ENGINEERING TOMORROW

Danfoss

Applications and Installation Manual - Revision S

Danfoss Turbocor® Twin-Turbine Centrifugal Compressors

TTS/TGS/TTH/TGH Compressors

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List of Changes

Revision	Date	Page	Description of Change
P	06-12-2019		Redevelopment of manual to include TTH/TGH compressors
P.1	12-12-2019		Update to include TG490 and Medium Temp
Q	04-06-2020		Major Revision H upgrade
R	02-01-2021		Includes High SST and general review/update
S	07-29-2021	Complete review/many small changes made	Includes new TTS 575V option

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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

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Chapter 1.0 Introduction

This Applications and Installation Manual is intended to be a guide for application data/installation procedures specific to Danfoss Turbocor compressors. It is not intended to inform on fundamental safety, refrigeration and electrical design skills. It is assumed and presumed that persons using this manual are appropriately certified and have detailed knowledge, experience and skills in respect to designing for and working with high pressure refrigerants and medium voltage electrical components (to 1 KV high power AC & DC) as well as complex control systems.

Some potential safety situations may not be foreseen or covered in this guide. Danfoss LLC assumes personnel using this manual and working on Danfoss LLC compressors are familiar with, and carry out, all safe work practices necessary to ensure safety for personnel and equipment.

1.1 Scope

This manual is designed for use with Bearing Motor Compressor Controller (BMCC) software, Version 4.0.0 and later.

Table 1-1 Application Manual Applicability

Manual	Release Date	BMCC Firmware Versions
M-AP-001-XX Rev E	September 2013	CC 2.3.1213
M-AP-001-XX Rev L	October 2016	CC 3.1.4
M-AP-001-XX Rev M	November 2017	CC 4.0 and later
M-AP-001-XX Rev M.1	November 2017	CC 4.1 and later
M-AP-001-XX Rev N	May 2018	CC 4.1 and later
M-AP-001-XX Rev P.1	November 2019	CC 4.2 and later
M-AP-001-XX Rev R	January 2021	CC 4.3 and later

1.2 Document Symbols

The following symbols are used in this document.

NOTE: Provides additional information such as a tip, comment, or other useful, but not imperative information. A Note is displayed in the format shown below.

NOTE

DANGER: Indicates 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 below.

• • • DANGER! • • •

CAUTION: Indicates 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 below.

• • • CAUTION • • •

Table 1-2 Acronyms and Terms

Acronym/Term	Definition
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.
AHRI	Air-Conditioning, Heating, and Refrigeration Institute (www.ari.org;www.ahrinet.org).
ANSI	American National Standards Institute.
ASHRAE	American Society of Heating Refrigeration and Air-Conditioning Engineers (www.ashrae.org).
Axial Bearing	Bearing that controls the horizontal movement (Z axis) of the motor shaft.
Backplane	A printed circuit board (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.
Bus Bars	Heavy-gauge metal conductors used to transfer large electrical currents.
Capacitor	A passive component that stores energy in the form of an electrostatic field.
Cavity Sensor	Negative Temperature Coefficient (NTC) temperature sensor located behind the Backplane for the purpose of sensing motor-cooling vapor temperature. Provides

Acronym/Term	Definition
	overheat protection to motor windings.
CE	Conformance European. The CE marking (also known as CE mark) is a mandatory conformity mark on many products placed on the single market in the European (EU) Economic Area. The CE marking certifies that a product has met EU health, safety, and environmental requirements, which ensure consumer safety.
CEC	Canadian Electrical Code.
Choke	Definitive point on compressor map where mass flow rate is at maximum for compressor speed and lift conditions.
CIM	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 Input/Output (IO) board.
Compression Ratio	The absolute discharge pressure divided by the absolute suction pressure.
CPR	Compressor Performance Rating.
CSA	Canadian Standards Association (www.csa.ca).
dB	Logarithmic scale that measures sound and loudness.
dBA	Sound level measurement that has been adjusted based on how the human ear perceives sounds in the air.
DC Bus	High DC voltage simultaneously connected to multiple compressor components via metallic bus bars, including the capacitors.
DC-DC Converter	DC-DC converters supply and electrically isolate the high and low DC voltages that are required by the control circuits. When the compressor is switched on, the High-Voltage (HV) DC-DC Converter receives its 15VAC supply from the Soft-Start Board. Once the DC DC-DC Converter bus voltage has risen to a pre-determined level, the HV DC-DC Converter's onboard circuits are powered by the DC bus (460-900VDC). The HV DC-DC Converter delivers +24VDC (with respect to 0V) to the Backplane, and HV+ (+250VDC with respect to HV-) to the magnetic Bearing Pulse Width Modulation (PWM) Amplifier via the Backplane.
Diffuser	Part of a centrifugal compressor in the fluid module that transforms the high-velocity, low- pressure gas exiting the impeller into higher-pressure, low-velocity gas discharged into the condenser.
EMC	Electromagnetic Compatibility.

Acronym/Term	Definition
EMF	Electromotive Force.
EMI	Electromagnetic Interference.
EMI Filter	A circuit or device that provides electromagnetic noise suppression for an electronic device.
EPDM	Ethylene propylene diene monomer – type of synthetic rubber.
ETL	ETL Testing Laboratories, now a mark of Intertek Testing Services.
EXV	Electronic Expansion Valve. Pressure-independent refrigerant metering device driven by electrical input.
Feedthrough	An insulated conductor connecting two circuits on opposite sides of a barrier such as a compressor housing or PCB.
FLA	Full Load Ampere.
Generator Mode	A function of the compressor where the stator becomes a generator, creating sufficient power to allow for the shaft to graduate slowly and drop onto the touchdown bearings safely. This occurs when the inverter has insufficient power to sustain safe and normal operation and is typically due to a loss of power.
Harmonics	Harmonics are multiples of the fundamental frequency distortions found in electrical power, subjected to continuous disturbances.
HFC	Hydrofluorocarbon.
HFC-134a	A positive-pressure, chlorine-free refrigerant having zero ozone depletion potential.
HV	High Voltage.
Hz	Hertz.
IEEE	Institute of Electrical and Electronic Engineers (www.ieee.org).
IGV	Inlet Guide Vanes. The IGV assembly is a variable-angle guiding device that pre-rotates refrigerant flow at the compressor intake and is also used for capacity control. The IGV assembly consists of movable vanes and a motor. The vane angle, and hence, the degree of pre-rotation to the refrigerant flow, is determined by the BMCC and controlled by the Serial Driver. The IGV position can vary between approximately 0-percent and 110-percent open.
Impeller	Rotating part of a centrifugal compressor that increases the pressure of refrigerant vapor from the lower evaporator pressure to the higher condenser pressure.

Acronym/Term	Definition
ISO	International Organization for Standardization.
I/O Board	Input/Output Board facilitating a connection between the compressor controller and/ or PC and the compressor. It allows the user to control the compressor and allows the compressor to return status and sensor information to the user. Also known as the CIM.
Inverter	The Inverter converts the DC bus voltage into an adjustable frequency and adjustable amplitude, three-phase simulated AC voltage.
kPa	Kilopascal.
kPag	Kilopascal Gauge.
kW	Kilowatt.
kV	Kilovolt.
LBV	Load Balance Valve. A modulating valve that can be installed to bypass discharge gas to the inlet of the evaporator to provide gas flow at certain conditions such as startup, surge, and further unloading of the compressor.
LED	Light-Emitting Diode.
Levitation	The elevation or suspension of the compressor shaft by the magnetic field created by the magnetic bearings.
Line Reactor	A transformer-like device designed to introduce a specific amount of inductive reactance into a circuit. When this occurs, it limits the change in current in the line, which in turn filters the waveform and attenuates electrical noise and harmonics associated with an inverter/drive output.
LLC	Limited Liability Company.
LRA	Locked Rotor Ampere.
LVD	Low voltage directive.
Modbus	A serial communications protocol published by Modicon in 1979 for use with its programmable logic controllers (PLCs). It has become a de facto standard communications protocol in industry, and is now the most commonly available means of connecting industrial electronic devices. Modbus allows for communication between many devices connected to the same network, for example a system that measures temperature and humidity and communicates the results to a computer.
Monitor Program	A software program provided by Danfoss LLC that can be downloaded to a PC or laptop computer to monitor, regulate, control or verify the operation of a compressor.

Acronym/Term	Definition
Motor Back EMF	Back electromotive force is a voltage that occurs in electric motors where there is relative motion between the armature of the motor and the external magnetic field and is also a parameter used to evaluate the strength of the permanent magnets of the shaft. One practical application is to use this phenomenon to indirectly measure motor speed as well as estimate position.
MSDS	Material Safety Data Sheet.
NEC	National Electric Code (www.necplus.org).
NEMA	National Electrical Manufacturers Association.
Nm	Newton meter. A unit of torque. 1 Nm = 0.738 pound-force foot (lbf/f).
NTC	Negative Temperature Coefficient. Refers to thermistor characteristic. Decrease in temperature results in a rise in resistance (ohms).
ODF	Outside Diameter Flare.
OEM	Original Equipment Manufacturer.
PCB	Printed Circuit Board.
PLC	Programmable Logic Controller.
Pressure Ratio	See "Compression Ratio".
PE	Protective Earth.
PSIG	Pounds per square in gauge.
PWM	Pulse Width Modulation.
Radial Bearing	Bearings that control the position of the shaft on the X and Y axis.
Rectifier	A rectifier is an electrical device that converts AC current to pulsating DC current.
Resistor	A resistor is an electrical component that limits or regulates the flow of electrical current in an electronic circuit.
RPM	Revolutions per minute.
SCR	Silicon-Controlled Rectifier. The SCR is a four-layer, solid-state device that controls current and converts AC to DC.
Serial Driver	A PCB plug-in responsible for the operation of the IGV stepper motor and optional

Acronym/Term	Definition
	expansion valves. It contains four relays for the solenoid valves, compressor status and compressor run status respectively.
SDT	Saturated Discharge Temperature.
SMT	Service Monitor Tools a PC program provided byDanfoss LLC. A user friendly way of displaying compressor data to the user and offer adjustment of predetermined parameters. The user interface adjusts itself according to the active access level at the compressor.
Soft-Start Board / Soft-Starter	The Soft-Start Board limits in-rush current by progressively increasing the conduction angle of the SCRs. This technique is used at compressor startup while the DC capacitors are charging up. The Soft-Start Board takes as input a 3-phase voltage source at 50/60Hz from the input terminal and a DC voltage signal from the SCR output. In turn, it outputs pulses to the SCR and provides power to the High-Voltage (HV) DC-DC Converter. All voltages from the Soft-Start Board are with respect to the positive DC bus and not the compressor ground.
SST	Saturated Suction Temperature.
Surge	The condition at which the compressor cannot sustain the discharge pressure, allowing refrigerant to temporarily and rapidly re-enter the compressor fluid path, creating a cavitating effect. This is an undesirable situation that should be avoided.
Ton	The basic unit for measuring the rate of heat transfer (12,000 BTU/H; 3.516 kw/H).
Touchdown Bearings	Carbon races or ball bearing for the purpose of preventing mechanical interference between the shaft and the magnetic bearings should they lose power or fail.
TT	Twin Turbine.
Two-Stage Centrifugal compressor	Type of centrifugal compressor having two impellers. The first-stage impeller raises the pressure of the refrigerant vapor approximately halfway from the cooler pressure to the condenser pressure, and the second-stage impeller raises the pressure the rest of the way. With a two-stage compressor, an interstage economizer may be used to improve the refrigeration cycle efficiency.
UL	Underwriters Laboratories (www.ul.com).
VAC	Volts Alternating Current.
Vaned Diffuser	An assembly of plates with curved vanes that serve to slow, compress, and reduce refrigerant rotation as it enters the second-stage impeller.
Vaneless Diffuser	Similar to a Vaned Diffuser, except that it does not possess any de-swirl vanes.

Acronym/Term	Definition
VDC	Volts Direct Current.
VFD	Variable Frequency Drive.
W	Watt.

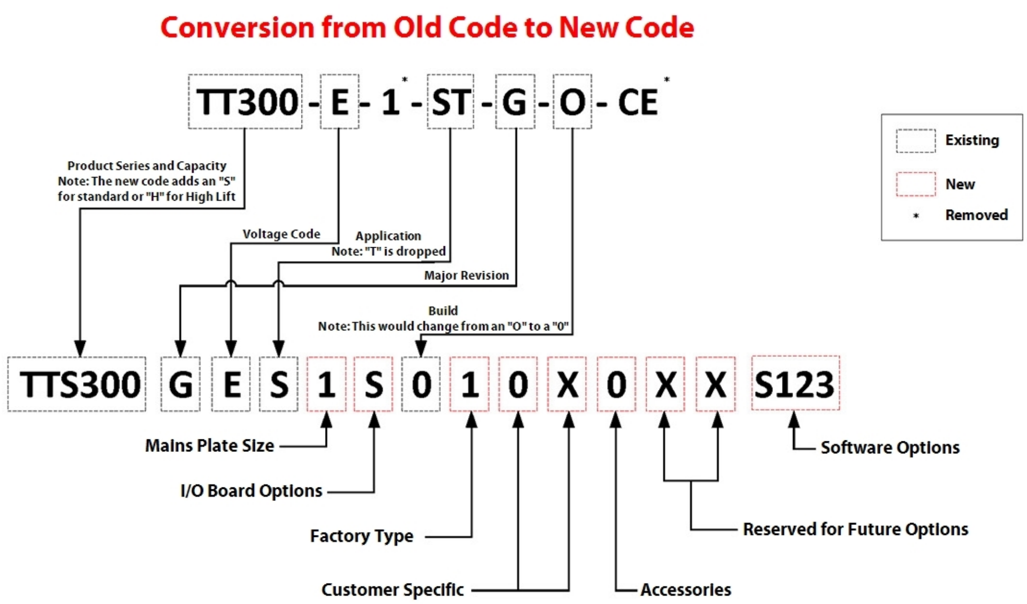
Chapter 2.0 Compressor Overview

The TTS/TGS/TTH/TGH Centrifugal series of compressors is a group of compressors that covers the nominal capacity range from 90 to 200 Tons (TTS/TTH) and 70 to 150 Tons (TGS/TGH). This series of compressors are an oil free centrifugal design based on magnetic bearing technology.

As of May 6, 2019, the product nomenclature changed. Figure 2-1 Old Type Code to New Type Code Rev D maps the old structure of the Type Code to the new structure. Additionally, the “Series” indicators not 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 2-2 Compressor Nomenclature for a complete description for the new Type Code.

2.1 TTS/TGS/TTH/TGH Compressor Nomenclature

Figure 2-1 Old Type Code to New Type Code Rev D



Type Code Definition

Product Series and Capacity
- 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
- TGS490: TG Series 490 Aero Config
- TGS520: TG Series 520 Aero Config
- TGH285: TG High Lift Series 285 Aero Config
- TTH375: TT High Lift Series 375 Aero Config

Major Revision
- E: Major Revision E
- F: Major Revision F
- G: Major Revision G

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

Application
- S: Standard Application
- M: Medium Temperature Application
- J: Standard Temp KHK Listed
- K: Medium Temp KHK Listed

Mains Plate Size
- 1: Mains Plate 2.00"
- 2: Mains Plate 2.48"
- 3: Mains Plate 3.00"
- 4: Mains Plate 3.50"

I/O Board Option
- S: I/O Board included with 5m cable
- M: No I/O Board, 5m cable included

Build
- 0: New Compressor
- C: Rebuilt Certified Compressor

Factory Type
- 1: TLH Factory (CE Rated)
- 2: HYN Factory (CH Rated)
- 3: TLH Factory (NC Rated)

Customer Specific Configuration
- 0: Gen Covers/Plate, EN/FR/CH

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

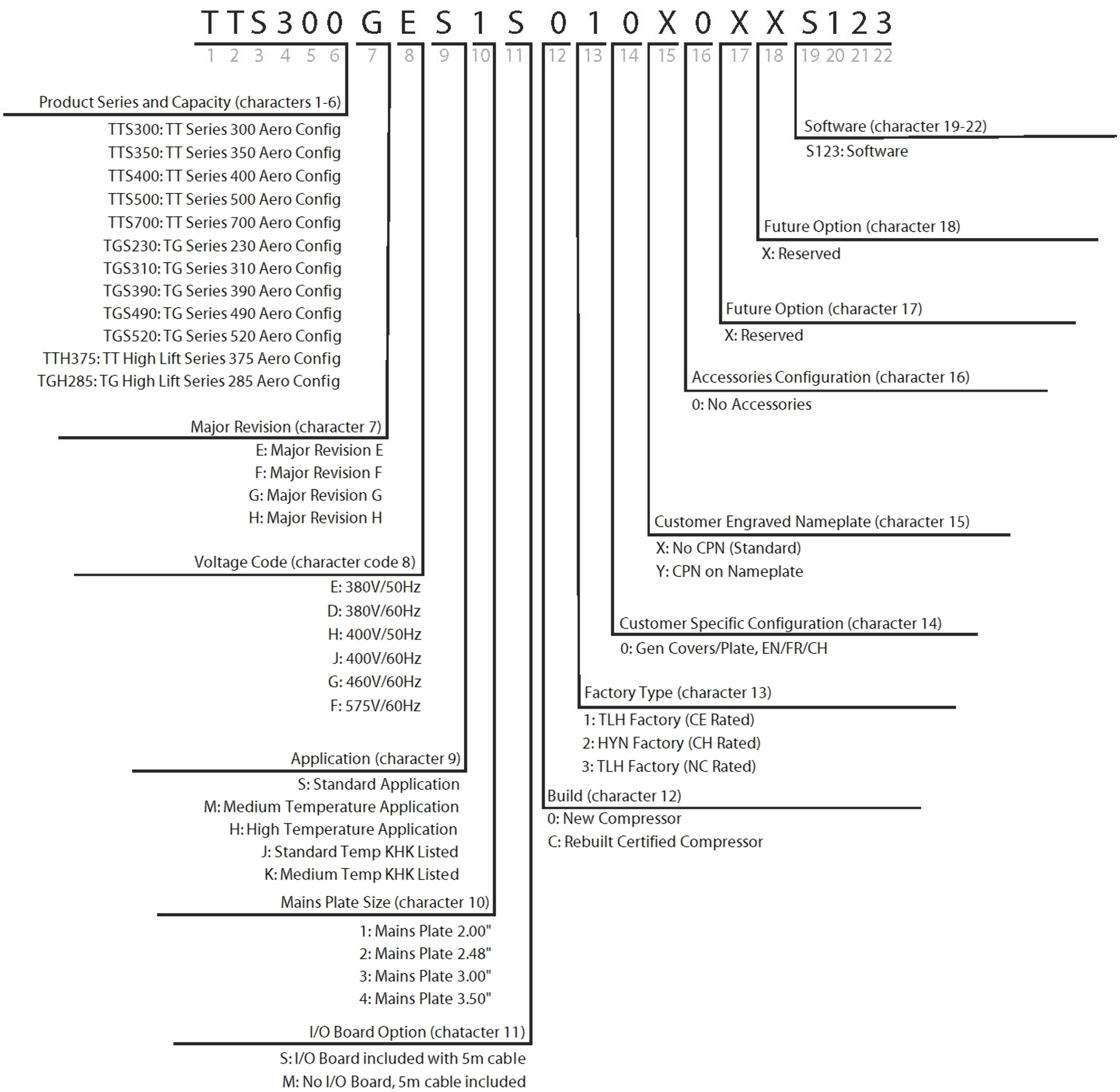
Accessories Configuration
- 0: No Accessories

Future Option
- X: Reserved
- X: Reserved

Software
- S123: Software Revision

Figure 2-2 Compressor Nomenclature

Turbocor TT/TG Series Type Code



2.2 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 2-1 Refrigerant Used with Turbocor Compressors

Compressor Series	Refrigerants	ASHRAE/ANSI Standard 34 Classifications
TTS/TTH	R134, 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
- R513A refrigerant is only compatible with EPDM O-rings

NOTE

To ensure a reliable chiller system, all system components, most notably expansion valves, solenoid valves, and sensors, be appropriate for application in oil-free systems as determined by the component manufacturer. In addition, all chiller system components exposed to refrigerant should be approved by their manufacturer for use with that refrigerant.

2.3 Environment

The compressor should not be operated at an altitude higher than 3000 m.

The compressor should be stored and operated within the following ambient temperature ranges:

- Storage: -30°C to 70°C (-22°F to 158°F)
- Operation: -1°C to 51°C (30°F to 124°F)
- Mains Power Applied Non Operating Limit: -25°C (-13°F)
- Humidity: 0-95% Non Condensing

• • • CAUTION • • •

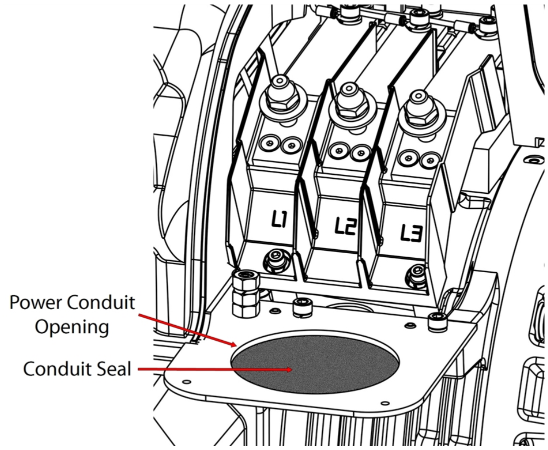
Power must be applied to all compressors on the chiller for a minimum of 24 hours prior to starting the compressors.

If a compressor is stored in an ambient condition where the humidity is at or above 85% for an extended amount of time, the following precautions must be taken prior to giving the compressor a demand (Run) command.

- Prior to powering the compressor/chiller, visually inspect the top-side power electronics to ensure there are no signs of oxidation or any other signs of moisture or condensation.
- Ensure all covers are in place and secured. The Danfoss Turbocor compressors have integrated seals in each cover which prevent ingress of moisture and contaminants; however, if the covers are not in place and properly secured, outside air and contaminates can intrude and potentially affect the electronics.

- Seal any open space around the mains power wire and conduit at the mains input plate of the compressor to prevent ingress of outside air and contaminants that could come from the mains power cabinet.

Figure 2-3 Mains Plate Sealing



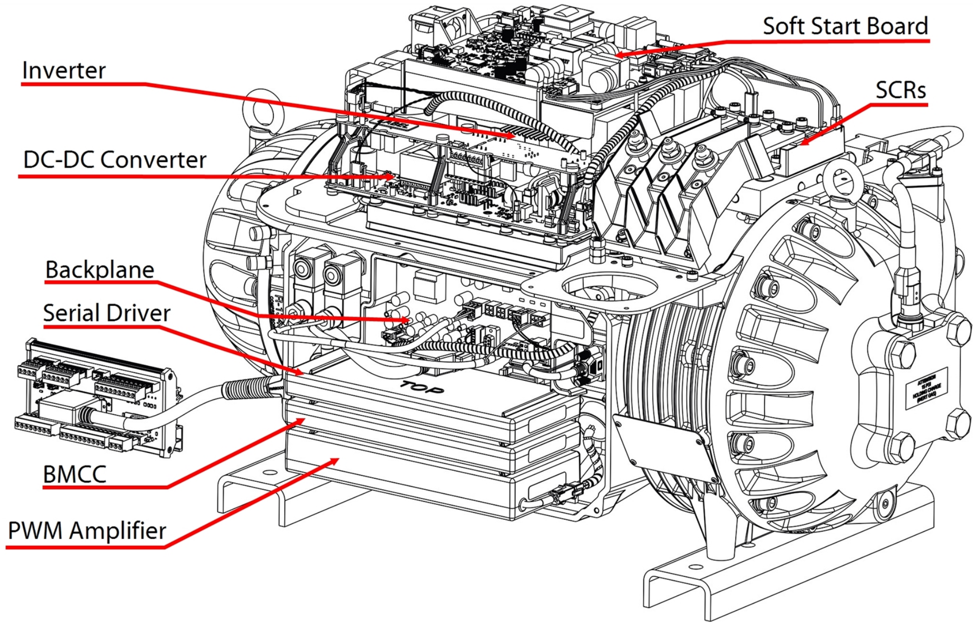
NOTE
• Contact Danfoss LLC Applications for lower ambient temperature operations. Refer to Figure Operating Envelopes. in this manual for details of the operating conditions. These conditions are in line with the AHRI 540 Standard. • All compressors/components should be protected from environments that could cause corrosion to exposed metals. For outdoor installations, a weather-proof enclosure with vents is recommended to house the compressor. • TTS/TGS/TTH/TGH compressors can operate below -1°C ambient if refrigerant circuit is maintained at a minimum of -1°C Saturated temperature.

2.4 Configurations of the TTS/TGS/TTH/TGH Compressor Models

The compressor, motor, and power assemblies are packaged in the design.

• • • CAUTION • • •
It is important to take all precautions to avoid refrigerant migration, especially on air-cooled units. If the compressor is filled with liquid, there is a high risk of bearing damage, thus putting the compressor out of service. The compressor warranty will be voided if the compressor is damaged due to refrigerant migration.

Figure 2-4 Major Components



2.5 Compressor Module

This section provides a brief overview of the Compressor Module.

The Compressor Module is comprised of three portions:

- Aerodynamics - The aerodynamics portion manages the refrigerant compression process from the suction to the discharge including the inlet guide vane assembly.
- Motor - The motor portion contains a direct-drive, high-efficiency, permanent-magnet synchronous motor powered by pulse-width-modulating (PWM) voltage supply. The high-speed variable-frequency operation that affords high-speed efficiency, compactness and soft start capability. Motor cooling is by liquid refrigerant injection.
- Electronics - The electronics is divided into two (2) sections: Power electronics located on the top of the compressor including soft-start, DC-DC, Silicon-Controlled Rectifier (SCR), capacitors, and inverter. Control electronics located on the side of the compressor including: backplane, BMCC, serial driver, and PWM.

