 Compressors

Highlift Compressors



TGS Compressors

Our products can be found in a variety of applications such as rooftops, chillers, residential air conditioners, heatpumps, coldrooms, supermarkets, milk tank cooling and industrial processes.

http://turbocor.danfoss.com

Danfoss LLC 1769 E. Paul Dirac Drive, Tallahassee, Fl, 32310 USA | +1 850-504 4800