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Chapter 3.0 Functional Description

Compressor operation begins with a call for cooling from a chiller controller. The compressor controller then begins compressor ramp-up.

3.1 Main Fluid Path

The following paragraphs describe the flow of refrigerant from the intake to the discharge port of the compressor (refer to Figure 3-1 Compressor Fluid Path TGS230/TTS300 and Figure 3-2 Compressor Fluid Path (TGS310, TTS350, TGS390, TGS490, TTS400, TGS520, and TTS700).

The refrigerant enters the suction side of the compressor as a low-pressure, low-temperature, superheated gas. The refrigerant gas passes through a set of adjustable Inlet Guide Vanes (IGVs) that are used to control the compressor capacity at low-load conditions. The first compression element the gas encounters is the first-stage impeller. The centrifugal force produced by the rotating impeller results in an increase in both gas velocity and pressure. The high-velocity gas discharging from the impeller is directed to the second-stage impeller through de-swirl vanes. The gas is further compressed by the second-stage impeller and then discharged through a volute via a diffuser (a volute is a curved funnel increasing in area to the discharge port; as the area of the cross-section increases, the volute reduces the speed of the gas and increases its pressure). From there, the high-pressure/high-temperature gas exits the compressor at the discharge port.

Figure 3-1 Compressor Fluid Path TGS230/TTS300

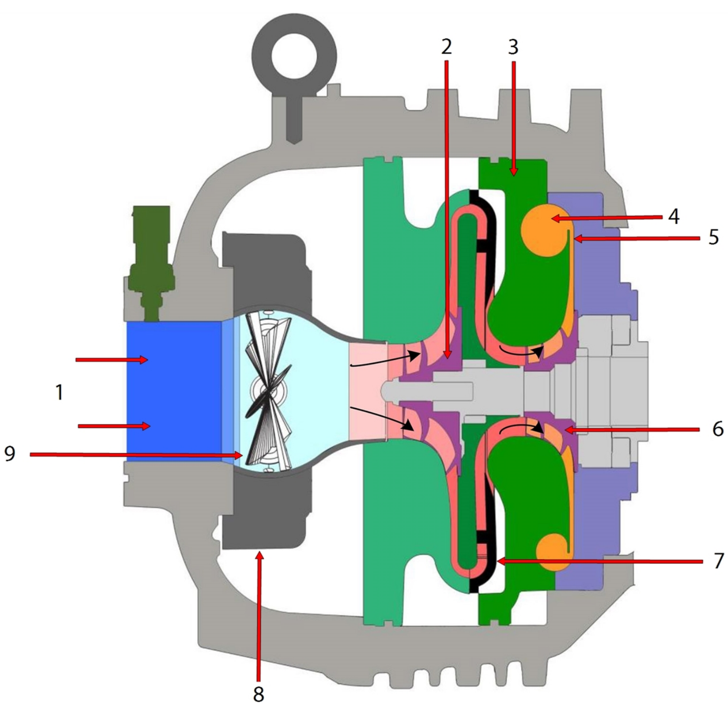


Table 3-1 Compressor Fluid Path TGS230/TTS300

No.	Description	No.	Description
1	Low-Pressure/Low Temperature Gas	6	Second-Stage Impeller
2	First-Stage Impeller	7	Vaned Diffuser
3	Volute Assembly	8	IGV
4	Discharge Port	9	Vanes
5	High-Pressure/High Temperature Gas		

Figure 3-2 Compressor Fluid Path (TGS310, TTS350, TGS390, TGS490, TTS400, TGS520, and TTS700)

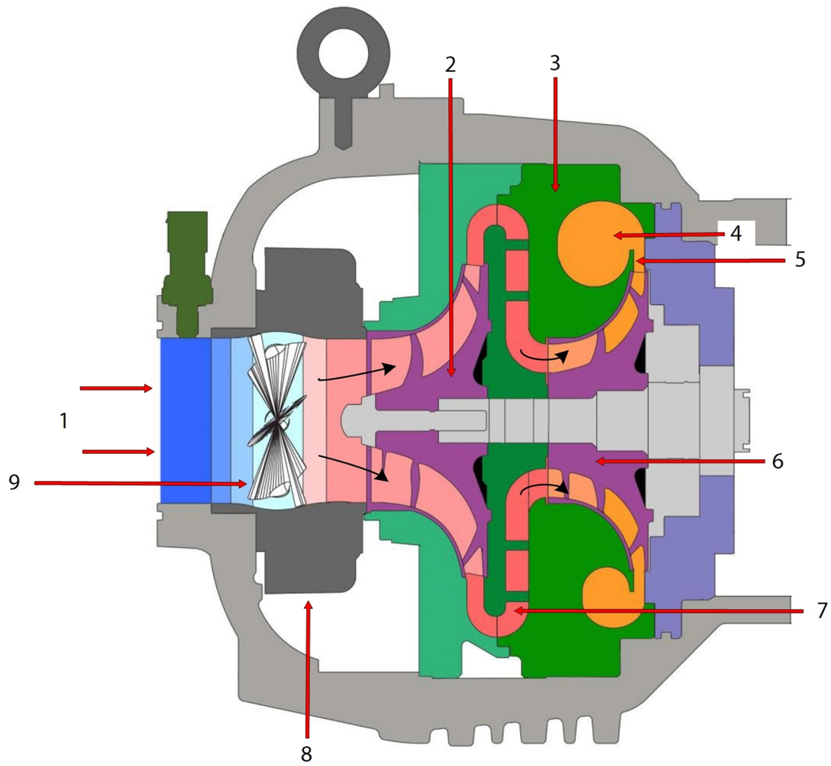


Table 3-2 Compressor Fluid Path (TGS310, TTS350, TGS390, TGS490, TTS400, TGS520, and TTS700)

No.	Description	No.	Description
1	Low-Pressure/Low Temperature Gas	6	Second-Stage Impeller
2	First-Stage Impeller	7	Vaneless Diffuser
3	Volute Assembly	8	IGV
4	Discharge Port	9	Vanes
5	High-Pressure/High Temperature Gas		

3.2 Motor Cooling

Liquid refrigerant is channeled at full condenser pressure from the main liquid line to the compressor to cool the electronic, mechanical, and electromechanical components (refer to Figure 3-3 Compressor Cooling Circuit (TGS230 / TTS300) and Figure 3-4 Compressor Cooling Circuit (TTS300 Split-Cooling, TGS310, TTS350, TGS390, TGS490, TTS400, TTS700, and TGS520).

• • • CAUTION • • •

A minimum operating pressure ratio of 1.5 is required to maintain adequate cooling of the compressor, unless the system is fitted with an appropriately selected liquid pump cooling pump.

The sub-cooled refrigerant enters the compressor through two solenoid valves and associated fixed orifices located behind the service access cover. The orifices cause the refrigerant to expand, thereby lowering its temperature. Both valves open in response to the temperature sensed in the motor and inverter.

From the outlet of the orifices, the refrigerant is directed to the heatsink plate of the inverter and to the underside of the SCR heatsink. The refrigerant also passes through grooves surrounding the motor stator. As the refrigerant flows through the grooves, it vaporizes into a gas. At the coil outlet, the refrigerant gas is channeled back to the suction inlet via the motor cavity, thereby cooling the rotor. All models with the exception of the TTS300 and TGS230 use a split-cooling method where the motor and electronics portions are cooled separately by refrigerant liquid.

Figure 3-3 Compressor Cooling Circuit (TGS230 / TTS300)

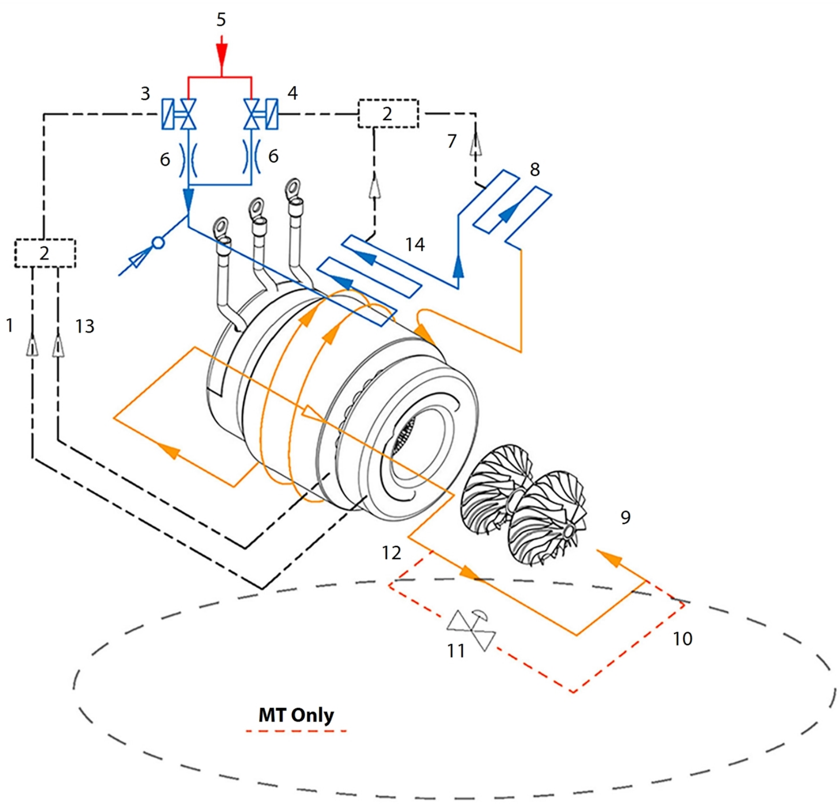


Table 3-3 Compressor Cooling Circuit (TGS230 / TTS300)

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

Figure 3-4 Compressor Cooling Circuit (TTS300 Split-Cooling, TGS310, TTS350, TGS390, TGS490, TTS400, TTS700, and TGS520)

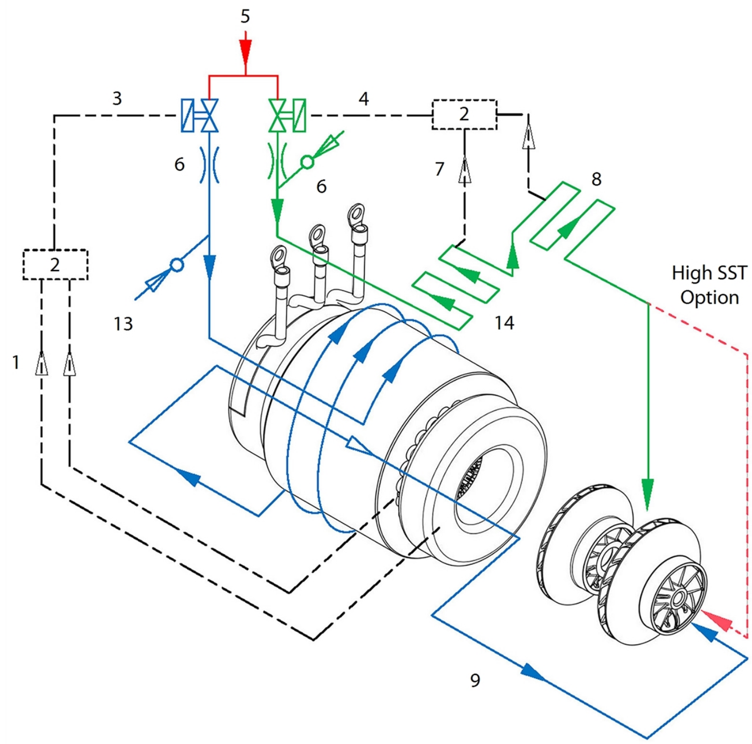


Table 3-4 Compressor Cooling Circuit (TTS300 Split-Cooling, TGS310, TTS350, TGS390, TGS490, TTS400, TTS700, and TGS520)

No.	Description	No.	Description
1	From Motor Winding Temp Sensor	7	From Inverter Temp Sensor
2	BMCC	8	SCR
3	Solenoid M	9	Motor/Rotor Cooling Gas and Leakage
4	Solenoid E	10	From Motor Cavity Temp Sensor
5	Liquid Refrigerant Inlet	11	Inverter
6	Orifice		

Figure 3-5 Highlift Cooling Circuit Flow Diagram (TGH285/TTH375)

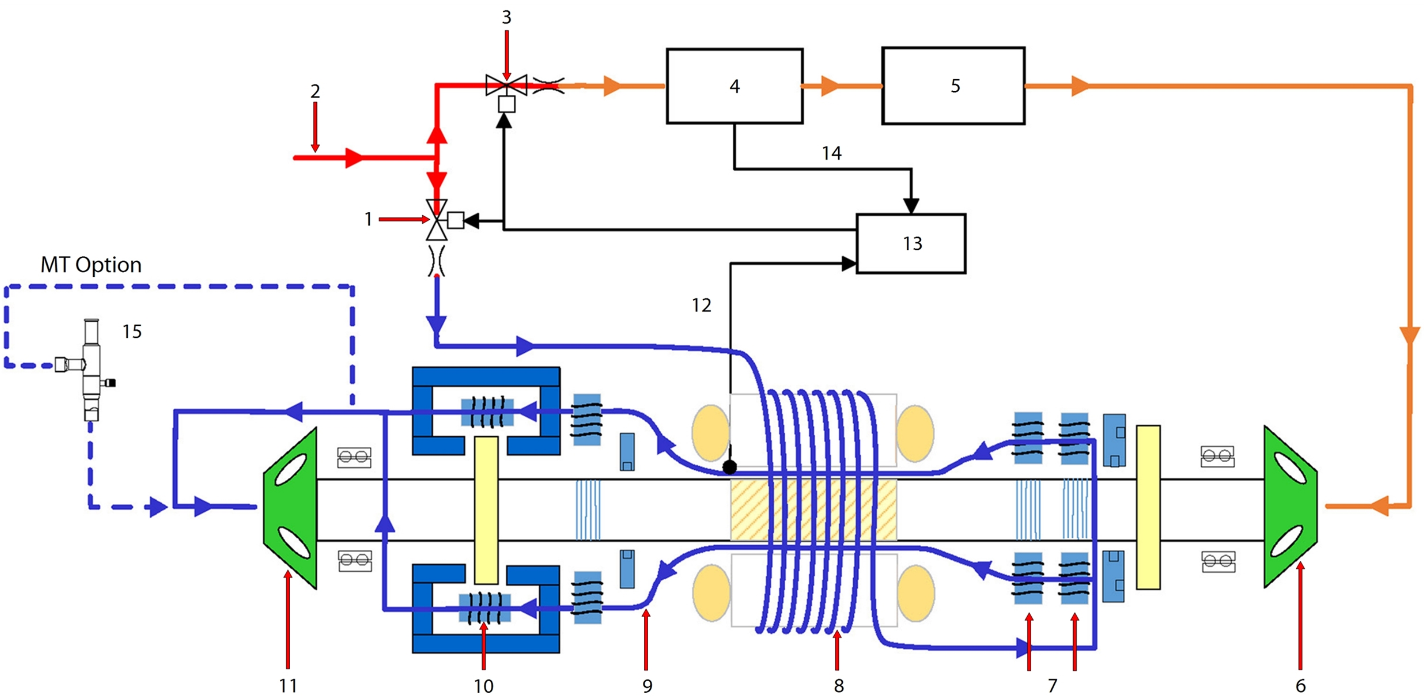


Table 3-5 Highlift Cooling Circuit Flow Diagram (TGH285/TTH375)

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		

3.3 Inlet Guide Vanes

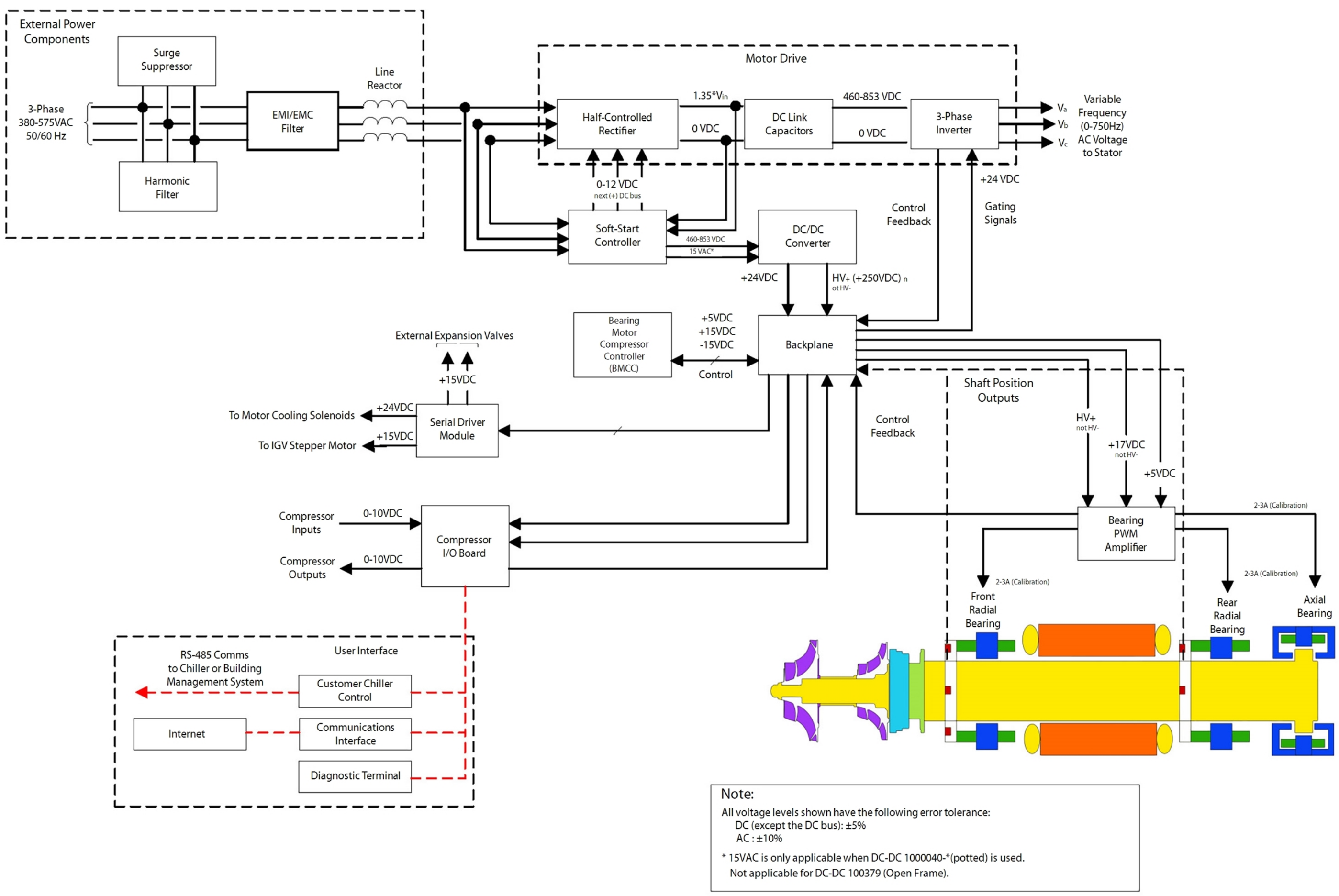
The Inlet Guide Vane (IGV) assembly is a variable-angle guiding device that is used for capacity control. The IGV assembly consists of movable vanes and a motor. The vane opening is determined by the BMCC and controlled by the Serial Driver. The IGV position can vary between 0-110% where 0% is fully closed and 110% is fully open with the vanes at a 90° angle.

3.4 Compressor Control Overview

Refer to Figure 3-6 Compressor Control System Functional Block Diagram which shows a functional block diagram of the compressor control and monitoring system. Refer to Figure 3-8 Magnetic Bearing Control System which displays the component locations. The major components include:

- Motor Drive
- Soft-Start Board
- BMCC
- Bearing PWM Amplifier
- Backplane
- Serial Driver
- HV DC-DC Converter

Figure 3-6 Compressor Control System Functional Block Diagram



3.4.1 Motor Drive System

Normally, AC power to the compressor remains on even when the compressor is in the idle state. The compressor motor requires a variable-frequency three-phase source for variable-speed operation. The AC line voltage is converted into a DC voltage by SCRs. DC capacitors at the SCR output serve as energy storage and filter out the voltage ripple to provide a smooth DC voltage. The inverter that converts the DC voltage into an adjustable three-phase AC voltage. PWM signals from the BMCC control the inverter output frequency and voltage. By modulating the on and off times of the inverter power switches, three-phase variable sinusoidal waveforms are obtained.

If the power should fail while the compressor is running, the motor switches into generator mode, thereby sustaining the capacitor charge. The rotor can then spin down safely in a controlled sequence preventing damage to components.

NOTE

The variable frequency drive (VFD) or inverter, supplied as standard with all Turbocor compressors, is mechanically, electrically, and logically integrated with the operation of the compressor and its supporting magnetic bearing system. One of the most critical functions handled by this tight integration is the regenerative power feature which extracts power from the spinning rotor to ensure that the magnetic bearing system is fully functional during a power loss event. Because of the close integration between the compressor and the VFD, Danfoss LLC cannot support the use of non-integrated VFDs due to the extensive development required to ensure the same functionality and reliability as the standard integrated VFD.

3.4.2 Soft Start

The Soft Start limits inrush current by progressively increasing the conduction angle of the SCRs. This technique is used at compressor start-up while the DC capacitors are charging up. The Soft Start function and the variable-speed drive combined limit the inrush current at startup.

3.4.3 Bearing Motor Compressor Controller

The hardware and software for the compressor controller and the bearing/motor controller physically reside in the BMCC. The BMCC is the central processor of the compressor.

3.4.4 Compressor Control

The Compressor Controller is continuously updated with critical data from external sensors that indicate the compressor's operating status. Under program control, the compressor controller can respond to changing conditions and requirements to ensure optimum system performance.

3.4.5 Capacity Control

One of the Compressor Controller's primary functions is to control the compressor's motor speed and IGV position in order to satisfy load requirements and to avoid surge and choke conditions. However, the majority of capacity control can be achieved via motor speed.

3.4.6 Expansion Valve Control

The onboard Electronic Expansion Valve (EXV) driver uses manual control only. Depending on the application, a load balancing (hot gas bypass) valve can be manually driven by the auxiliary EXV output. Load balancing allows the compressor to obtain lower capacities at higher pressure ratios. The valve opens to lower the overall pressure ratio and thereby reduces the lift, enabling the compressor to reduce speed/unload.

3.4.7 Motor/Bearing Control

The magnetic bearing system physically supports a rotating shaft while enabling non-contact between the shaft and surrounding stationary surfaces. A digital bearing controller and motor controller provide the PWM command signals to the Bearing PWM Amplifier and Inverter, respectively. The bearing controller also collects shaft position inputs from sensors and uses the feedback to calculate and maintain the desired shaft position.

3.4.8 Monitoring Functions

The Compressor Controller monitors more than 60 parameters, including:

- Gas pressure and temperature monitoring
- Line voltage monitoring and phase failure detection
- Motor temperature
- Line currents
- External interlock

3.4.9 Abnormal Conditions

The Compressor Controller responds to abnormal conditions by monitoring:

- Surge RPMs
- Choke RPMs
- Power failure/phase unbalance
- Low/high ambient temperature
- High discharge pressure
- Low suction pressure
- Motor-cooling circuit failure (over temperature)
- Refrigerant loss
- Power supply
- Overcurrent

3.4.10 Bearing PWM Amplifier

The Bearing PWM Amplifier supplies current to the radial and axial magnetic bearing actuators. The PWM Amplifier consists of high-voltage switches that are turned on and off at a high frequency, as commanded by the PWM signal from the BMCC.

3.4.11 Serial Driver

The Serial Driver module performs serial-to-parallel conversion on the stepper motor drive signals from the BMCC. The module also contains four normally open relays under BMCC control. Two of the relays drive the motor-cooling solenoids, and the other two are used to indicate compressor fault status and running status. The status relays can be wired to external control circuits.

3.4.12 Backplane

The Backplane physically interconnects the onboard plug-in modules with the power electronics, IGV stepper motor, motor-cooling solenoids, rotor position sensors, and pressure/temperature sensors.

The Backplane also features onboard, low-voltage DC-DC converters for generating +15V, -15V, +5V, and +17V from an input of +24VDC. The Backplane receives its +24VDC power input from the High-Voltage (HV) DC-DC Converter mounted on the topside of the compressor.

The Backplane is also equipped with status-indicating Light-Emitting Diodes (LEDs). All LEDs are yellow except for the alarm LED, which is green/red. Table 3-6 Backplane LEDs describes the LEDs functions.

Table 3-6 Backplane LEDs

LED	Function
+5V, +15V, +17HV, +24V	LEDs are lighted when DC power is available.
Cool-H, Cool-L	LEDs are lighted when their respective coil is energized.
Run	LED is lighted when the shaft is spinning.
Alarm	LED is green when in normal status, red when in alarm status.
D13, D14, D15, D16	LEDs indicate IGV status and flash when IGV is moving.

3.4.13 High-Voltage DC-DC Converter

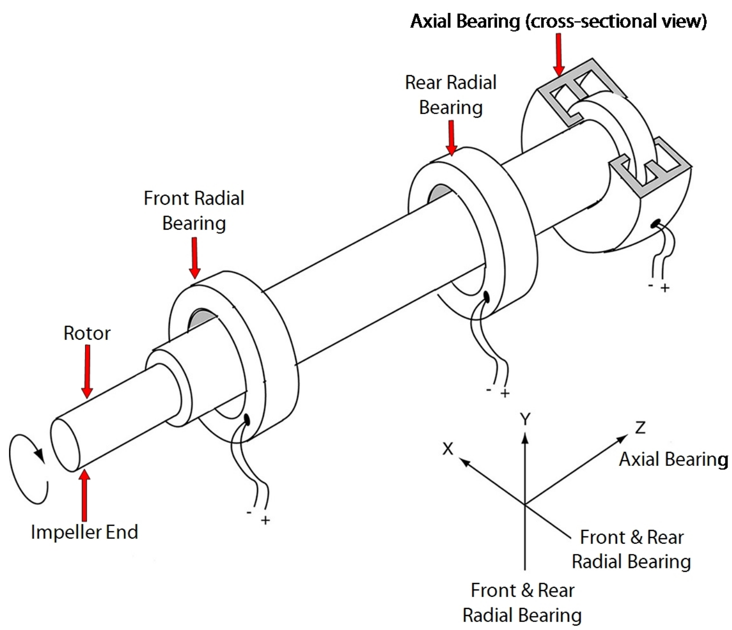
DC-DC converters supply and electrically isolate the high and low DC voltages that are required by the control circuits. The HV DC-DC Converter delivers 24VDC and 250VDC from an input of 460-900VDC. The 24VDC and 250VDC are used to power the Backplane and magnetic bearing PWM Amplifier, respectively.

3.5 Magnetic Bearing System

3.5.1 Overview

A rotating shaft, under changing load conditions, will experience forces in both radial and axial directions. In order to compensate for these forces, a five-axis bearing system is used, incorporating two radial bearings of two axes each, and one thrust (axial) bearing. Refer to Figure 3-7 Magnetic Bearing Configuration

Figure 3-7 Magnetic Bearing Configuration

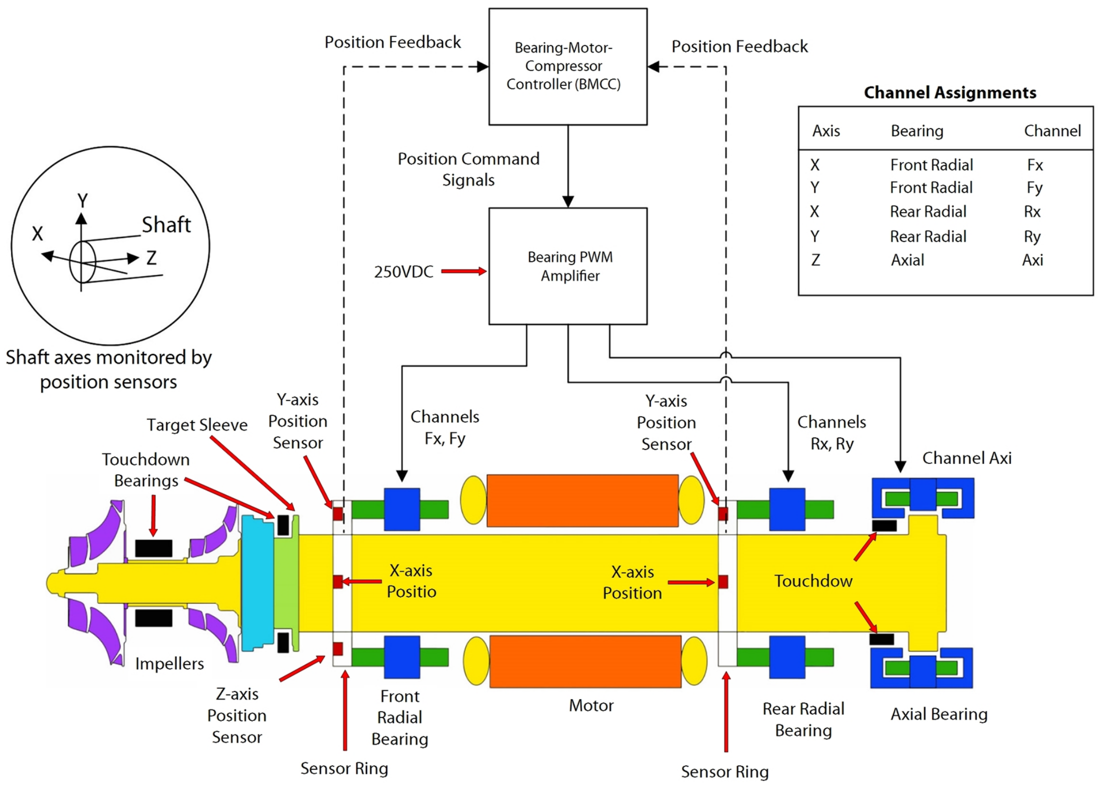


3.5.2 Bearing Control System

The Bearing Control System uses rotor position feedback to close the loop and maintain the rotor in the correct running position (refer to Figure 3-8 Magnetic Bearing Control System). The Bearing Controller issues position commands to the Bearing PWM Amplifier. The position commands consist of five channels with each channel allocated to one of the five bearing actuator coils (one coil for each axis). The amplifier uses Inverter technology to convert the low-voltage position commands to the 250VDC PWM signals that are applied to each bearing actuator coil.

Rotor position sensors are located on rings attached to the front and rear radial bearing assemblies. The front sensor ring contains sensors that read the rotor position along the X, Y, and Z axes. The rotor position along the Z (or axial) axis is read by measuring the distance between the sensor and a target sleeve mounted on the rotor. The rear sensor ring contains sensors that read the position along the X and Y axes. Information from the position sensors is continuously fed back to the bearing controller.

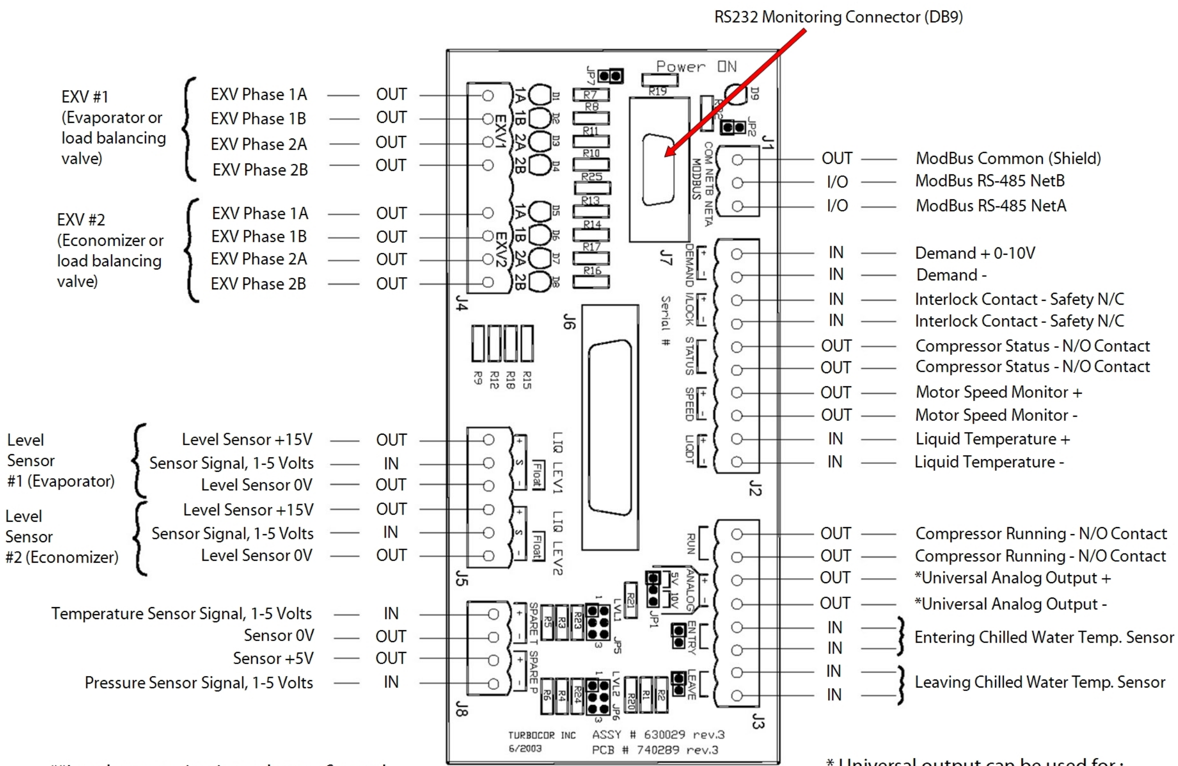
Figure 3-8 Magnetic Bearing Control System



Chapter 4.0 Control Interface Wiring

The Compressor I/O Board is the entry point for control wiring from the chiller/plant to the compressor. Refer to Figure 4-1 Typical Control Wiring. Figure 4-2 Modbus Grounding Diagram for the proper Compressor I/O Board connectivity.

Figure 4-1 Typical Control Wiring



**Level sensor circuit can be configured for two types of sensors using jumpers JP5 and JP6.

* Universal output can be used for :
output manual control
0-5VDC or 0-10VDC

Figure 4-2 Modbus Grounding Diagram

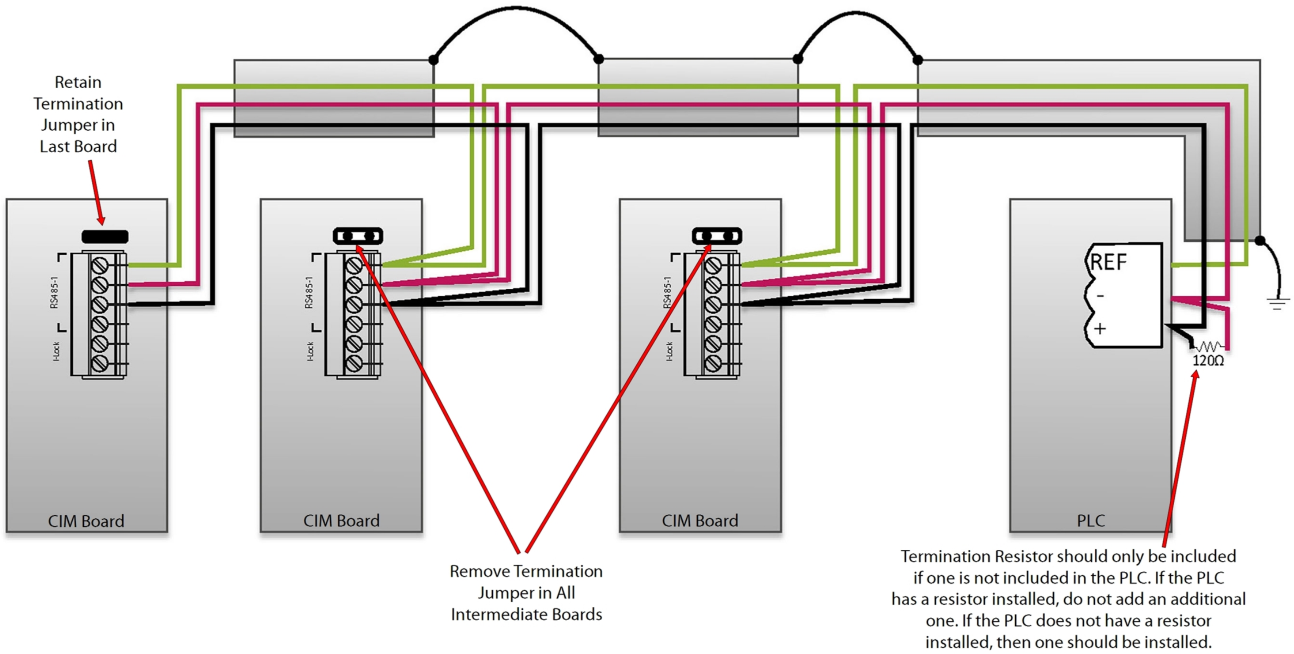


Table 4-1 Control Wiring Details

I/O	Description
COM (shield)	Shield for RS-485 communication.
Modbus RS-485 NetB/NetA	Modbus over RS-485 communication port.
Stepper Motor 1 Phase 1A, 1B, 2A, 2B, and Stepper Motor 2 Phase 1A, 1B, 2A, 2B	Optional output connections for controlling the main electronic expansion valve (evaporator) or auxiliary electronic expansion valve (economizer or load balancing valve). 200ma Maximum output on each driver. Valve frequency will effect operational characteristics.
Level Sensor +15V (Evaporator)	Power supply for level sensor #1.
Sensor Signal (Evaporator)	Input from a level sensor to control the main expansion valve (evaporator).
Level Sensor +15V (Economizer)	Power supply for level sensor #2.
Sensor Signal (Economizer)	Input from a level sensor to control the auxiliary expansion valve (economizer).
Demand 0 - 10V	Analog input from customer-supplied controller to drive the compressor, i.e., 0 - max. kW input with a deadband of 2VDC for the respective compressor model. Only available in 3.1.4; removed in 4.x forward.
Interlock	Connects to a set of external normally closed contacts that typically open in the event of loss of chilled water or air flow. Typically a 1.5VDC Output signal. NOTE: This is not a safety certified interlock.
Status	An internal normally open contact that is closed during normal operation and opens in the event of a compressor fault. With the circuit open, the compressor will not restart until the demand signal has been reset to 0 (via chiller/unit controller). Circuit rated at 1A @ 30VDC/24VAC or .03A @ 120VAC.
Liquid Temperature	Optional input for monitoring temperature. The temperature sensor must be an NTC type 10K @ 25°C

I/O	Description
	thermistor.
Run	An internal N/O contact that is closed while the compressor is running. The speed at which the contact closes is user-configurable via the monitor program. Circuit rated at 1A @ 30VDC/24VAC or 0.3A @ 120VAC.
Analog	Universal analog output manually controlled as a percentage of total voltage written through Modbus. This can be configured for 0-5V or 0-10V via on board jumpers.
Entering Chilled Water Temp	Analog input indicating water temperature. The temperature sensor must be an NTC type 10K @ 25°C thermistor. Refer to the Service Manual for thermistor specification.
Leaving Chilled Water Temp	Analog input indicating water temperature. The temperature sensor must be an NTC type 10K @ 25°C thermistor. Refer to the Service Manual for thermistor specification.
Spare T +/-	Optional input for monitoring temperature. The temperature sensor must be an NTC type 10K @ 25°C thermistor.
Spare P +/-	Can be connected to a 0-5V type pressure sensor.

Table 4-2 Jumper Details

Jumper	Function and Setup
JP1	Determines the operating voltage range (0-5V or 0-10V) of the ANALOG output. If used, set the jumper to the appropriate range.
JP2	Modbus termination jumper: install the jumper if Modbus is used and if the Modbus connection is at the end of a run.
ENTRY	Install the jumper if there is no temperature sensor connected to the "Entering Chilled Water" analog input.
LEAVE	Install the jumper if there is no temperature sensor connected to the "Leaving Chilled Water" analog input.
JP5/JP6	Jumpers J5 and J6 are used to match the characteristics of the liquid level sensors. **Voltage-type Level Sensor** - If using a voltage-type 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 Interface module. Consult vendor documentation for sensor lead identification. **Resistive-type Float Sensor** - If using a resistive-type 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 Interface module.
JP7	Supplies 5VDC to pin 1 on the 9-pin connector to power an optional Bluetooth adapter. Install if Bluetooth device is being used in RS-232 connection (DB9). *NO LONGER APPLIES*

4.1 Control Wiring Connection Guidelines

To ensure proper control wiring techniques, follow these guidelines:

1. The ground reference of the external circuit connected to the Compressor I/O Board must be at the same potential as the ground reference on the Compressor I/O Board.
2. The Interlock circuit should be voltage-free. For instance, all external contractors/switches must not introduce current into the circuit.
3. Analog outputs (such as Motor Speed) must be received by the external circuit without sending current back to the Compressor I/O Board.

4. All interlock and analog output cables should be shielded with one end of the shield connected to the common analog or digital ground bus. The other end of the shield must not be grounded as this would create a ground loop. Refer to Figure 4-2 Modbus Grounding Diagram.

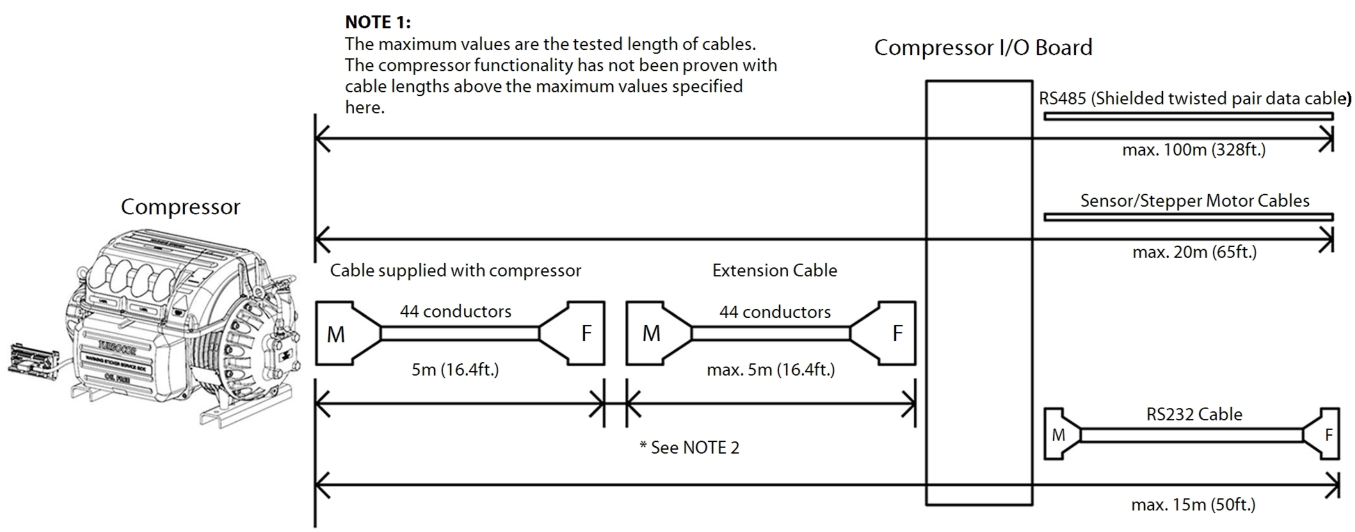
4.2 Interface Cable

The cable that carries the I/O communication to the compressor is 5 meters (16.4 feet) in length and is equipped with high-density 44-pin connectors (female at one end and male at the other end). An extension cable is available from your local supplier. An optional 10 meter (32.8 ft) cable is also available in the Spare Parts Selection Guide.

NOTE
If an I/O extension cable is used, heat-shrink tubing should be applied to the mating cable connectors to maintain good conductivity and protect the connection from heat and humidity.

For RS-485 communication, the maximum cable length should not exceed 100 meters (328 feet). If using RS-232 communication, the cable length should not exceed 15 meters (50 feet) between the PC and the compressor (refer to Figure 4-3 I/O Wiring Specifications.)

Figure 4-3 I/O Wiring Specifications



NOTE 2:
If an I/O extension cable is used, heat-shrink tubing should be applied to the matching cable connectors to maintain good conductivity and protect the connection from heat and humidity.

EXTENSION CABLE SPECIFICATION:

Cable - UL style 2464, 44 conductors, 24AWG stranded coper foil/braid shield, PVC jacket.

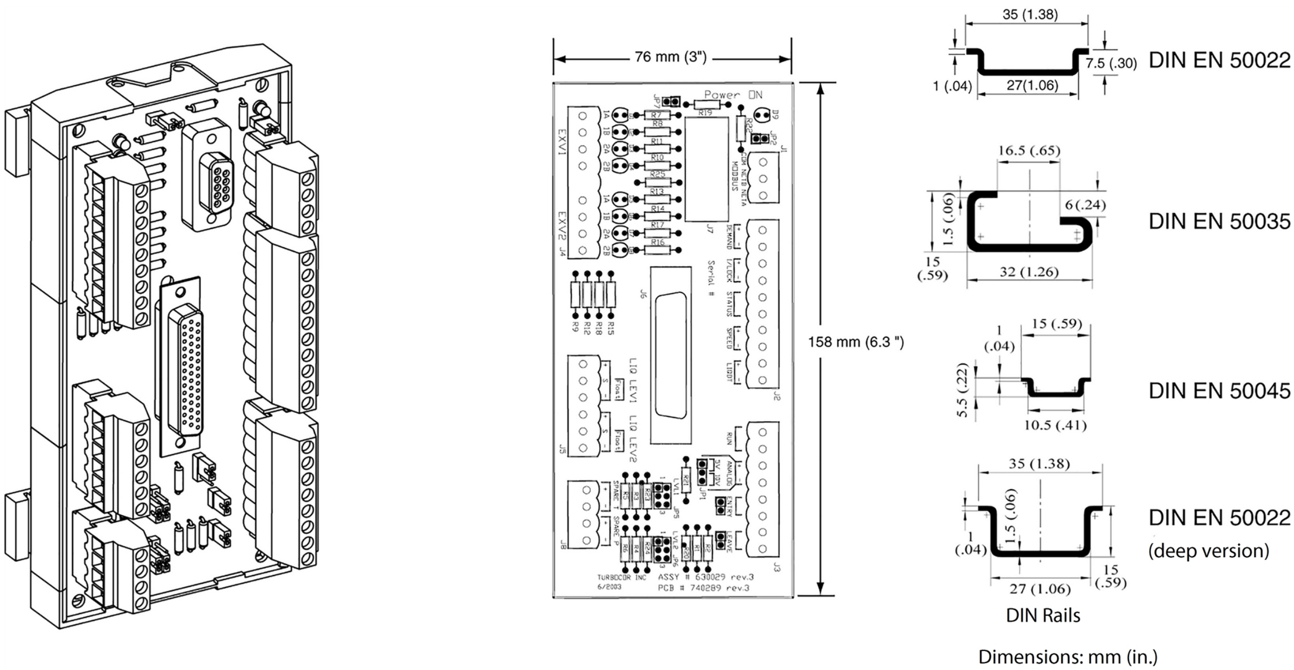
Connectors - A 44 male pin high-density D-sub to a 44 pin female, high-density D-sub.

4.3 Compressor I/O Board Mounting Details

The Compressor I/O Board (Figure 4-4 Compressor I/O Board) must be installed in a Underwriters Laboratories (UL) approved electrical enclosure equipped with DIN EN 50022, 50035, or 50045 mounting rails. The board should be mounted in a dry area, free from vibration and electrical noise.

NOTE
The UL listed enclosure should protect against moisture and other corrosive elements.

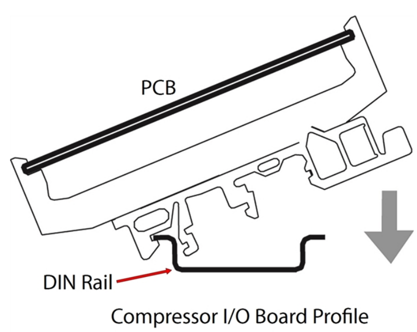
Figure 4-4 Compressor I/O Board



4.3.1 Compressor I/O Board Mounting Instructions

1. Tilt the I/O Board as shown in Figure 4-5 Compressor I/O Board Installation in order to engage it into the DIN Rail.
2. Lower the I/O Board until it snaps into place.

Figure 4-5 Compressor I/O Board Installation



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Chapter 5.0 General Specifications

5.1 Construction

- Compressor - Semi-hermetic design
- Main Housing - Dimensionally-stabilized aluminum
- Covers - High-impact, UV stabilized, flame-resistant polymer (TGS series is identified by green cover)
- Shaft - High-strength alloy
- Impellers - High-strength aluminum
- Motor - Permanent magnet, synchronous, DC
- Bearings - Integrated, digitally-controlled, magnetic
- Compressor Control - Integrated, digital capacity control
- Enclosure - IP54 rating

5.2 Maximum Pressure

The maximum pressure that the compressor can operate is regulated directly by two control settings: (1) Alarm Limit and (2) Fault Limit. It is also controlled by a Pressure Ratio alarm limit monitoring the ratio between the Discharge and Suction Pressures.

Table 5-1 Discharge Pressure Alarm and Fault Settings

Model	Alarm		Fault	
	kPa(g)	PSIG	kPa(g)2	PSIG3
TGS230ST*	1239	180	1299	188
TGS230MT*	1116	162	1176	171
TGS310	1240	180	1300	189
TGS490	1240	180	1300	189
TGS390	876	127	926	134
TGS520	876	127	926	134
TGH285	1510	218	1586	229
TTS300ST*	1190	173	1240	180
TTS300MT*	1190	173	1240	180
TTS350	1730	251	1800	261
TTS400	1190	173	1240	180
TTS700	1190	173	1240	180
TTH375	2016	292	2116	306

* In the TGS230/TTS300 compressors, the alarm and fault settings default to lower values of operation, which are typically deemed appropriate for Water-Cooled conditions. These values allow for adjustment for compressors placed in Air-Cooled applications, which can have the value increased up to 1730 kPa(g)/250 PSIG for the Alarm and 1800 kPa(g)/260 PSIG for the Fault.

5.3 Maximum Discharge Temperature

The maximum temperature that the compressor can operate is regulated directly by the Fault Limit.

The Maximum Discharge Temperature Limits are defined in Table 5-2 Discharge Temperature Fault Settings.

Table 5-2 Discharge Temperature Fault Settings

Unit	Compressor	TGS230ST	TGS230MT	TGS310	TGS490	TGS390	TGS520	TGH285	TTS300ST	TTS300MT	TTS350	TTS400	TTS700	TTH375
°F	Fault	212	194	203	203	194	194	212	121	194	203	194	194	212
°C	Fault	100	90	95	95	90	90	100	100	90	95	90	90	100

NOTE

While the values here are represented in Gauge Pressure, the values in the registers will be defined in Absolute Pressure. Refer to the OEM Programming Manual to identify the specific registers associated with the Discharge Pressure Alarm and Discharge Pressure Fault Limits.

The compressor will also adjust its operation if the pressure ratio exceeds the alarm limit. The Pressure Ratio alarm limit is defined in Table 5-3 Maximum Pressure Ratio Limits.

Table 5-3 Maximum Pressure Ratio Limits

	TGS230ST*	TGS230MT*	TGS310	TGS490	TGS390	TGS520	TGH285	TTS300ST*	TTS300MT*	TTS350	TTS400	TTS700	TTH375
Alarm	4	4	5.2	5.2	3.5	3.5	6.3	4	4	5.2	3.5	3.5	6.3
Fault	5.2	5.2	5.5	5.5	4	4	6.5	5.2	5.2	5.5	4	4	6.5

*The TGS230/TTS300 compressor allows for adjustment of this setting. Compressors which are placed in Air-Cooled applications can have this value increased up to 4.8.

NOTE

Pressure ratio must be calculated using absolute pressures. Refer to the OEM Programming Manual to identify the specific register associated with the Pressure Ratio Alarm Limit.

Beyond these control limits, the Maximum Design High-Side Pressure for the compressor is shown in Table 5-4 Maximum Allowable Pressure [PS].

Table 5-4 Maximum Allowable Pressure [PS]

Unit	All TTS & TGS Compressors	TTH/TGH Compressors
kPag	2070	2303
psig	300	334

5.4 Suction Pressure Limits

The Suction Pressure Alarm and Fault Limits are displayed in the Table 5-5 Suction Pressure Alarm and Fault Settings.

Table 5-5 Suction Pressure Alarm and Fault Settings

Model	Alarm		Fault	
	kPa(g)	PSIG	kPa(g)	PSIG
TGS230ST	99	14	79	11
TGS230MT	40	6	29	4
TGS310	99	14	79	11
TGS390	99	14	96	14
TGS490	99	14	79	11
TGS520	99	14	96	14
TGH285ST	99	14	79	11
TGH285MT	5	0.73	-4	-0.6
TTS300ST	177	26	152	22
TTS300MT	91	13	76	11
TTS350	177	26	152	22
TTS400	177	26	166	24
TTS700	177	26	166	24
TTH375ST	177	26	152	22
TH375MT	43	6.3	32	4.6

NOTE

Pressure ratio is the ratio of absolute discharge to absolute suction pressure. It can be calculated as follows:

- (DP + 101) / (SP + 101) (kPa) OR
- (DP + 14.7) / (SP + 14.7) (psi)

All TTS/TGS/TTH/TGH Series Turbocor compressors were designed for use in stationary building applications and are suitable for some marine applications (e.g., cruise ships, floating platforms). Danfoss Turbocor compressors are produced for civilian use and are not intended for safety critical systems. Misapplication of a Turbocor compressor will not be covered under Danfoss LLC's Standard Warranty Terms and Conditions.

5.5 Standards Compliance

It is the responsibility of the Original Equipment Manufacturer (OEM) to ensure that proper safety protocols are in place and that the chiller system has been designed in a manner that is compliant with all applicable local, national, and international codes and regulatory requirements governing the use of refrigerants, pressure, vessels, and electrical power. OEMs must also ensure compliance with the requirements stated in the refrigerant manufacturer's Material Safety Data Sheet (MSDS) and that other system components are compatible with the refrigerant, giving special attention to elastomers and seals.

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Chapter 6.0 Electrical Specifications

6.1 Supply Voltage and Frequency

Turbocor compressors are designed to operate with a power supply that is within an acceptable tolerance for each nominally rated voltage and frequency. The tables below specify the acceptable supply voltage and frequency ranges. Using a supply voltage/frequency at or beyond the range limit will cause the compressor to shut down.

Table 6-1 Acceptable AC Voltage Range

Nominal Voltage	Acceptable Voltage Range
380V	342 - 418 VAC
400V	360 - 440 VAC
460V	414 - 506 VAC
575V	518 - 635 VAC

6.2 Voltage Sag Immunity

Danfoss TTS/TGS Series Turbocor Compressors comply with SEMI F47-0706 and have been certified by a 3rd party testing agency tested in accordance with IEC 61000-4-34. Turbocor compressors meet the criteria of SEMI F47 based on 7.8.2 section (c) which allows for equipment that is a subsystem and/or component to pass by recovery without operator interface. In the event of a compressor fault, Turbocor compressors are able to be reset/run remotely via the OEMs' chiller controllers upon clearing of any active fault.

• • • CAUTION • • •

Application of a compressor to any voltage which is outside of the nominal rated voltage defined on the compressor nameplate will result in voiding of the compressor warranty from Danfoss LLC, unless otherwise stated by Danfoss LLC. This includes any application of a 400V compressor in a 380V application without the use of a transformer to correct the voltage going into the compressor.

NOTE

Refer to the TTS/TGS Compressor Nomenclature section of this manual for details on the compressor voltage availability.

Table 6-2 Acceptable Frequency Range

Nominal Frequency	Acceptable Frequency Range
50Hz	50Hz ±5% (47Hz-53Hz)
60Hz	60Hz ±5% (57Hz-63Hz)

6.3 Compressor Current Limit and Operating Range Settings

The new compressor controller (version 3.0.0 and above; Table 1-1 Application Manual Applicability Scope) is designed to allow a user to configure the current setting based on the intended application. The compressor defines the Full Load Ampere (FLA) and Locked Rotor Ampere (LRA) as a range on the nameplate. The settings for the FLA and LRA are adjustable using the Service Monitoring Tool (SMT) or directly from the customer controller application.

The 3-Phase Over Current Alarm FLA cannot be set higher than the 3-Phase Over-Current Fault limit LRA. The maximum fault limit and alarm limit settings are dependent upon the Voltage and Model. The Model type defines the range for the FLA and LRA values.

Table 6-3 FLA and LRA Value Range

Model	Voltage	FLA		LRA		Default	
		Min	Max*	Min	Max	FLA	LRA
TGS230	380V	40	106	44	117	40	44
TGS230	400V	40	106	44	117	40	44
TGS230	460V	40	99	44	110	40	44
TGS230	575V	40	79	44	88	40	44
TGS310	380V	50	150	55	165	50	55
TGS310	400V	50	150	55	165	50	55
TGS310	460V	50	135	55	145	50	55
TGS310	575V	50	105	55	116	50	55
TGS390	380V	50	123	55	137	50	55
TGS390	400V	50	123	55	137	50	55
TGS390	460V	50	108	55	120	50	55
TGS390	575V	50	86	55	96	50	55
TGS490	380V	50	210	55	231	50	55
TGS490	400V	50	210	55	231	50	55
TGS490	460V	50	180	55	198	50	55
TGS520	380V	50	149	55	165	50	55
TGS520	400V	50	142	55	158	50	55
TGS520	460V	50	123	55	137	50	55
TGS520	575V	50	99	55	110	50	55
TGH285	380V	50	150	55	165	50	55
TGH285	400V	50	150	55	165	50	55
TGH285	460V	50	131	55	145	50	55
TGH285	575V	50	105	55	116	50	55
TTS300	380V	40	145	44	160	40	44
TTS300	400V	40	145	44	160	40	44
TTS300	460V	40	135	44	150	40	44
TTS300	575V	40	110	44	121	40	44
TTS350	380V	50	210	55	231	50	55
TTS350	400V	50	210	55	231	50	55
TTS350	460V	50	180	55	198	50	55
TTS350	575V	50	144	55	159	50	55
TTS400	380V	60	170	66	187	60	66
TTS400	400V	60	170	66	187	60	66
TTS400	460V	60	150	66	165	60	66

Model	Voltage	FLA		LRA		Default	
		Min	Max*	Min	Max	FLA	LRA
TTS400	575V	60	120	66	132	60	66
TTS700	380V	60	206	66	227	60	66
TTS700	400V	60	196	66	216	60	66
TTS700	460V	60	170	66	187	60	66
TTS700	575V	60	136	66	150	60	66
TTH375	380V	50	210	55	231	50	66
TTH375	400V	50	210	55	231	50	55
TTH375	460V	50	180	55	198	50	55
TTH375	575V	50	144	55	159	50	55

NOTE

Refer to the OEM Programming Manual to identify specific registers associated with the "3-Phase Over Current Alarm (FLA) and 3-Phase Over Current Fault (LRA)."

6.4 Disconnects

An input disconnect (for example, a switch or circuit breaker) must be installed in the line before the compressor in accordance with applicable local, national, and international safety regulations (for example, NEC/CEC). Size the disconnect according to the full-load current.

• • • CAUTION • • •

The full-load current rating is based on the installation of a line reactor in the power line. Refer to the Spare Parts Selection Guide for specifications. Failure to use a line reactor will result in poor power factor and higher full-load current.

Refer to Figure 20-9 Typical Electrical Connections for interconnection details.

6.5 Motor Insulation Class

All TTS/TGS/TTH/TGH Series compressors have a motor insulation Class H rating or better according to the NEMA/UL Standard.

6.6 AC Input Line/Power Electronic Component Protection

Most safety regulations require that upstream branch protection be provided to protect input power wiring, personnel, and switching equipment from damage in the event of an over-current condition or equipment failure. Standard fuses and/or circuit breakers do not provide adequate protection for the compressor's power electronics components.

User-supplied, properly sized and selected fast-acting fuses must be installed according to the applicable local, national, and international safety regulations. The fuses must be installed in the line before each compressor's AC input terminals. This excludes TGS230 and TTS300 compressors as they come with fast-acting fuses.

Use only properly rated fast-acting line fuses suitable for semiconductor protection, such as Littelfuse JLLS series, Siemens Sitor 3NE1 series, or equivalent.

• • • DANGER! • • •

The full-load current rating is based on the installation of a line reactor in the power line. Refer to the Spare Parts Selection Guide for specifications. Failure to use a line reactor will result in poor power factor and higher full-load current.

NOTE

Fuse selection must be done using the FLA of the affected compressor to the next highest amp, but in any event should be a minimum of FLA x 1.25. Fast acting fuses must be installed as close as possible and immediately before the compressor; that is downstream from the line reactor. (Contact Danfoss LLC for more information).

6.7 Power Line Contactor

The power line contactor is optional. Consult local safety regulations to determine if a contactor is necessary for your application.

6.8 CE Compliance and EMI/EMC Filtering

To address EMI/EMC problems, Danfoss LLC recommends the installation of a UL-approved Electromagnetic Interference/Electromagnetic Compatibility (EMI/EMC) filter device on the input power line. Refer to the Spare Parts Selection Guide for details.

Although all Turbocor compressors are Conformance European (CE) listed, the compliance of the compressor with the EMC directive depends on the use of the CE EMI/EMC filter provided by Danfoss LLC. If this is not possible because of the nature of your application and/or installation, an alternative component with the same attenuation characteristics must be used to maintain compliance with the EMC Directive. It is the responsibility of the user to maintain compliance with the Directives. Contact a Danfoss LLC sales representative for more details.

Proper installation of the EMI/EMC filter can have a dramatic effect on overall performance. Although the filter reduces electrical noise on the power lines (conducted emissions), it should be located as close as possible to the compressor to reduce broadcasting of the noise (radiated emissions) from the power lines themselves. The capacitors within the filter short the noise to ground so it is imperative that the filter maintains a good ground. A short, heavy, stranded conductor from the filter chassis to the main ground bus is recommended for top performance. A battery braid, litz wire, or flexible welding cable with many fine strands, is recommended for best grounding performance. The multiple- strand cabling provides more surface area in order to conduct the high frequencies that are on the grounding cable.

Radiation of noise is also a concern for power line routing as it can effectively bypass the filter. Input and output filter leads should be separated by a maximum practical distance within enclosures and should be routed separately in interconnecting conduits when used.

NOTE

All TTS/TGS/TTH/TGH compressors are compliant with the following directives and standards:

LVD – Low Voltage Directive (2014/35/EU)

- EN 60335-1:2012+A11:2014 Household and similar electrical appliances – Safety – Part 1: General requirements
- EN 60335-2-34:2013 Household and similar electrical appliances – Safety – Part 2-34: Particular requirements for motor-compressors

EMC – Electromagnetic Compatibility Directive (2014/30/EU)

- EN IEC 61000-6-2:2019 - Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments
- EN IEC 61000-6-4:2019 - Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments

6.9 Surge Protection

All Turbocor compressors have been tested in accordance with IEC Standard 1000-4-4. Electrical Fast Transient/Burst Requirement. For additional protection, a surge suppressor can be installed in parallel with the compressor. It is recommended to install surge suppression in sites that are susceptible to lighting.

6.10 Line Reactor

It is mandatory to install a 5% line reactor for every Turbocor compressor. The installation of the line reactor should be according to Figure 20-9 Typical Electrical Connections. The rule of selecting the Line Reactor is:

PReactor_Rated [kW] = LRA [A]*URated [V]*1.73*0.9*/1000.

6.11 Harmonic Current Filtering (IEEE 519)

If it is necessary to provide additional current harmonic reduction beyond that provided by the standard 5% line reactor, Danfoss LLC recommends the installation of a harmonic filter device in parallel with the compressor as shown in Figure 20-9 Typical Electrical Connections. The rule of selecting the Harmonic filter is:

PFilter_Rated [kW] = LRA [A]*URated [V]*1.73*0.9/1000.

NOTE

Turbocor compressors are qualified for Class 3 Voltage Harmonics according to IEC 61000-2-4

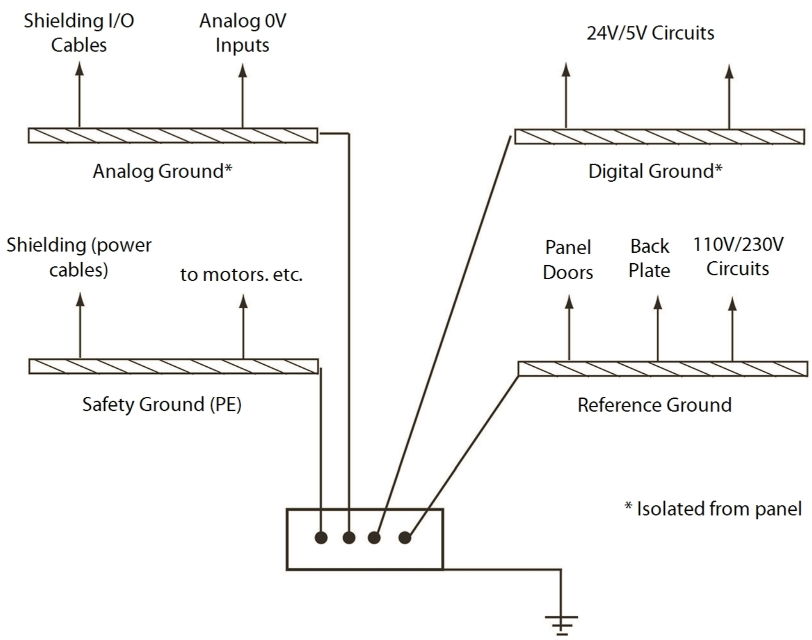
6.12 Grounding (Earth) Connection Guidelines

1. All metal parts should be connected to ground, including the shields of electrical cables.
2. Verify continuity of all ground connections.
3. Ensure solid ground connections (both mechanical and electrical). Connections must be clean, and grease and paint free.
4. At one point, usually the entrance of the power supply panel, all grounds should be connected together (refer to 6.13 Equipment Panel).

From an EMC standpoint, it is best to categorize different types of grounds and treat them independently (refer to Chapter 6.0 Electrical Specifications):

- Safety ground (Protective Earth [PE]) and shields of mains cables
- Analog grounds, shielding of interface cables
- Digital grounds
- Reference ground (panel doors, backplate, etc.)

Figure 6-1 Typical Ground Connections



NOTE

Application of Turbocor compressors in any power system without a standard earth ground system should be reviewed and approved by the Turbocor application organization.

6.13 Equipment Panel

Normally, the line reactor, EMI/EMC filter(s), and the harmonic filter will be installed in a panel. This could be the same panel where the controls are located. When designing a panel, attention should be given to the following recommendations:

- All metal parts should be properly connected to ensure an electrical connection. Connect panel doors with braided cable.
- Keep power cables and interface cables separate. Use metal cable glands for shielded cables.
- The wire-loom going to the panel door should be shielded using a metal-braided hose that is connected to ground at both ends.
- Electrical panel must have a dedicated ground conductor in accordance with relevant electrical safety regulations.
- Verify that the panel ground conductor is sized in accordance with relevant electrical safety regulations.

NOTE

- The installing electrical contractor is responsible for connecting the panel ground to the facility ground in accordance with relevant electrical codes and standards, such as NEC Section 250 in the U.S. or its equivalent for other countries.
- Special filtering and measuring may be required in installations such as hospitals that are prone to being influenced by other electronic equipment.

6.14 Mains Input Cable Specification

The aim of electrical cables is to be a carrier (conductor) for electrical power. The influence of the power source on the environment, or the influence of the environment on the power source, should be such that neither the proper functioning of the compressor nor equipment in its environment is adversely affected. Therefore, Danfoss LLC advises to use some type of shielded cable for the mains input.

When using shielded cable, select a cable with an effective shield. A cable with an aluminum foil will be far less effective than a specially designed conductive braid. It is best to connect both ends of the cable shield to ground since the shield is not part of the signal path. Alternatively, non-shielded conductors may be used if they are carried inside of a code-approved electrical metallic conduit of the flexible or rigid types.

The mains input cable should be CSA, UL, or CE approved, three-wire with a common shield and single ground. The cable must be rated for 90°C (194°F) minimum at the maximum applicable current. It is recommended that the cable be double-jacketed, e.g., teck cable type. Refer to Table 6-4 Main Cable Connector Plate Hole Sizes for cable gland specifications.

Table 6-4 Main Cable Connector Plate Hole Sizes

Model	380V	400V	460V	575V
TTS300/TGS230	2.5"	2.5"	2.5"	2.5"
TTS350/TGS310	2.5"	2.5"	3"	N/A
TTS400/TGS390	2.5"	2.5"	3"	3"
TGS490	2.5"	2.5"	3"	N/A
TTS700/TGS520	2.5"	2.5"	3"	N/A
TTH375/TGH285	2.5"	2.5"	3"	N/A

NOTE

The plate hole sizes shown in Table 6-4 Main Cable Connector Plate Hole Sizesare standard production sizes for standard compressors released at the time of this publication. OEMs have the flexibility to change those sizes according to their needs. Please refer to the Spare Parts Selection Guide for more information on available sizes or contact your Key Account Manager for possible changes. If OEMs are ordering compressors using the New Type Code configuration the mains plate connector size can be selected at the time of order.

6.15 Idle Power Consumption

TTS/TGS/TTH/TGH series compressors have an idle power consumption of 45 W.

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Chapter 7.0 Compressor Performance

7.1 Performance Ratings

Compressor performance, including applicable capacity range, varies based on the operating conditions. The capacity range, efficiency, and other operational information for each compressor can be determined only by using the authorized software known as the Compressor Performance Rating (CPR) Engine or CPR Engine. This software and a selection tool is available on our website.

7.2 Tolerance of Performance Ratings

The CPR rating conditions are based on flange-to-flange and do not take into effect any line pressure drops or piping inconsistent with the guidance in the manual.

Compressors are guaranteed to meet the published performance ratings in the current CPR tool within the tolerance band published in CPR. Higher accuracy is predicted in the speed only range and tolerance increases in the mechanical unloading range (IGV < 110%). Higher tolerances are also published in the low lift and ultra-low lift ranges. Refrigerant choice may also impact the rating tolerance.

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Chapter 8.0 Operating Envelopes

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Rating Envelope Limits

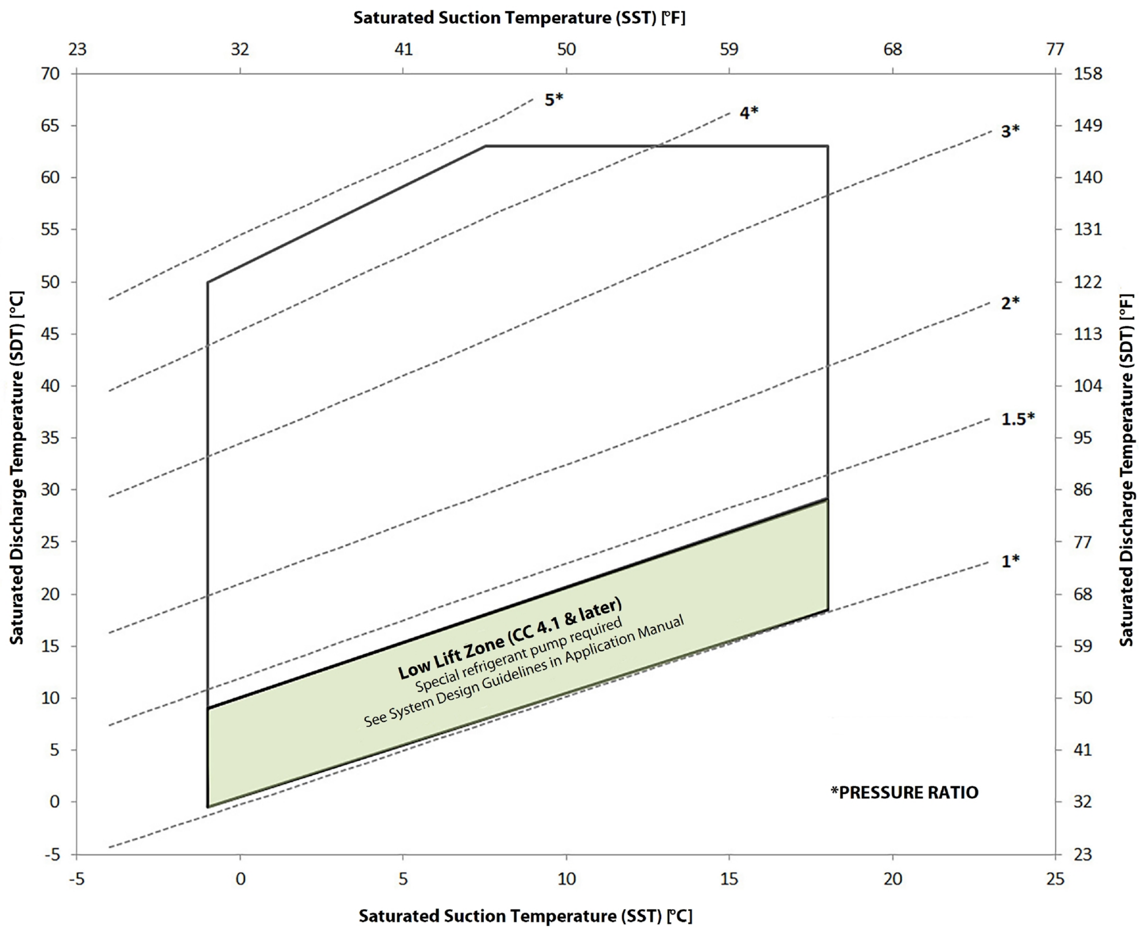
The rating envelopes which follow are only a representative guide to the operating range of each compressor model. Be certain that expected operation is verified by a rating using the most recent version of the CPR tool. **If you have any questions about whether the compressor you are rating is appropriate for the application conditions, please consult your local Danfoss LLC Application Engineer for expert guidance.**

Danfoss LLC has recently developed several variants of our compressors, each of which is designed to operate in a specific Saturated Suction Temperature (SST) range. Danfoss LLC strongly urges selecting a compressor which covers the range of SST expected for the application. Danfoss LLC will not accept responsibility for any rating discrepancies resulting from operation outside of the SST ranges in these envelopes or those in the current CPR rating.

There are also possible cases where operation at SST condition limits above those specified and rated for a particular variant, **but operation may be limited** by the maximum ambient temperature around the compressor, the saturated discharge temperature, and the compressor power input. Before offering a compressor to the market above the SST limits of each variant, they must be validated by the OEM through controlled testing at steady state conditions at the application conditions required for a minimum of 3.5 hours. **This validation test must be reviewed and approved by Danfoss LLC Applications** to ensure the compressor is able to maintain stable operation within the limits tested.

The BMCC does not prevent operation below the SST limit for some compressor variants. This flexibility is intended to permit operation during transitional periods which may occur during a pull-down or batch loading process. Extended operation below the minimum SST limits for a compressor variant **may result in the rejection of a warranty claim** if the root cause of the failure is determined to be related to extended operation with SST below the variant limit.

Figure 8-1 Operating Envelope[1], Standard SST: TTS300 and TGS230



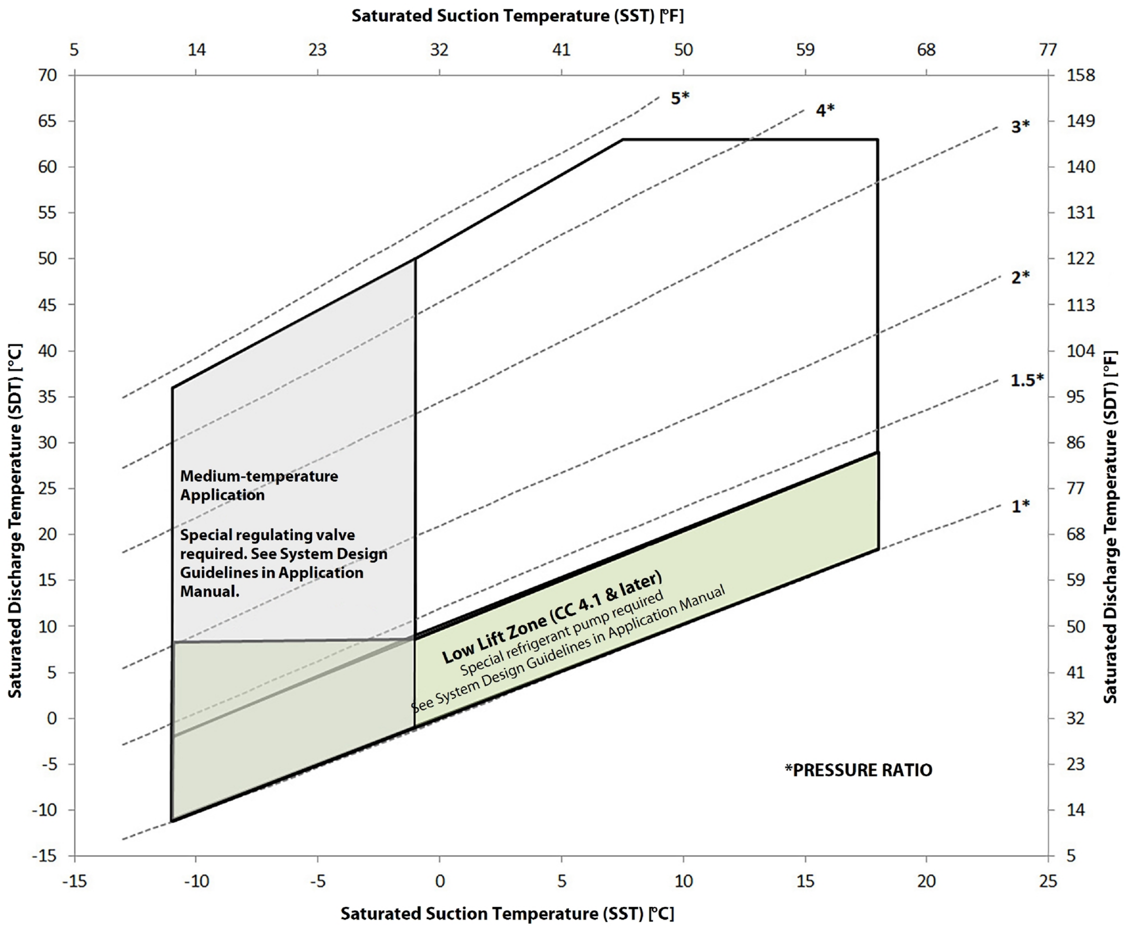
NOTE

The maximum Saturated Discharge Temperature (SDT) of the operating envelope represents the limit for compressors with maximum FLA settings. The SDT for a compressor with a lower maximum current rating is lower than that shown and is related to the FLA rating of the particular compressor.

The lower limit is related to minimum pressure ratios required to effect proper motor and power electronics cooling with standard refrigerant circuit components.

[1] The actual obtainable capacity will be dependent on specific operating characteristics of each compressor model. Refer to the current authorized compressor selection/rating software for more exact values and conditions.

Figure 8-2 Operating Envelope[1], Medium Temperature: TTS300 and TGS230



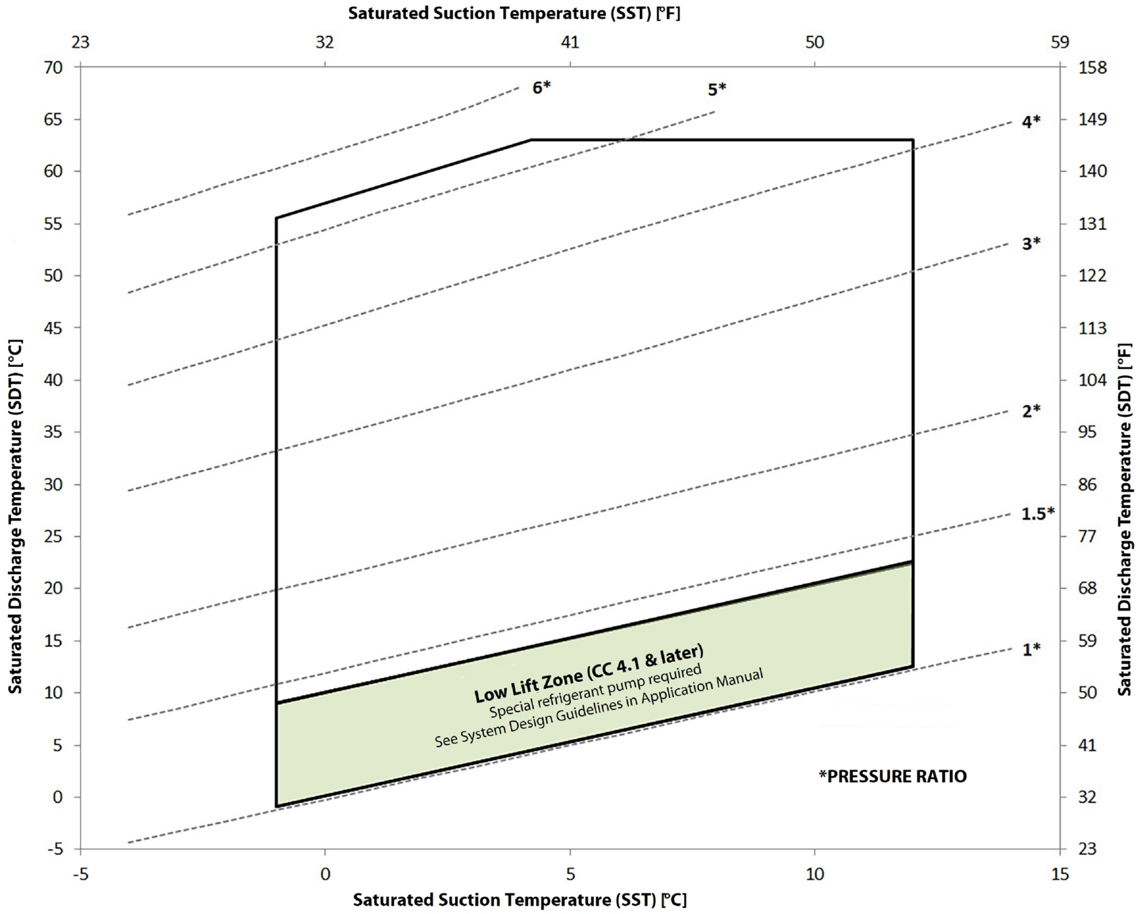
NOTE

The maximum SDT of the operating envelope represents the limit for compressors with maximum FLA settings.

The SDT for a compressor with a lower maximum current rating is lower than that shown and is related to the FLA rating of the particular compressor. The lower limit is related to minimum pressure ratios required to effect proper motor and power electronics cooling with standard refrigerant circuit components.

[1] The actual obtainable capacity will be dependent on specific operating characteristics of each compressor model. Refer to the current authorized compressor selection/rating software for more exact values and conditions.

Figure 8-3 Operating Envelope[1], Standard SST: TT350, TGS310, and TGS490



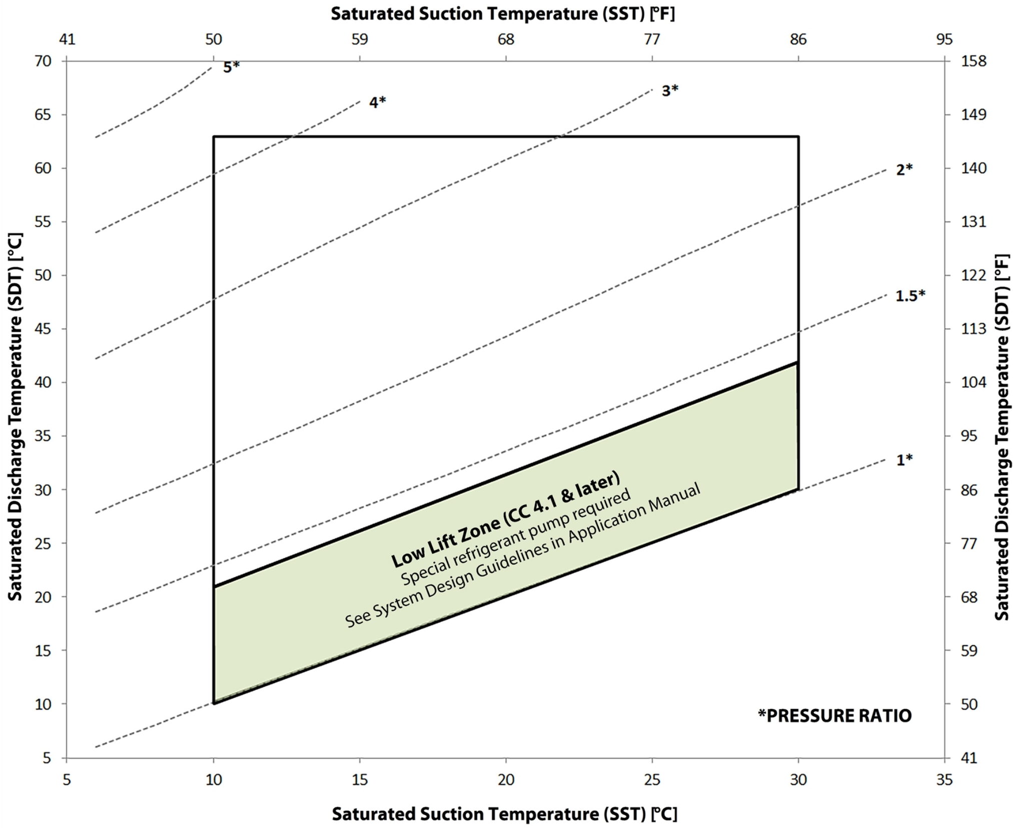
NOTE

The maximum SDT of the operating envelope represents the limit for compressors with maximum FLA settings.

The SDT for a compressor with a lower maximum current rating is lower than that shown and is related to the FLA rating of the particular compressor. The lower limit is related to minimum pressure ratios required to effect proper motor and power electronics cooling with standard refrigerant circuit components.

[1] The actual obtainable capacity will be dependent on specific operating characteristics of each compressor model. Refer to the current authorized compressor selection/rating software for more exact values and conditions.

Figure 8-4 Operating Envelope[1], High SST: TTS350, TGS310, and TGS490



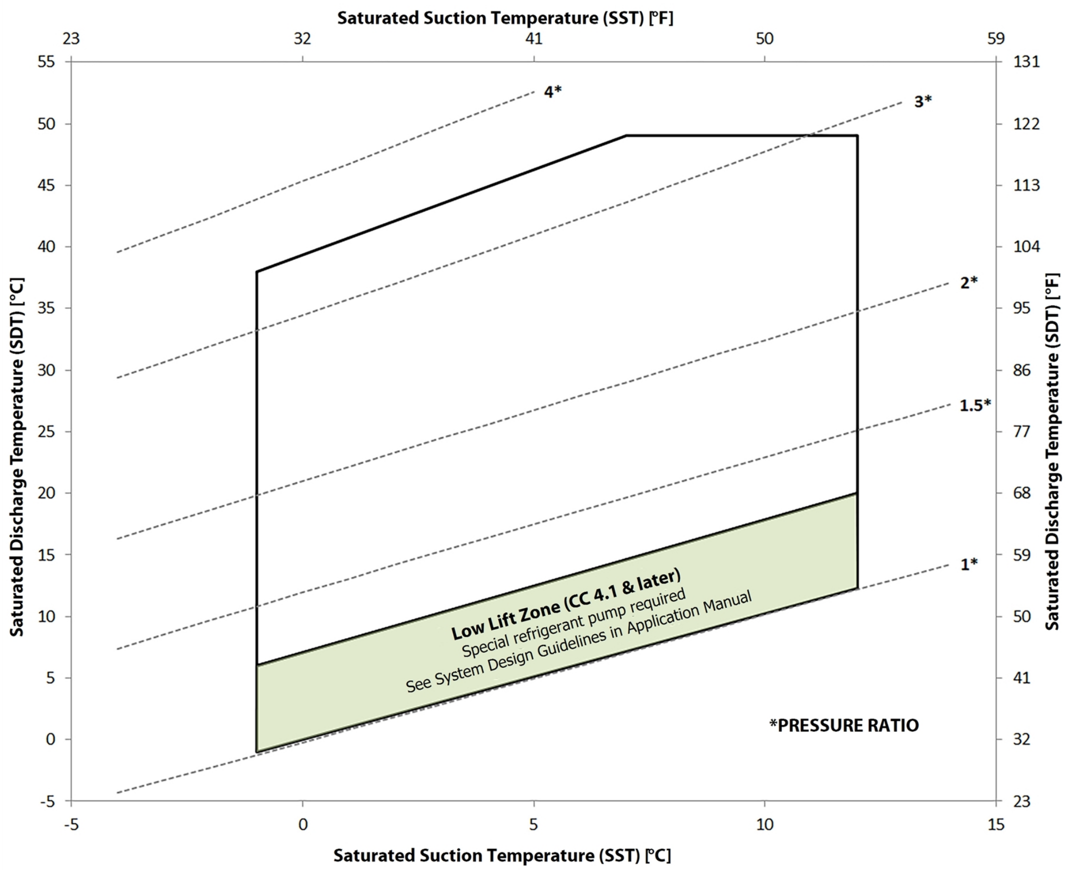
NOTE

The maximum SDT of the operating envelope represents the limit for compressors with maximum FLA settings.

The SDT for a compressor with a lower maximum current rating is lower than that shown and is related to the FLA rating of the particular compressor. The lower limit is related to minimum pressure ratios required to effect proper motor and power electronics cooling with standard refrigerant circuit components.

[1] The actual obtainable capacity will be dependent on specific operating characteristics of each compressor model. Refer to the current authorized compressor selection/rating software for more exact values and conditions.

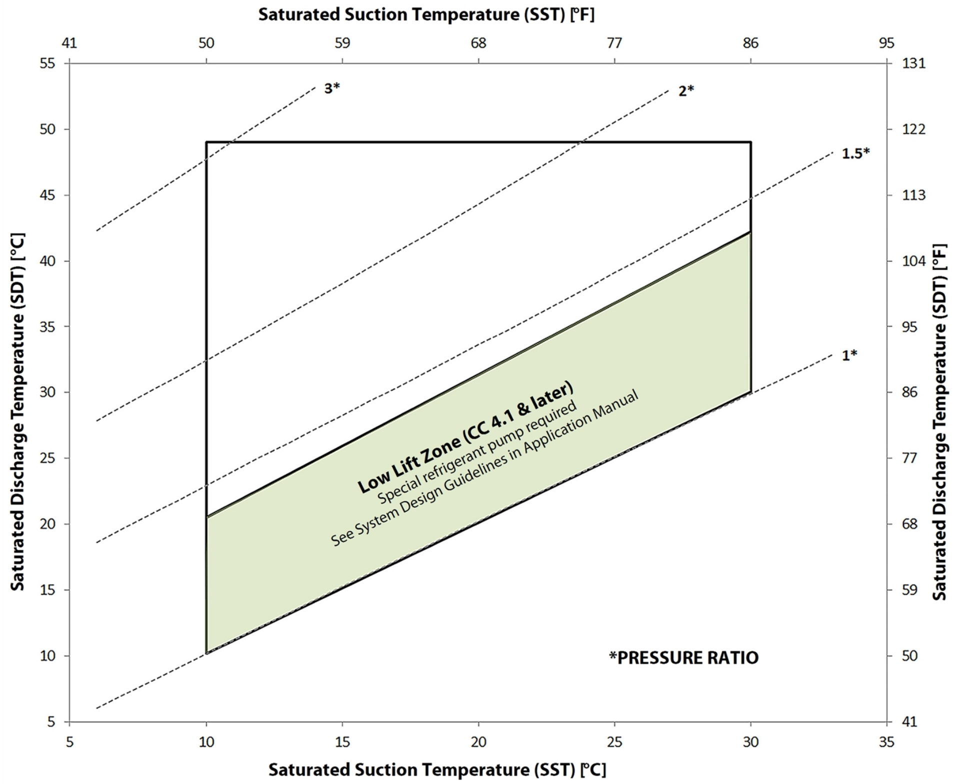
Figure 8-5 Operating Envelope(1), Standard SST: TTS400 and TGS390



NOTE
The maximum SDT of the operating envelope represents the limit for compressors with maximum FLA settings. The SDT for a compressor with a lower maximum current rating is lower than that shown and is related to the FLA rating of the particular compressor. The lower limit is related to minimum pressure ratios required to effect proper motor and power electronics cooling with standard refrigerant circuit components.

(1) The actual obtainable capacity will be dependent on specific operating characteristics of each compressor model. Refer to the current authorized compressor selection/rating software for more exact values and conditions.

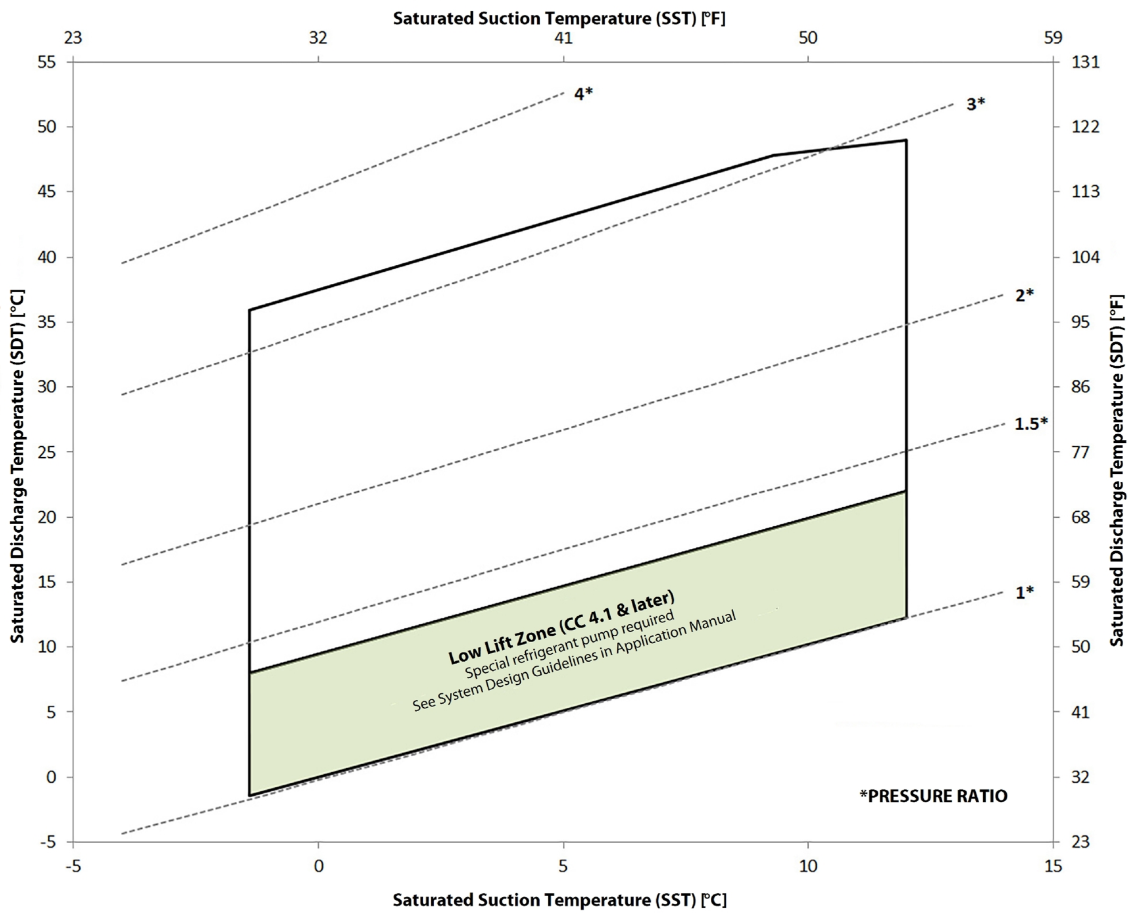
Figure 8-6 Operating Envelope[1], High SST: TTS400 and TGS390



NOTE
The maximum SDT of the operating envelope represents the limit for compressors with maximum FLA settings. The SDT for a compressor with a lower maximum current rating is lower than that shown and is related to the FLA rating of the particular compressor. The lower limit is related to minimum pressure ratios required to effect proper motor and power electronics cooling with standard refrigerant circuit components.

[1] The actual obtainable capacity will be dependent on specific operating characteristics of each compressor model. Refer to the current authorized compressor selection/rating software for more exact values and conditions.

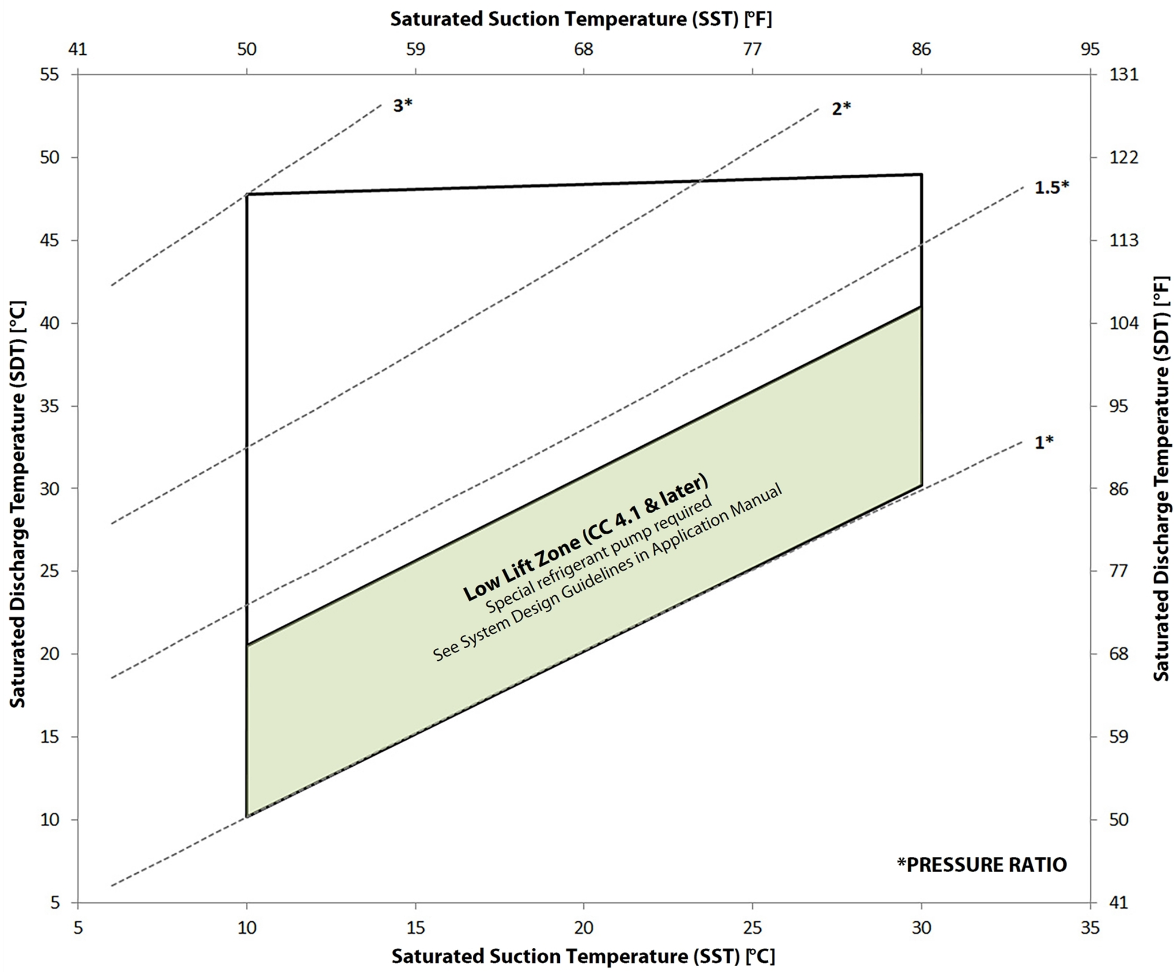
Figure 8-7 Operating Envelope[1], Standard SST: TTS700 and TGS520



NOTE
The maximum SDT of the operating envelope represents the limit for compressors with maximum FLA settings. The SDT for a compressor with a lower maximum current rating is lower than that shown and is related to the FLA rating of the particular compressor. The lower limit is related to minimum pressure ratios required to effect proper motor and power electronics cooling with standard refrigerant circuit components.

[1] The actual obtainable capacity will be dependent on specific operating characteristics of each compressor model. Refer to the current authorized compressor selection/rating software for more exact values and conditions.

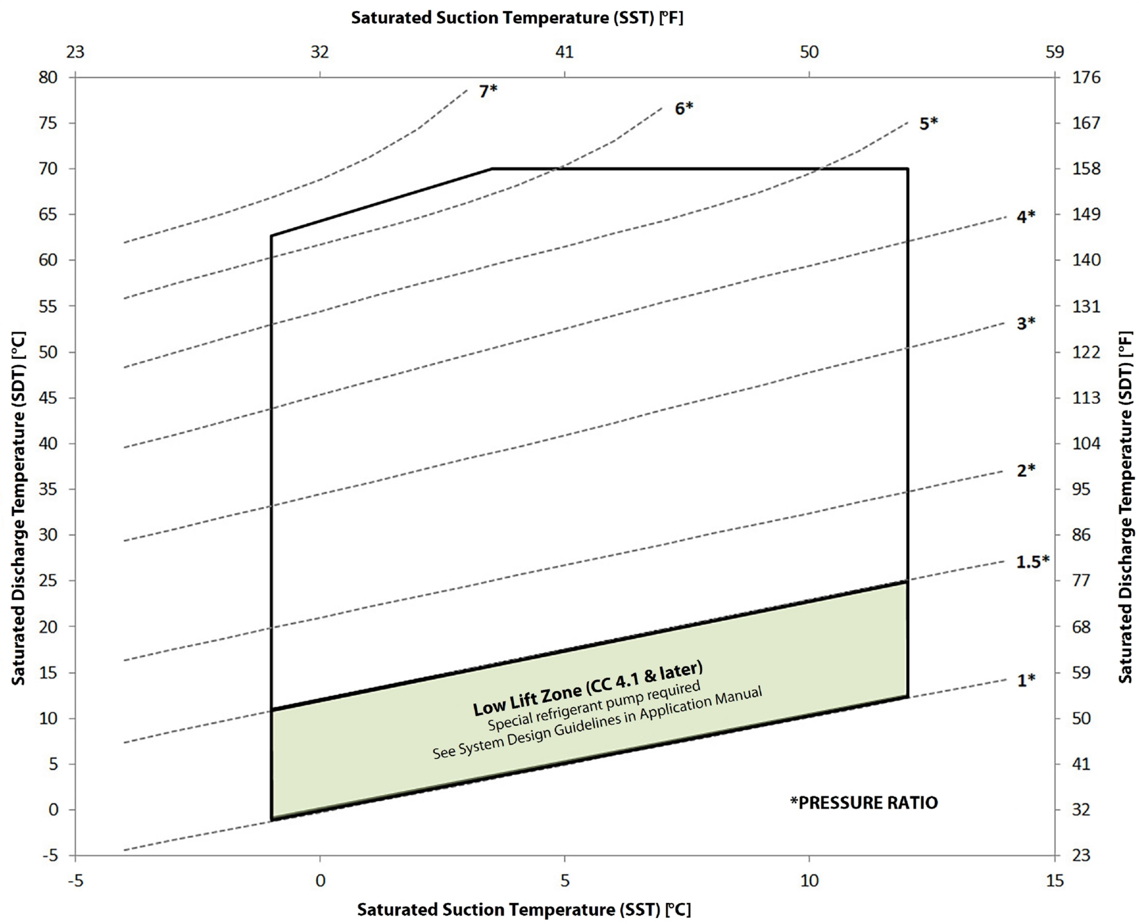
Figure 8-8 Operating Envelope(1), High SST: TTS700, and TGS520



NOTE
The maximum SDT of the operating envelope represents the limit for compressors with maximum FLA settings. The SDT for a compressor with a lower maximum current rating is lower than that shown and is related to the FLA rating of the particular compressor. The lower limit is related to minimum pressure ratios required to effect proper motor and power electronics cooling with standard refrigerant circuit components.

(1) The actual obtainable capacity will be dependent on specific operating characteristics of each compressor model. Refer to the current authorized compressor selection/rating software for more exact values and conditions.

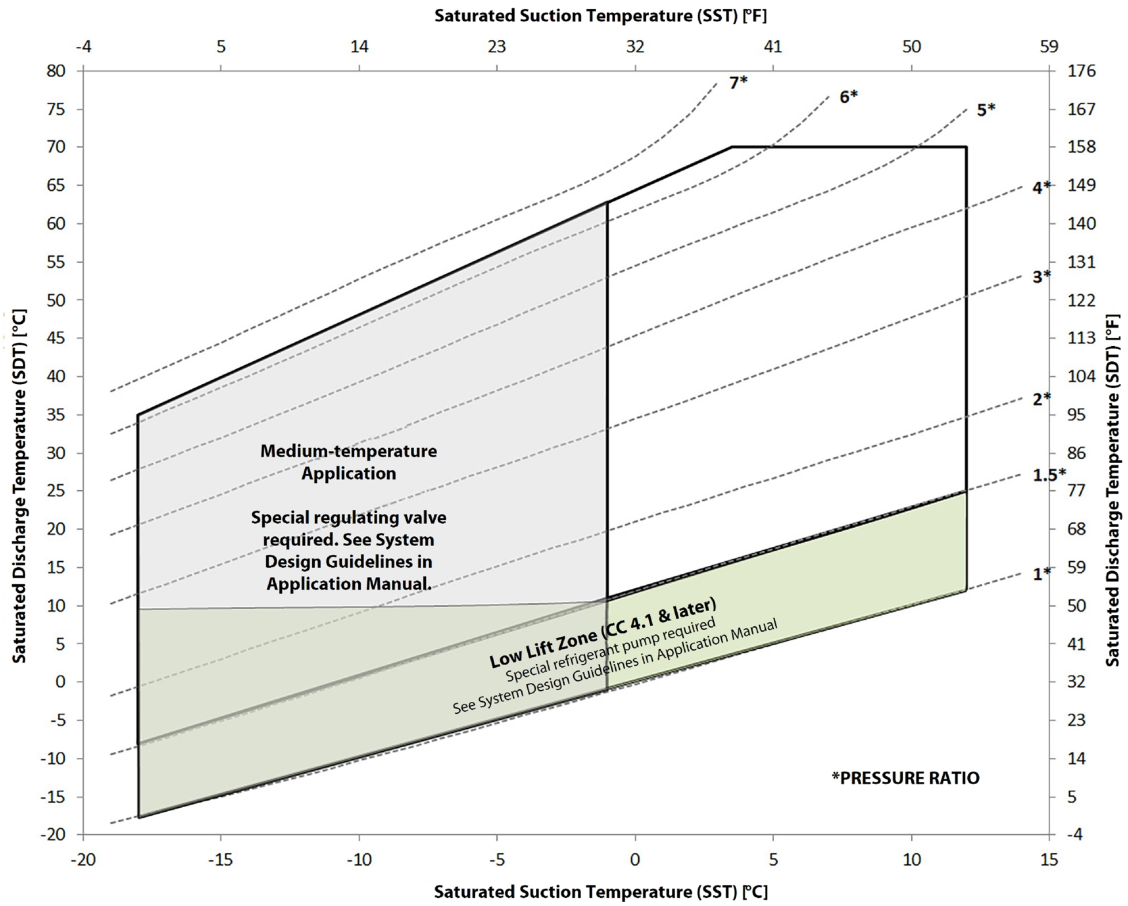
Figure 8-9 Operating Envelope[1], Standard SST: TTH375/TGH285



NOTE
The maximum SDT of the operating envelope represents the limit for compressors with maximum FLA settings. The SDT for a compressor with a lower maximum current rating is lower than that shown and is related to the FLA rating of the particular compressor. The lower limit is related to minimum pressure ratios required to effect proper motor and power electronics cooling with standard refrigerant circuit components.

(1) The actual obtainable capacity will be dependent on specific operating characteristics of each compressor model. Refer to the current authorized compressor selection/rating software for more exact values and conditions.

Figure 8-10 Operating Envelope[1], Medium Temperature: TTH375/TGH285



NOTE
The maximum SDT of the operating envelope represents the limit for compressors with maximum FLA settings. The SDT for a compressor with a lower maximum current rating is lower than that shown and is related to the FLA rating of the particular compressor. The lower limit is related to minimum pressure ratios required to effect proper motor and power electronics cooling with standard refrigerant circuit components.

(1) The actual obtainable capacity will be dependent on specific operating characteristics of each compressor model. Refer to the current authorized compressor selection/rating software for more exact values and conditions.

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Chapter 9.0 Minimum Unloading Capacity

Due to the nature of centrifugal compression, the minimum stable load is dependent on the pressure ratio imposed on the compressor by the chiller system. All compressor performance, including unloading, should be determined through use of the relevant compressor selection/rating programs.

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Chapter 10.0 Control Logic Guidelines for Multiple Compressors

Due to the nature of centrifugal compression, special control logic must be implemented for proper staging of multiple Danfoss LLC compressors when installed on a common circuit. This section is intended only as a guide without going into details. Control details are specific to each OEM's individual control strategy. The Danfoss LLC centrifugal compressors can be controlled by staging compressors and running the on line compressors in parallel.

Staging valve: The Staging valve is piped in upstream of the check valve to provide a low pressure bypass path and is used to reduce the pressure ratio in the system to assist in startup and shutdown of a compressor. Staging valves are mandatory for all Danfoss LLC compressors.

Load balancing valve (hot gas bypass): The Load Balance Valve (LBV) is piped downstream of the check valve and is primarily used in low load conditions to keep the compressor operational instead of cycling off. It is possible to use a staging valve as a LBV but sizing and control can be a little more challenging and for that reason they are both frequently installed in many systems.

For additional details related to starting, stopping, staging, for all aspects of single and multiple compressor control, please consult the OEM Programming Manual.

NOTE

The hot gas evacuated by the staging valve must be injected downstream of the main EXV in order to desuperheat the gas prior to entering the suction of the compressor.

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If the staging valve is used as a LBV, there are two major risks:

- Check valve chattering if the bypassed flow is too high, this chattering will lead to bearing faults due to vibrations (Please contact Danfoss LLC for further information)
- High suction superheat which may lead to compressor fault

Staging valve sizing method: Using CPR, rate a compressor at the maximum pressure ratio for which the chiller is designed to operate. Use the maximum Evaporator Mass Flow Rate to select an appropriately sized staging valve.

Load Balancing Valve Sizing: Using CPR, rate the compressor at the minimum load and conditions at which the compressor is expected to operate. Use the Evaporator Mass Flow Rate to determine the required mass flow which must be bypassed through the load balance valve to reach the desired minimum load.

NOTE

Danfoss LLC highly recommends the use of a solenoid valve as a staging valve as it is faster to provide pressure relief to the compressor in case of emergency shutdown. We recommend to command the Solenoid valve with the "compressor status" contact on the I/O board. Staging valve (solenoid type) can be selected from Danfoss portfolio e.g., EVR32 for TTS300 & TTS350 and EVR40 for TTS400 & TTS700 compressors. These valves should provide satisfactory starting and shutdown functionality, however Danfoss LLC Applications strongly recommends testing with supervision of an Application Engineer to ensure proper operation during all start and stop conditions.

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Chapter 11.0 Product Certification

All TTS/TGS/TTH/TGH Series compressors are ETL listed and CE marked and have been tested in accordance with UL 60335-2-34:2017 Ed.6, CSA C22.2 No. 60335-2-34:2017 Ed.2 and EN 60335-2-34:2013.

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Chapter 12.0 Guide Specifications

This section contains written specifications for the TTS/TGS/TTH/TGH series compressors for use in system design specifications.

12.1 General

Construction shall utilize a two-stage, variable-speed, centrifugal compressor design requiring no oil for lubrication. Compressor shall be constructed with cast aluminum casing and high-strength thermoplastic electronics enclosures. The two-stage centrifugal impellers shall consist of cast and machined aluminum. The motor rotor and impeller assembly shall be the only major moving parts.

12.2 Refrigerant

TTS and TTH compressors are designed for use with R134a and R513A while TGS and TGH compressors are designed for use only with R1234ze(E) and R515B.

12.3 Compressor Bearings

The compressor shall be provided with radial and axial magnetic bearings to levitate the shaft, thereby eliminating metal-to-metal contact, and thus eliminating friction and the need for oil. The magnetic bearing system shall consist of front, rear, and axial bearings. Both the front and the rear bearings are to levitate the shaft at X and Y directions, and the axial at Z direction. Each bearing position shall be sensed by position sensors to provide real-time repositioning of the rotor shaft, controlled by onboard digital electronics.

12.4 Capacity Control

The compressor shall have a VFD for linear capacity modulation, high part-load efficiency, and reduced in-rush starting current. It shall include an Inverter that converts the DC voltage to an adjustable three-phase AC voltage. Signals from the compressor controller shall determine the inverter output frequency, voltage and phase, thereby regulating the motor speed. In case of power failure, the compressor shall be capable of allowing for a normal de-levitation and shutdown.

Compressor speed shall be reduced as condensing temperature and/or heat load reduces, optimizing energy performance through the entire range of capacity. Capacity modulates infinitely as motor speed is varied across the range. IGVs shall be built-in to further trim the compressor capacity in conjunction with the variable-speed control to optimize compressor performance at low loads. Refer to Danfoss LLC Selection Software for performance calculations and limits.

12.5 Compressor Motor

The compressor shall be provided with a direct-drive, high-efficiency, permanent-magnet synchronous motor powered by PWM voltage supply. The motor shall be compatible with high-speed variable-frequency operation that affords high-speed efficiency, compactness and soft start capability. Motor cooling shall be by liquid refrigerant injection.

12.6 Compressor Electronics

The compressor shall include a microprocessor controller capable of controlling magnetic bearings and speed control. The controller shall be capable of providing monitoring, including commissioning assistance, energy outputs, operation trends, and fault codes via a Modbus interface.

12.7 Ancillary Devices

A check valve shall be installed on the discharge port of all compressors to protect against backflow of refrigerant during coast down. It is recommended that the valve be located after the properly designed discharge cone adapter; preferably close to the condenser in the packaged system. The system must include an appropriately sized 5% impedance Line Reactor. One Line Reactor is required for each compressor and cannot be shared among multiple compressors. Please refer to the Spare Parts Selection Guide.

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Chapter 13.0 System Design Guidelines

In addition to the instructions detailed in the technical documentation set, this section provides basic guidelines and requirements for the design and manufacture of systems equipped with Danfoss Turbocor compressors.

NOTE
The compressor internal safety control settings are designed to provide protection for the compressor only. Designers MUST provide SYSTEM protection within their control design. Danfoss LLC will not be responsible for system protection other than the compressor.

13.1 General Requirements

1. Check for compliance with all installation, operating, commissioning, and service steps, as outlined in the documentation set. Check for the appropriate operating envelope and minimum unloading capacity for the intended application.
2. System components such as evaporators, condensers, valves, etc., should be properly selected and sized for appropriate performance and compatibility with applied refrigerant.
3. The system suction and discharge piping should be properly designed and selected for minimum pressure drop. Since the Turbocor compressor operates without lubricating oil, conventional piping considerations that ensure oil return, such as multiple risers and traps, are not required. In most cases, larger diameter lines will result in better compressor performance and efficiency.
4. For improved efficiency and better control, particularly at low load/low compression ratios, EXVs are strongly recommended. To take advantage of low pressure ratio operation to improve low load performance and efficiency, EXV capacity should be selected accordingly. Thermal expansion valves (TXVs) are not recommended due to the general inability of these devices to adequately cover the operating spectrum of centrifugal compressors, particularly at low compression ratios.
5. Take all necessary precautions to prevent any possibility of liquid floodback to the compressor. This means consideration during the ON and OFF cycles, particularly in multiple compressor installations. This WILL include, but is not limited to, the inclusion of a liquid line solenoid valve and piping, evaporator and condenser arranged in a manner that prevents free drainage of liquid to compressor.
6. The refrigeration piping system must be clean and free of all debris, in accordance with refrigeration-industry best practices, as particles can damage the compressor.
7. The system control should not be designed based on pump down cycle. The system cannot be pumped down due to the surge characteristics of centrifugal compressors.
8. Refer to Table 13-1 Recommended Minimum Copper Tube Size for recommended minimum pipe sizes.

Table 13-1 Recommended Minimum Copper Tube Size

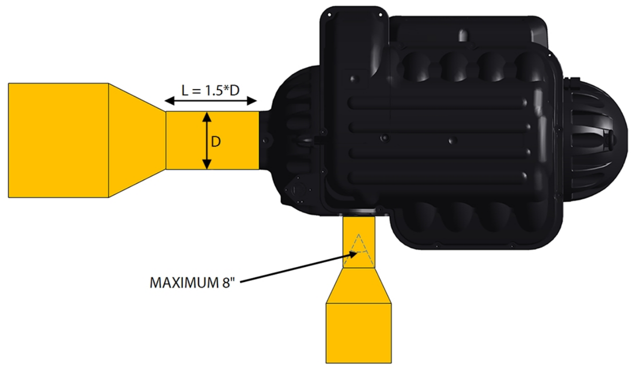
	TTS300/TGS230	TTS350/TGS310	TTS400/TGS390	TGS490	TTS700/TGS520	TTH375/TGH285
Suction	4"	4"	5"	5"	5"	4"
Discharge	2 5/8"	3 1/8"	4"	4"	4"	3 1/8"

NOTE
If steel pipe is used, the pipe must be selected to give the equivalent inside diameter to copper pipe.

Properly tapered trumpets with smooth transitions must be used to connect the compressor flanges to the pipework.

The discharge line exit transition should not be at an angle greater than eight 8° inclusive. The suction line length should be straight for 1.5 times the pipe diameter before entry into the compressor.

Figure 13-1 Discharge Cone to Illustrate the Piping Requirements



13.2 Economizer Option

Turbocor compressors use two stage centrifugal compression with interstage port availability. This feature provides advantages of capacity and efficiency improvement when an economizer is installed. The improvements in efficiency and capacity are a result of further sub-cooling of the liquid refrigerant. Two types of economizer arrangements can be used: sub-cooler or flash tank. Refer to Figure 14-3 Typical Refrigeration Piping Schematic with Flash Tank Economizer and Figure 14-4 Typical Refrigeration Piping Schematic with Closed Type Economizer. Refrigerant must enter the compressor through the economizer port in a “gas” state. Care must be taken to ensure that no liquid enters the compressor.

To determine compressor capacity and efficiency, the economizer performance rating option is available in the Selection Software on the TT/TG Software Section of the Danfoss LLC web page (www. turbocoroem.com). The circuit must be properly designed to reflect the specified heat exchanger approach with minimized pressure drops across the liquid side and expansion side. Piping design, including expansion device selection and pipe sizing, should be in accordance with best practices.

• • • CAUTION • • •

To prevent bypass of gas through an idle compressor the economizer refrigerant circuit should include an automatically actuated valve which closes upon compressor shutdown.

• • • CAUTION • • •

All TTH and TGH compressors must have an economizer which is active above 2.0 Pressure Ratio and to prevent reverse rotation, a normally closed solenoid valve installed in the interstage vapor line which must close immediately upon compressor shut down.

13.3 Motor/Electronics Cooling Requirements

NOTE

- Sub-cooled liquid must be fed to the motor/electronics cooling port of the compressor
- It must be in a pure liquid state with a minimum of 6°F (3.5°C) sub cooled at the connection point to the motor/electronics cooling port of the compressor

NOTE

Filter dryer, sight glass and service valve must be fitted in the motor-cooling liquid line.

It is essential that compressor motor and power electronics cooling is available immediately at start up. The compressor motor cooling liquid feed line must be configured and located so this occurs. Recommended minimum pipe size is 1/2” for all models. A larger size may be necessary in some situations such as systems with low subcooling on start or extended piping runs. A full-flow filter/drier must be installed and a liquid sight glass must be installed adjacent to each compressor. In multiple compressor systems, a single filter/dryer may serve multiple compressors but each compressor must have a dedicated sight glass.

13.4 Electrical Requirements

Power is permanently connected to the compressor connection terminals. A line reactor must be connected in series with the compressor connection. The line reactor enclosure or box should be properly ventilated to avoid overheating.

13.5 Application-Specific Requirements

13.5.1 Medium Evaporating Temperature Application (TGS230/TTS300/TGH285/TTH375)

NOTE

Medium Evaporating Temperature is defined as between 0 and -10°C (between 32 and 14°F) for TTS300/TGS230 and between 0 and -18°C (between 32 and -0.4°F) for TTH375/TGH285.

Check the operating envelope for limits, required compressor version, and accessories.

For medium-temperature applications, an evaporating pressure regulator, Type KVP, is included with the compressor and must be installed external to the compressor between the main suction line and the motor/electronics cooling outlet port adjacent to the inter stage port. The valve has a Solder ODF connection with 7/8" diameter (Danfoss KVP 22), set at a corresponding pressure to 0.8°C (34°F) saturated temperature (depending on the used refrigerant). Refer to C.1 Pressure Regulating Valve Installation InstructionsThe motor/electronics cooling outlet port is fitted with a 5/8” flare adapter.

NOTE

Danfoss LLC highly recommends the insulation of the suction and inter-stage pipe as well as the bottom of the compressor for MT applications to prevent ice buildups.

13.5.2 High Evaporating Temperature Application (TGS310/TTS350/TGS490/TGS390/TTS400/TGS520/TTS700)

NOTE

- High Evaporating Temperature is defined as between 12 and 30°C (53.6 and 86°F) and only applies to TGS310/TTS350/TGS490/TGS390/TTS400/TGS520/TTH700 compressors.
- The standard Evaporating Temperature is defined as between -1 and 12°C (30.2 and 53.6°F) and applies to all compressors.
- It is not recommended to run a High Evaporating Temperature compressor in Standard Evaporating Temperature conditions as it will eventually lead to a failure.

1. Check the operating envelope for limits and always validate the application with CPR engine in order to make sure the compressor will work properly.
2. Make sure not to run a High Evaporating Temperature compressor in Standard Evaporating Temperature conditions as it will eventually lead to failure.

13.5.3 Limited Capacity at Low Pressure Ratios

Figure 13-2 Centrifugal Performance Dynamics illustrates the capacity reduction imposed by compressor logic when a compressor is operated at low lift conditions without a low lift pump and without the low lift function activated. This capacity limitation is common during a warm building pull down cycle during low ambient conditions but can also be encountered under other operating conditions with extended operation with low pressure ratios. If more capacity is desired during operation during low lift conditions the condensing temperature can be increased, or alternatively the low lift pump and low lift function can be activated if the refrigeration system is so equipped with these features. Reference Figure 14-1 Typical Refrigeration Piping Schematic. and the OEM Programming Manual for more details on operation of the low lift function.)

13.5.4 Low Lift Application

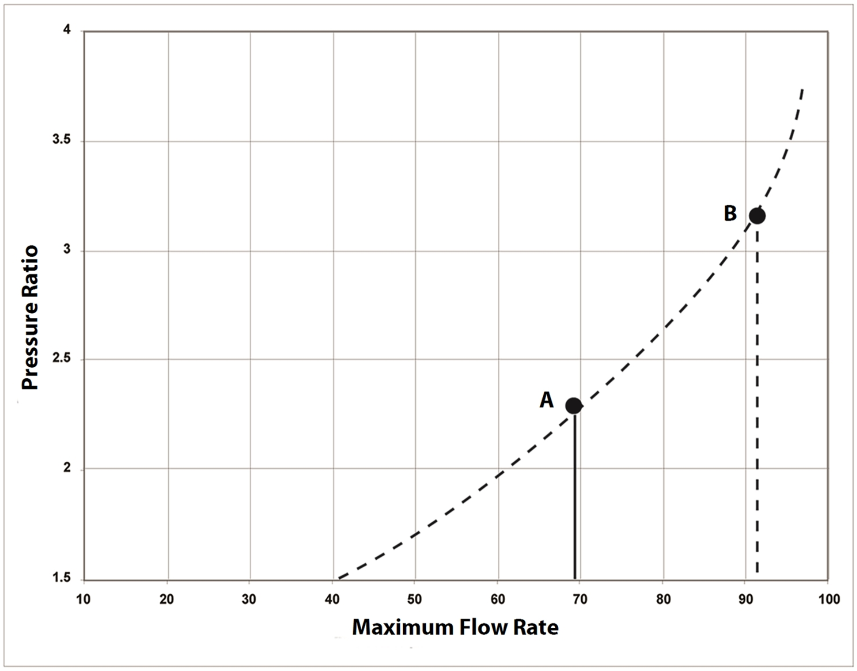
The standard TTS/TGS control limits compressor speed and capacity above a 1.5 pressure ratio to ensure adequate motor/inverter cooling. When enabled, the low lift option is meant to enable increased compressor speed and capacity at pressure ratios below 1.5. To ensure adequate cooling for extended operation with pressure ratios below 1.5, the chiller system must provide the subcooled refrigerant flow specified in Table 13-2 Low Lift Pump Sizing. An OEM-supplied liquid refrigerant pump will be required in most circumstances/designs. If an adequate supply of subcooled liquid is not provided, the compressor will limit speed and capacity to maintain safe operating temperatures. If safe temperatures cannot be maintained, the compressor will fault. Repeated operation without adequate motor cooling could result in damage to the compressor and evidence of such operation could limit warranty coverage.

Refer to Figure 14-1 Typical Refrigeration Piping Schematic for a possible pump design and Table 13-2 Low Lift Pump Sizing. Though each OEM may choose to use more sophisticated logic, a simplified control logic would turn the pump on at pressure ratios below 1.5 and off when the pressure ratio rises to 1.7. By default, the low lift option is not enabled. More details on enabling the low lift option and the alarm and faults associated with it are included in the OEM Programming Manual.

Table 13-2 Low Lift Pump Sizing

Model	Cooling Mass Flow (kg/s)	Head (kPa)
ALL	0.06	310

Figure 13-2 Centrifugal Performance Dynamics



NOTE
Contact Danfoss LLC Applications for compressor selection and technical advice.

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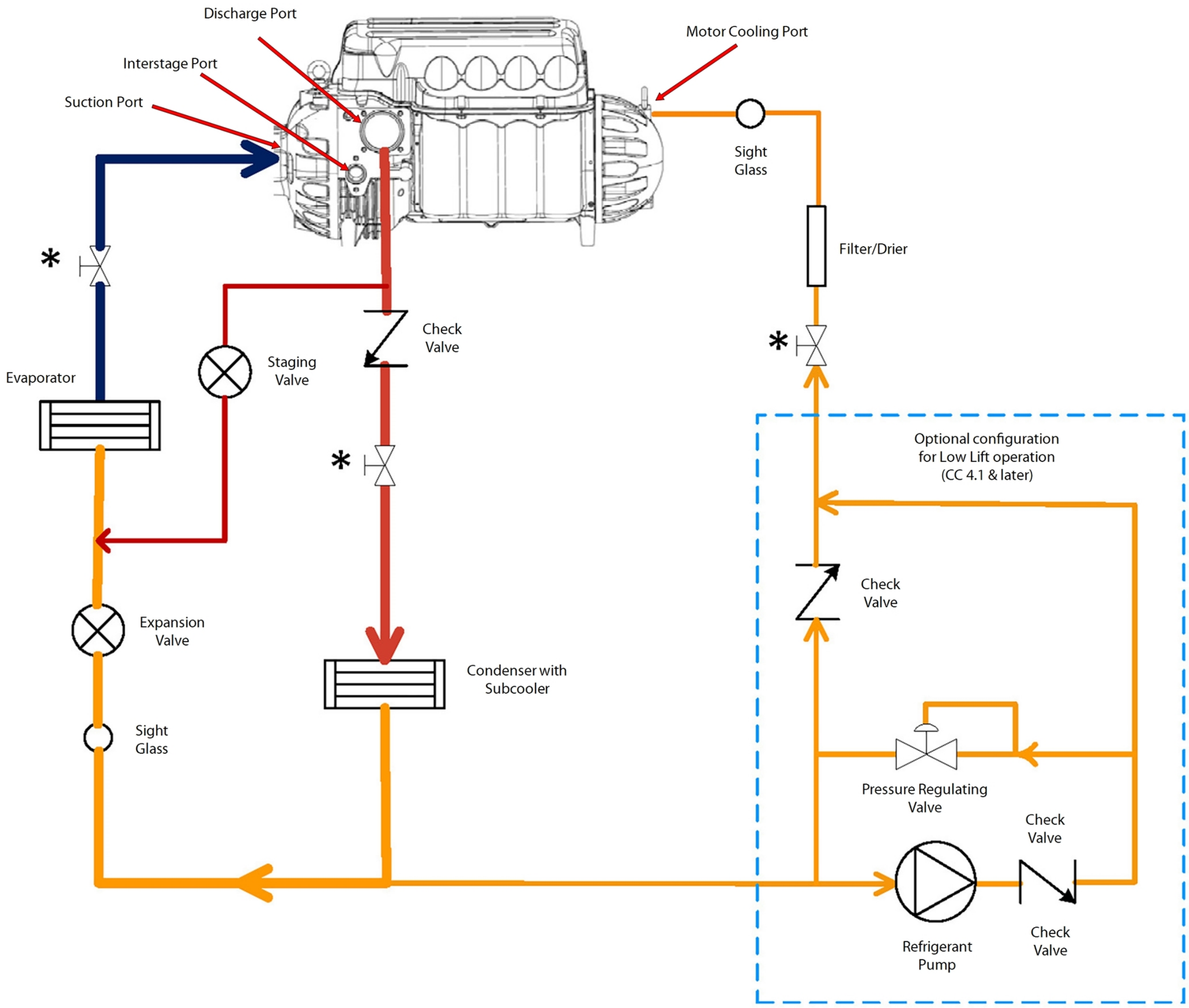
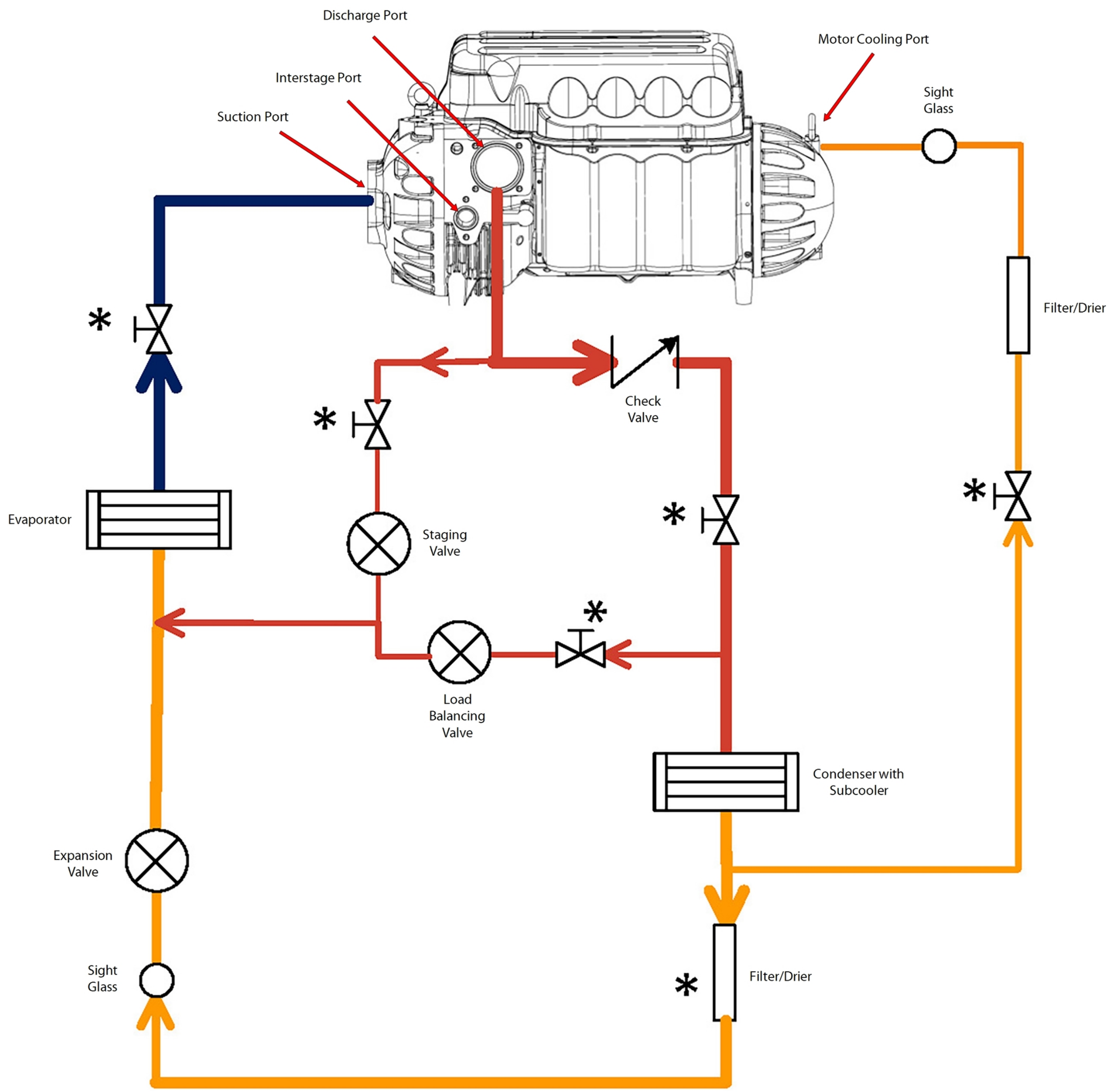
Chapter 14.0 Sample Refrigeration Circuits

Figure 14-1 Typical Refrigeration Piping Schematic



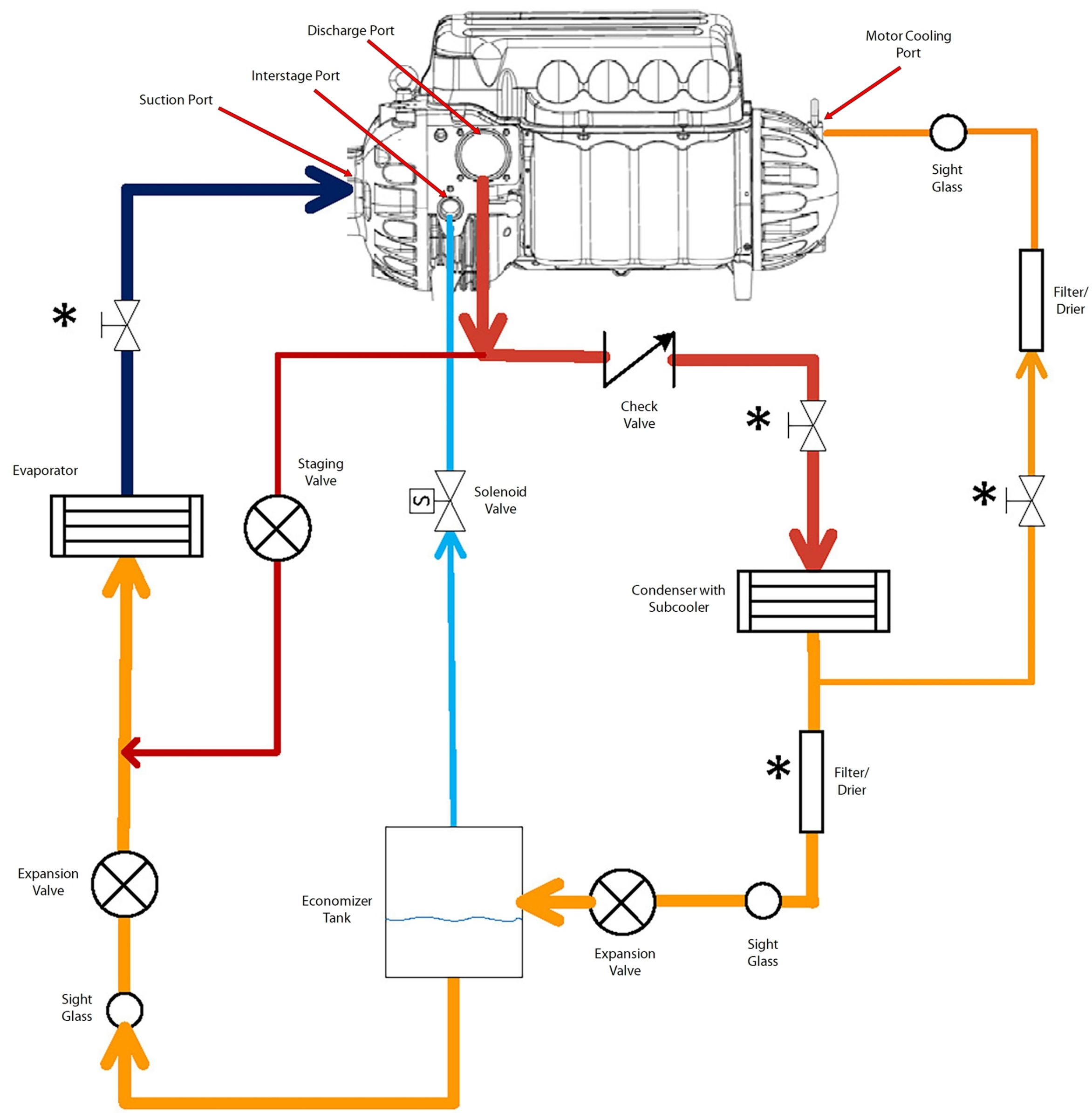
NOTE
* Service valves are optional

Figure 14-2 Typical Refrigeration Piping Schematic with Staging and Load Balancing Valve



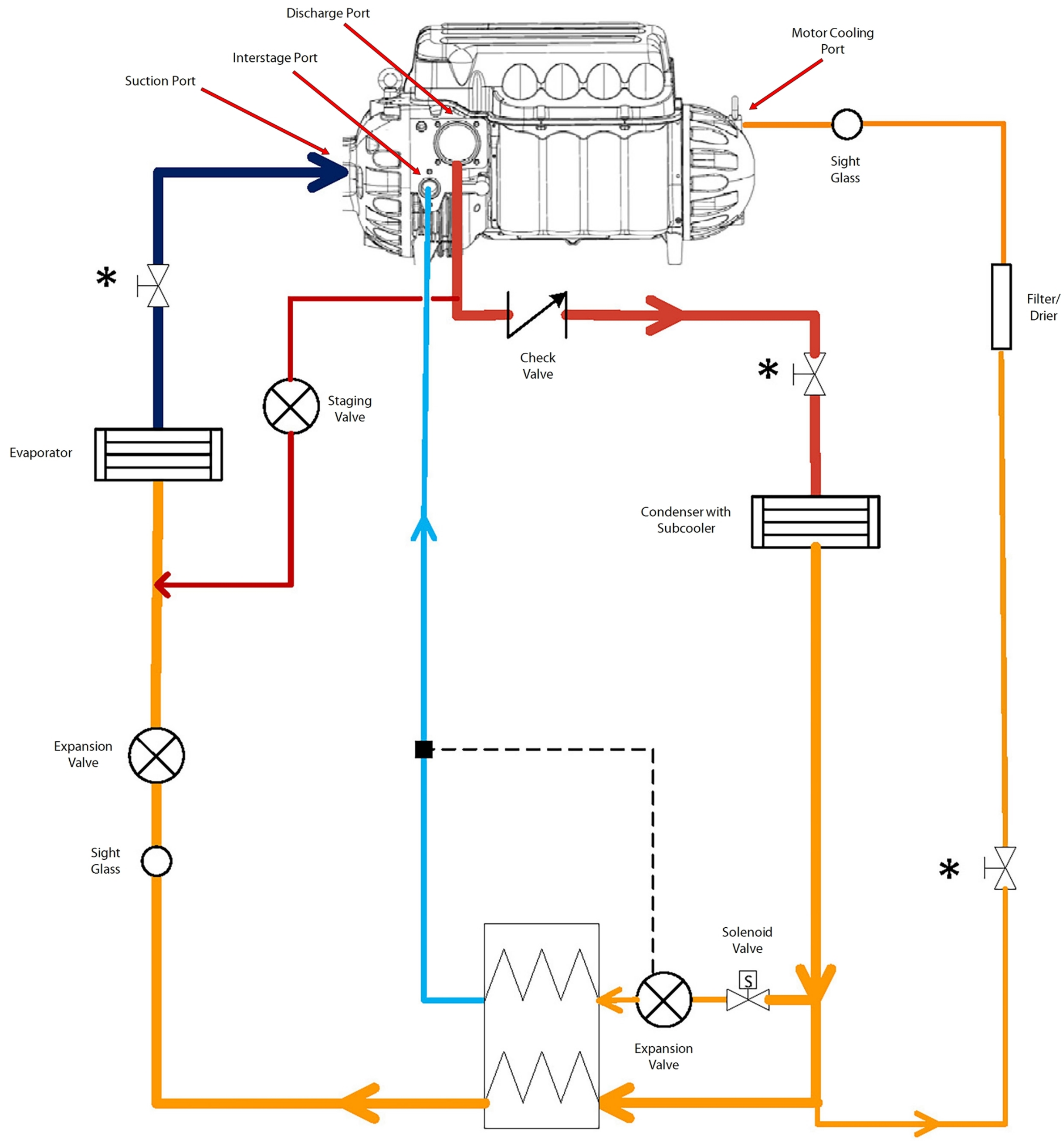
NOTE
* Service valves are optional

Figure 14-3 Typical Refrigeration Piping Schematic with Flash Tank Economizer



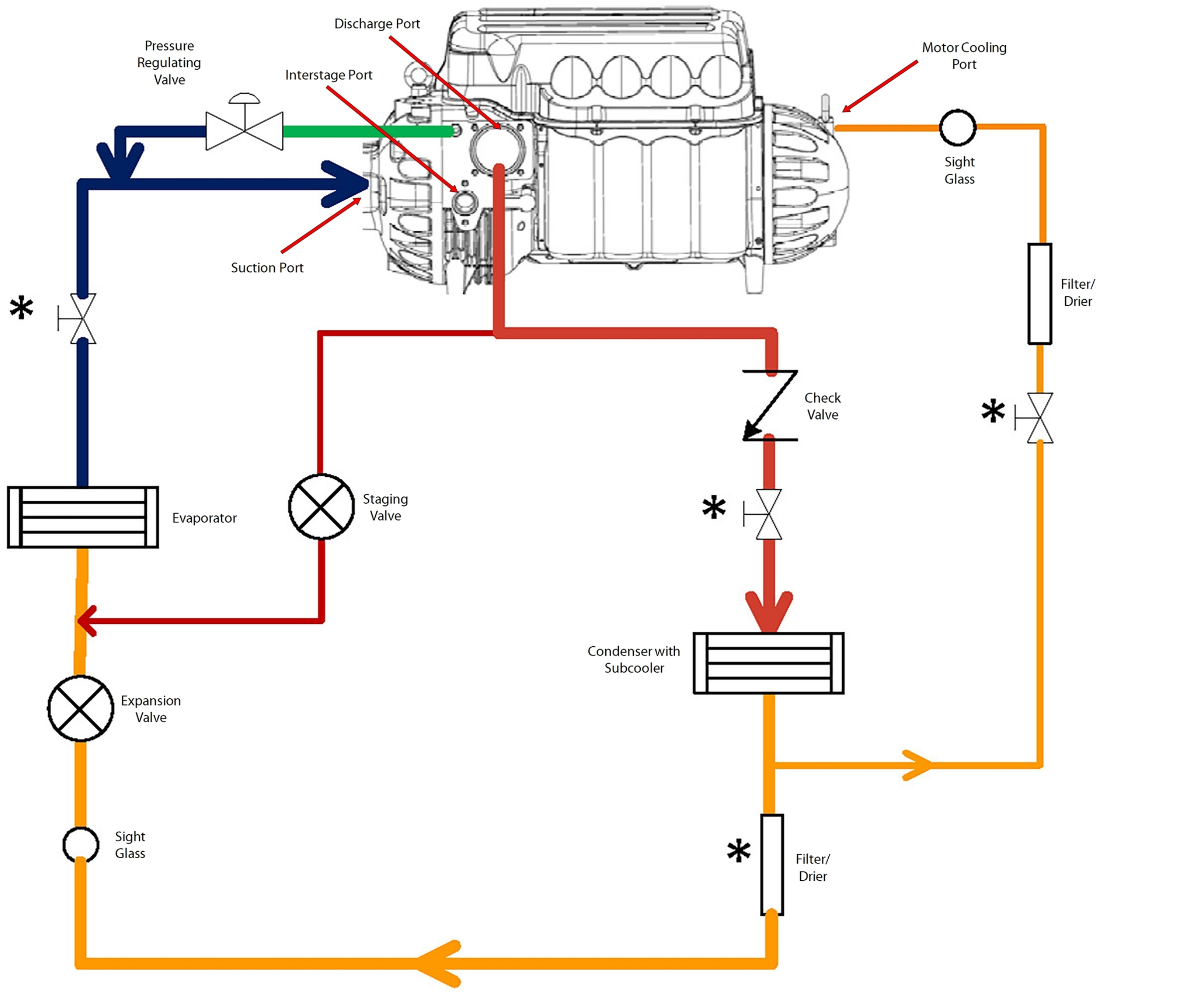
NOTE
* Service valves are optional

Figure 14-4 Typical Refrigeration Piping Schematic with Closed Type Economizer



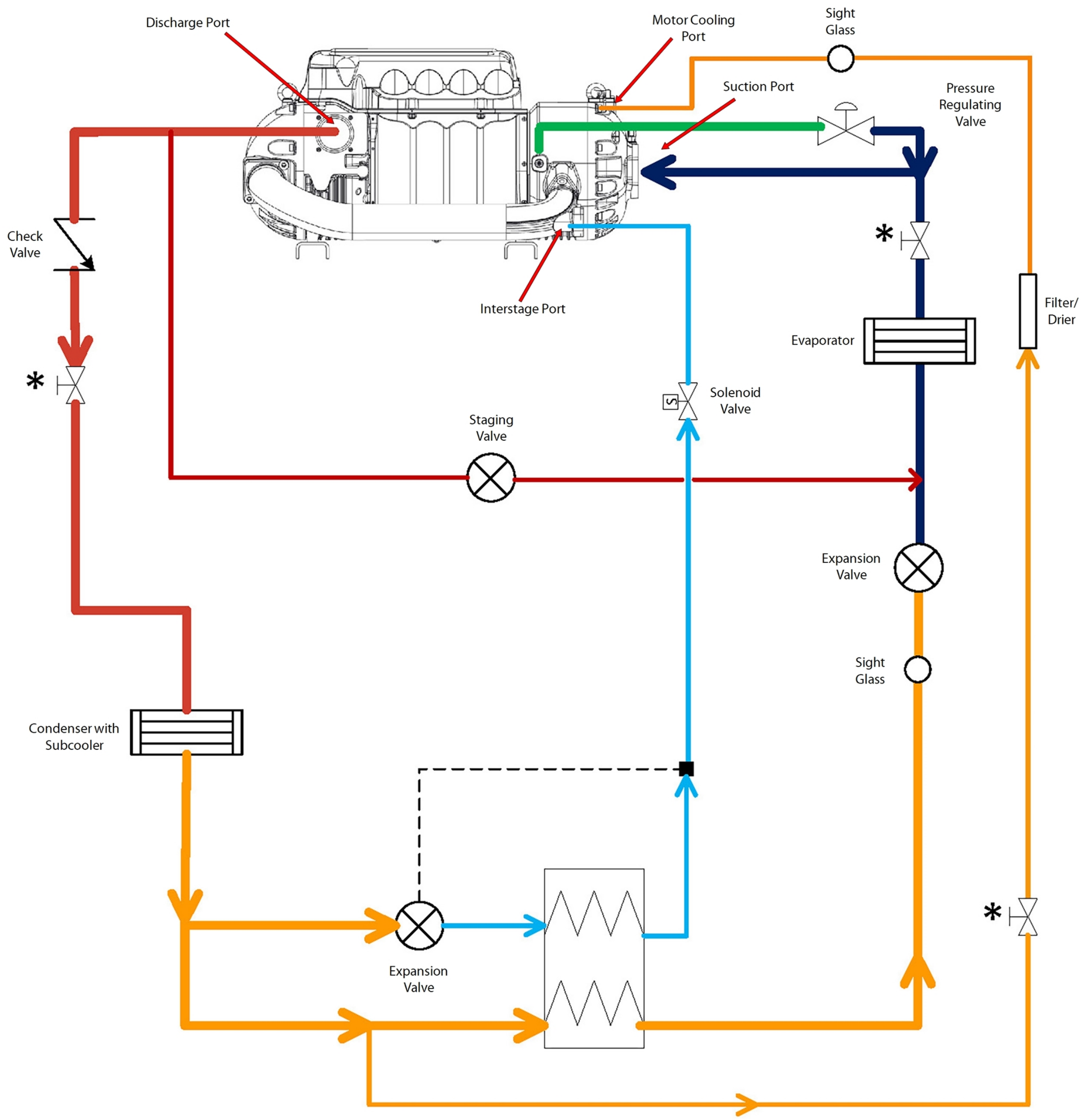
NOTE
* Service valves are optional

Figure 14-5 Typical Refrigeration Piping Schematic Using Motor-Cooling Pressure Regulating Valve (TTS300/TGS230 Medium Temperature Compressors Only)



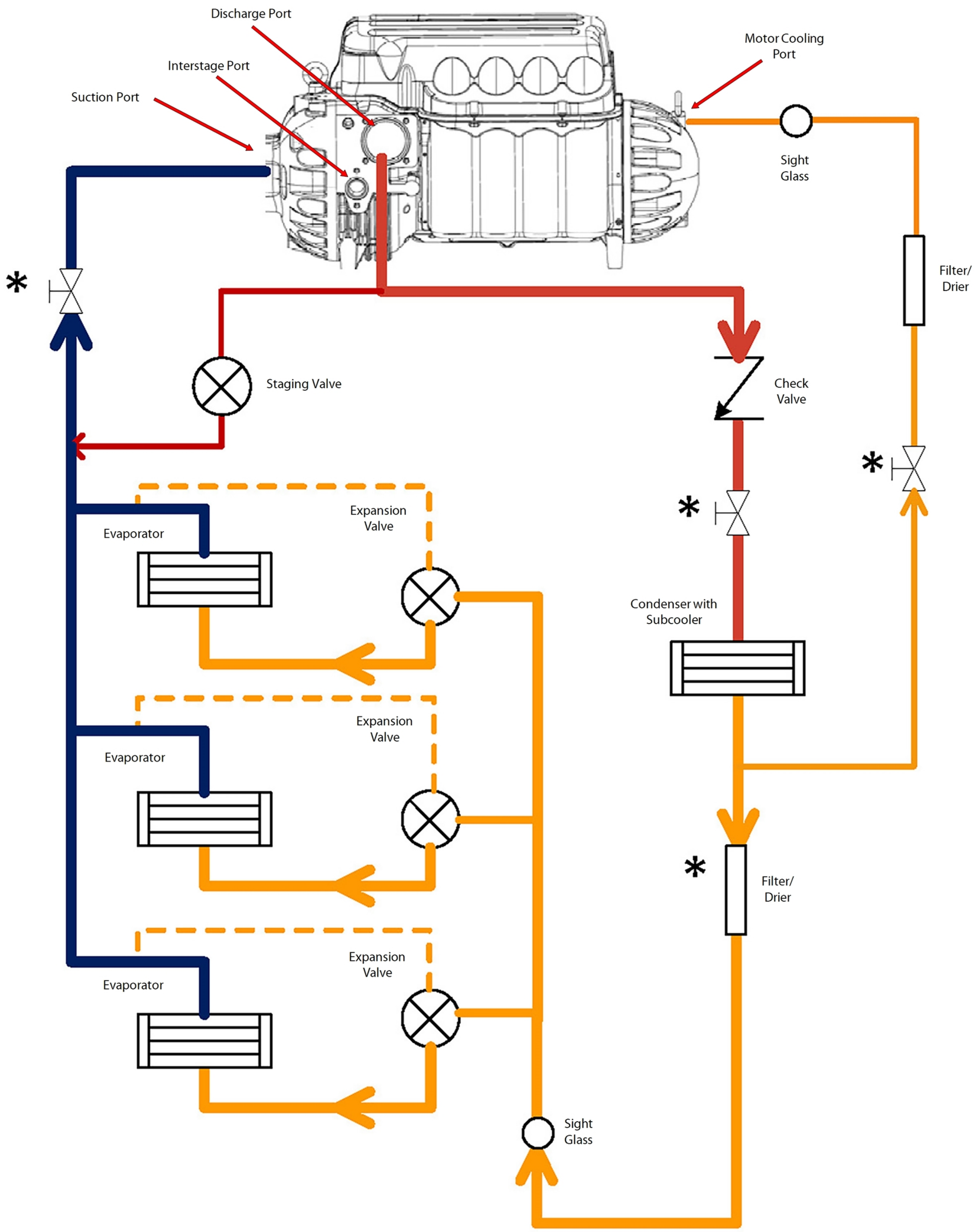
NOTE
* Service valves are optional

Figure 14-6 Typical Refrigeration Piping Schematic Using Motor-Cooling Pressure Regulating Valve (TTH/TGH Medium Temperature Compressors Only)



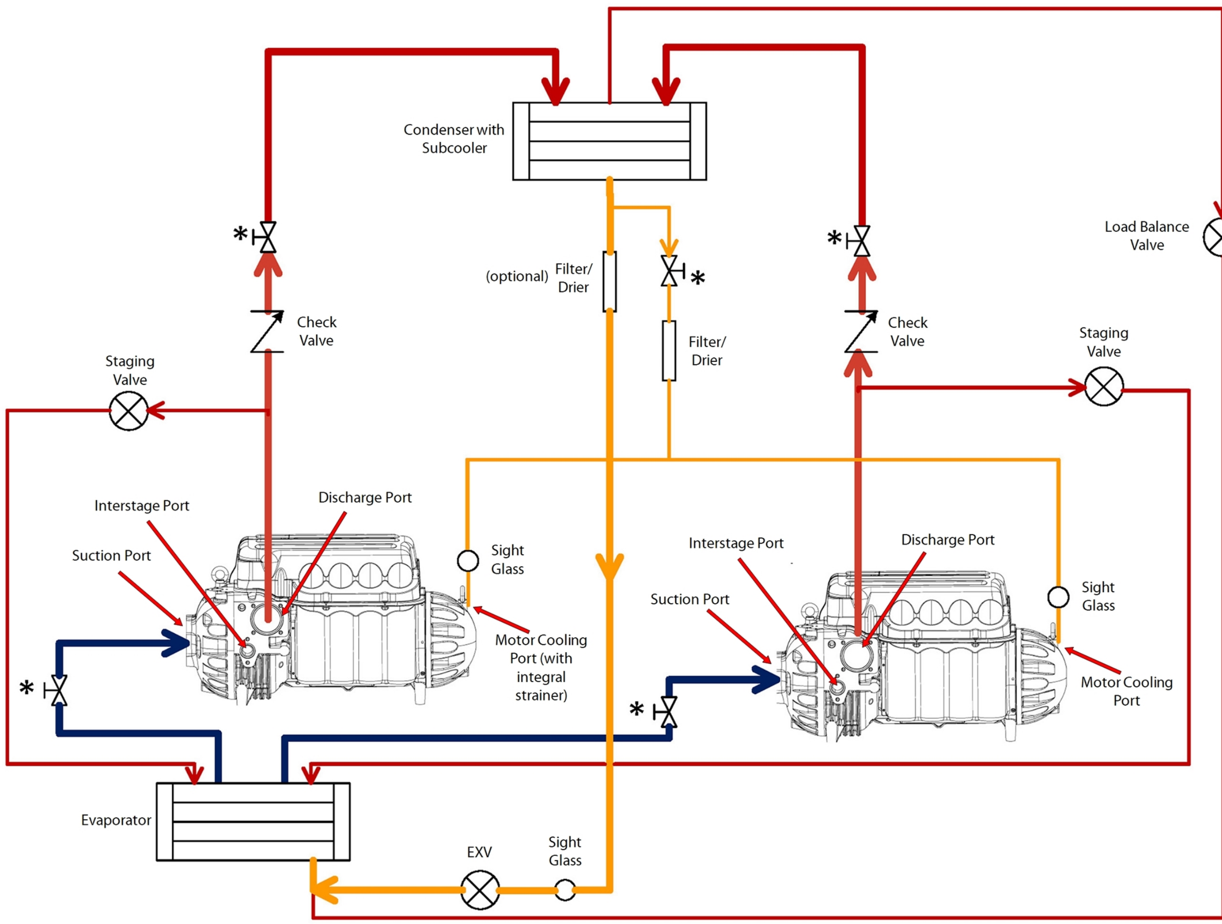
NOTE
• * Service valves are optional • Closed type economizer shown; open type can also be used

Figure 14-7 Typical Refrigeration Piping Schematic with Multiple DX Evaporators



NOTE
* Service valves are optional

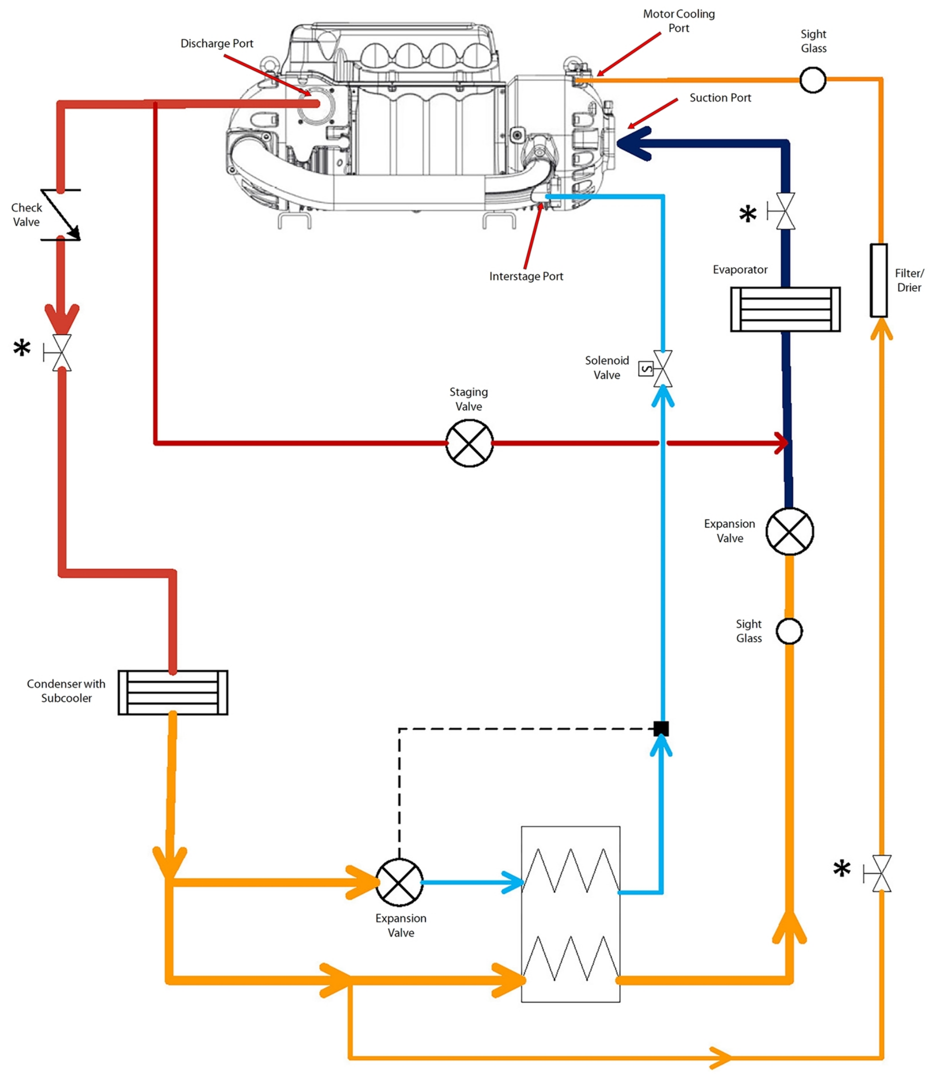
Figure 14-8 Multiple Compressors Single Circuit Piping Schematic



NOTE
Contact Danfoss LLC for compressor selection and further technical advice

NOTE
* Service valves are optional

Figure 14-9 TTH/TGH Piping Schematic with Required Economizer (Closed Type) and Vapor Line Solenoid



NOTE

Failure to include a solenoid valve in the compressor VAPOR line, wired to close immediately when the compressor shuts down, could result in serious damage to the compressor.

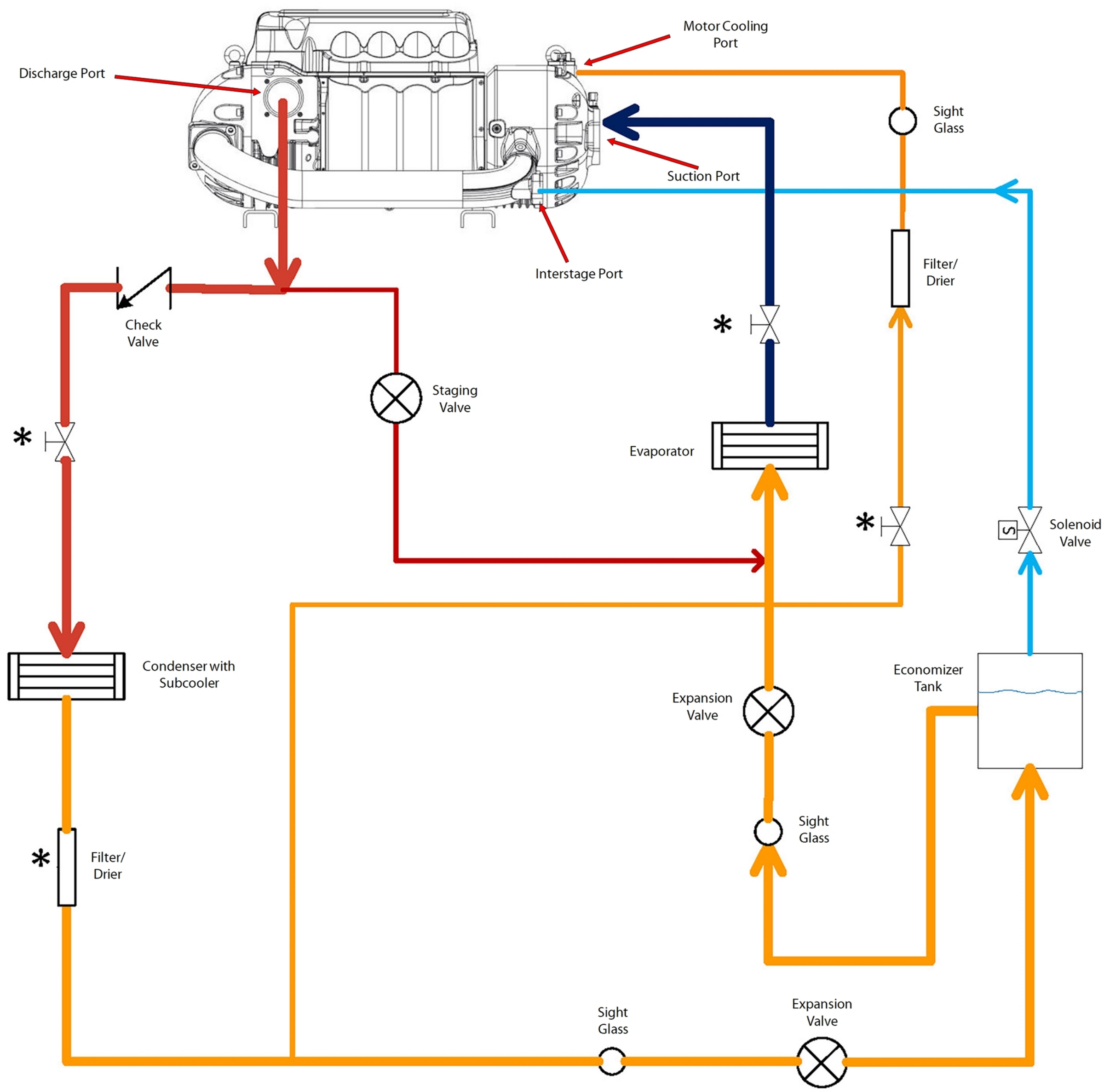
NOTE

All TGH/TTH compressors MUST include an active economizer (flash or plate style) when operated at pressure ratios above 2.0. If an economizer is not active at pressure ratios above 2.0, significant instability should be expected and the operating range of the compressor will not meet rated expectations. Economizer should be deactivated below PR 2.0

NOTE

* Service valves are optional

Figure 14-10 TTH/TGH Piping Schematic with Required Economizer (Flash Tank) and Vapor Line Solenoid



NOTE
* Service valves are optional

Chapter 15.0 Sound and Power Specifications

15.1 TTS300 and TTS400 Sound Power Measurements

The sound power levels on the TTS300 and TTS400 compressors are measured in compliance with ISO 9614-1 (1993) and are given in decibels and in A-scale dB(A).

Three series of sound power measurements were performed on the unit while in two (2) different modes:

- For TTS300: 250kW (70 ton) refrigeration capacity
- 315kW (90 ton) refrigeration capacity

For TTS400:

- 420kW (120 ton) refrigeration capacity
- 525kW (150 ton) refrigeration capacity

15.1.1 Results

The sound power measured under each operational mode is presented in Table 15-1 Sound Power Measurements for TTS300

- Table 15-1 Sound Power Measurements for TTS300
- Table 15-2 Sound Pressure Calculation for TTS300
- Table 15-4 Sound Power Measurements for TTS400
- Table 15-5 Sound Pressure Calculation for TTS400

These tables present the results of sound pressure calculations for various distances while the compressor is installed on top of a building.

- The sound data below should be used as a guide only.
- The following sound measurements are based on a specific physical setup, such as suction/discharge piping, evaporator and condensers, as well as specific pressure ratios. Any OEM system design would not necessarily match these conditions.
- OEMs are responsible for their system sound level measurements and their published data.

Below are the results from “Sound Power Measurements"on a Turbocor TTS300 compressor.

Table 15-1 Sound Power Measurements for TTS300

Operation Mode	Sound Power (A-Scale) dBA	Sound Power (Linear Scale) dB	Dominant Frequency
250 kW	81.5	81.5	1070 Hz
315 kW	86	85.5	1180 Hz

Table 15-2 Sound Pressure Calculation for TTS300

Distance in Relation to Compressor (Meters)	Operational Mode of Compressor (Capacity)	
	250 kW (70 Ton) dBA	315 kW (90 Ton) dBA
1	73.5	78.0
1.5	70.0	70.0
3	64	68.5
5	59.5	64.0
8	55.5	60.0

Table 15-3 Sound Power at Third Octave Band for TTS300

Sound Power, 250kW (70 Ton)			Sound Power, 315kW (90 Ton)		
Third octave band (Hz)	Linear scale (dB)	A-weighted (dBA)	Third octave band (Hz)	Linear scale (dB)	A-weighted (dBA)
160	55.5	41.8	160	59.6	45.8
200	62.0	51.7	200	64.9	54.9
250	63.9	55.6	250	67.7	59.5
315	68.7	62.0	315	69.9	63.4
400	66.9	62.3	400	66.6	62.2
500	71.5	68.6	500	65.7	62.6
630	60.2	58.4	630	71.8	69.8
800	65.1	64.5	800	67.7	67.2
1000	76.5	76.7	1000	70.5	70.6
1250	66.2	66.9	1250	82.3	83.0
1600	69.9	71.0	1600	72.6	73.9
2000	69.6	70.9	2000	73.3	74.7
2500	68.6	69.9	2500	72.8	74.3
3150	72.3	73.6	3150	75.3	76.7
4000	71.3	72.3	4000	74.6	75.8

Table 15-4 Sound Power Measurements for TTS400

Operation Mode	Sound Power (A-Scale) dBA	Sound Power (Linear Scale) dB
420 kW (120 Ton)	88.4	89.1
525 kW (150 Ton)	88.1	89.2

Table 15-5 Sound Pressure Calculation for TTS400

Distance in Releation to Compressor (Meters)	Operational Mode of Compressor (Capacity)	
	420 kW (120 Ton) dBA	525 kW (150 Ton) dBA
1	80.5	80
1.5	77	76.5
3	71	70.5
5	66.5	66
8	62.3	62

Table 15-6 Sound Power at Third Octave Band for TTS400

Sound Power, 420kW (120 Ton)			Sound Power, 525kW (150 Ton)		
Third octave band (Hz)	Linear scale (dB)	A-weighted (dBA)	Third octave band (Hz)	Linear scale (dB)	A-weighted (dBA)
160	51	65	160	55	70
200	49	67	200	50	62
350	60	70	250	61	70
315	60	68	315	62	69
400	64	71	400	65	75
500	63	65	500	62	66
630	78	79	630	76	79
800	80	81	800	78	80
1000	83	82	1000	82	83
1250	82	81	1250	81	81
1600	77	76	1600	75	74
2000	77	76	2000	75	74
2500	75	74	2500	76	76
3150	75	75	3150	75	76
4000	72	71	400	73	73

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Chapter 16.0 Physical Data

This section contains data relative to compressor mounting, service clearance, and piping connections.

NOTE

The dimensions in the following figures show measurements in metric with imperial in parenthesis.

Table 16-1 Physical Dimensions

Model	Length	Width	Height	Shipping Weight (Includes all shipping material)	Compressor Total Weight (Compressor Only)
TTS300/TGS230	788 mm (31.02")	518 mm (20.4")	487 mm (19.17)	134 kg (296 lbs)	123.4 kg (272 lbs)
TTS350/TGS310/TGS490	788 mm (31.02")	518 mm (20.4")	487 mm (19.17")	143 kg (315 lbs)	132 kg (291 lbs)
TTS400/TGS390	788 mm (31.02")	518 mm (20.4")	487 mm (19.17")	142 kg (312 lbs)	130.6 kg (288 lbs)
TTS700/TGS520	788 mm (31.02")	518 mm (20.4")	487 mm (19.17")	144 kg (318 lbs)	132 kg (294 lbs)
TTH375/TGH285	932 mm (36.7")	590 mm (23.2")	487 mm (19.17")	181 kg (400 lbs)	163.7 kg (361 lbs)

16.1 Clearance

Adequate clearance around the compressor is essential to facilitate maintenance and service. Removal of the compressor top and service-side covers requires a minimum clearance of 600 mm (24”) and 406 mm (16”), respectively.

NOTE

If insulators are used at the four mounting base points, the overall height of the compressor will change. Be sure to measure accordingly based on the insulator used.

Figure 16-1 Suction View All Models (Excluding TTH/TGH Compressors)

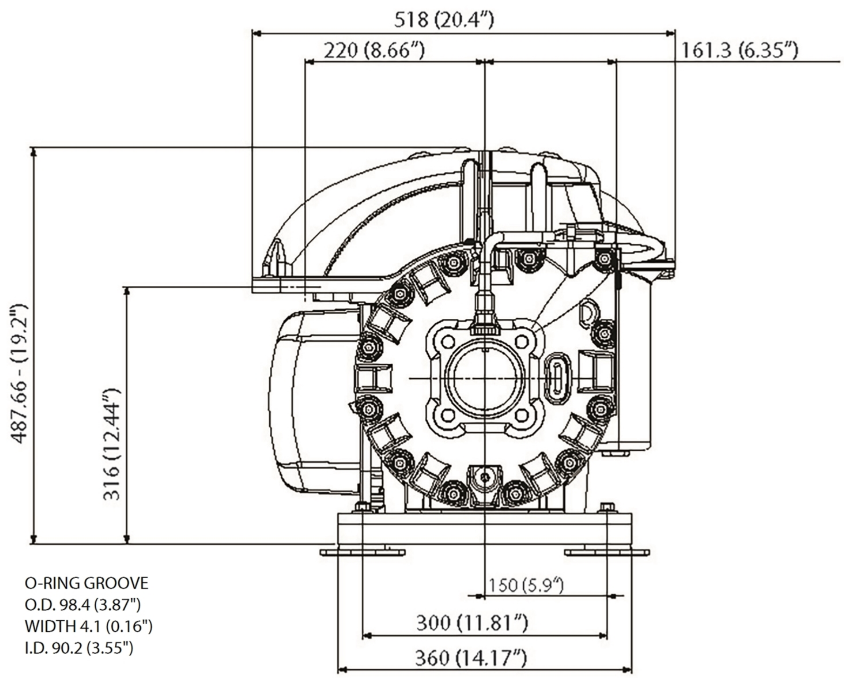


Figure 16-2 Service Side View (Excluding TTH/TGH Compressors)

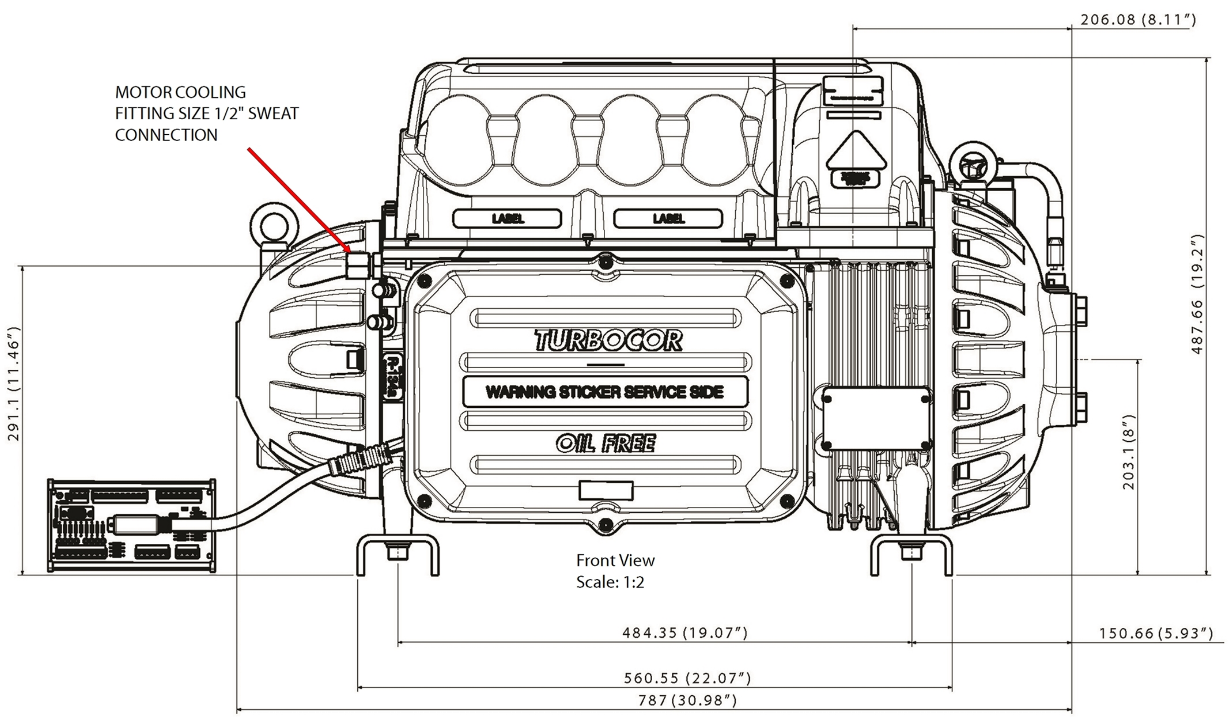


Figure 16-3 Discharge Side View (Excluding TTH/TGH Compressors)

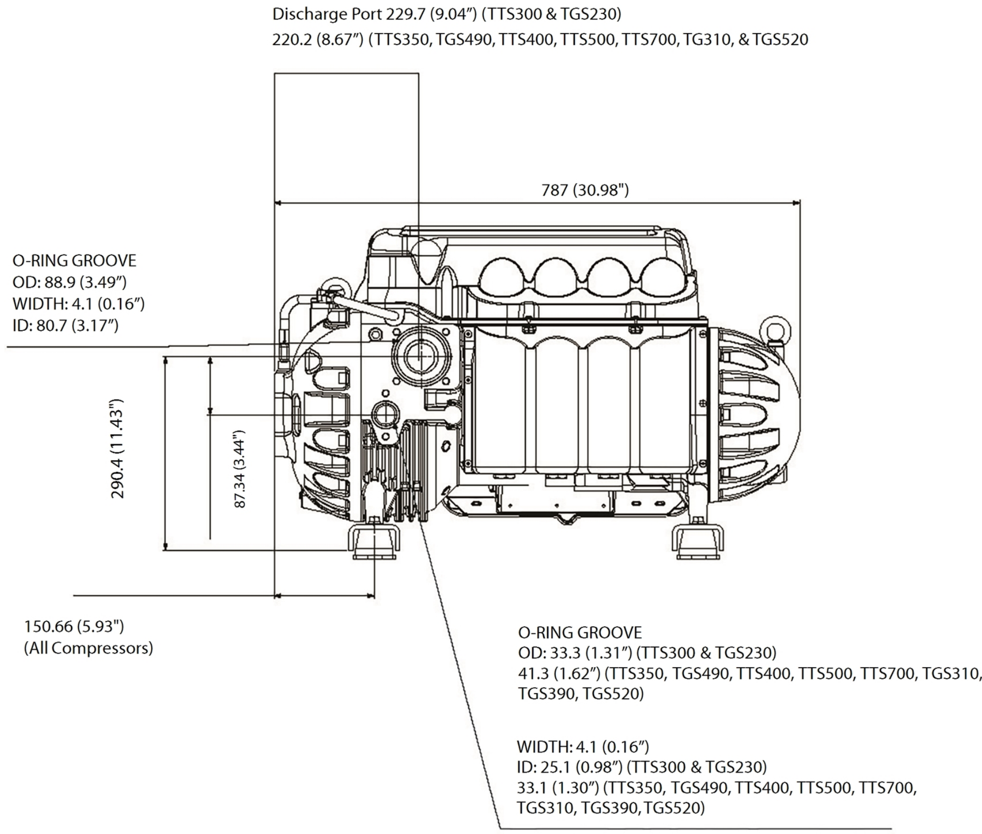


Figure 16-4 TTH/TGH Suction Side View

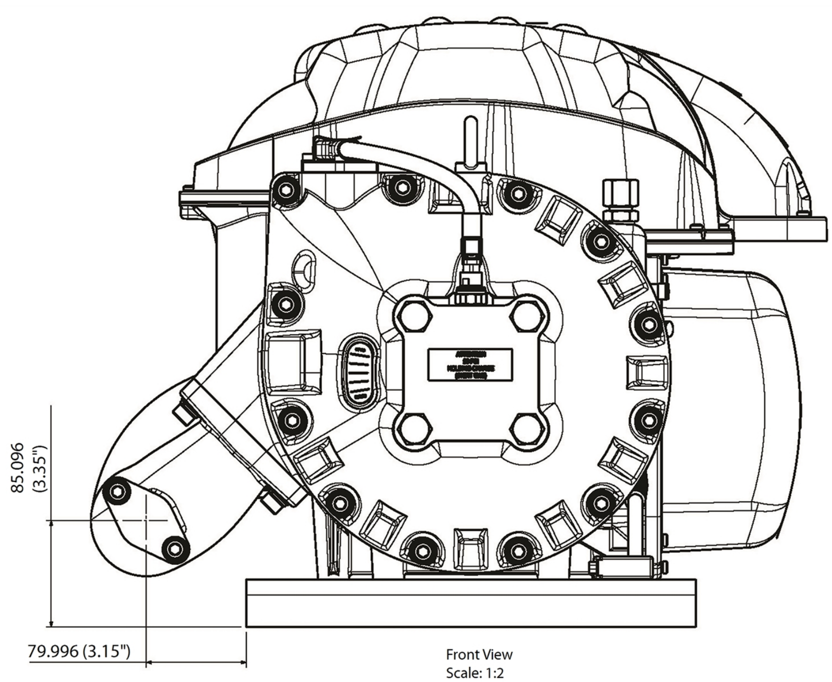


Figure 16-5 TTH/TGH Service Side View

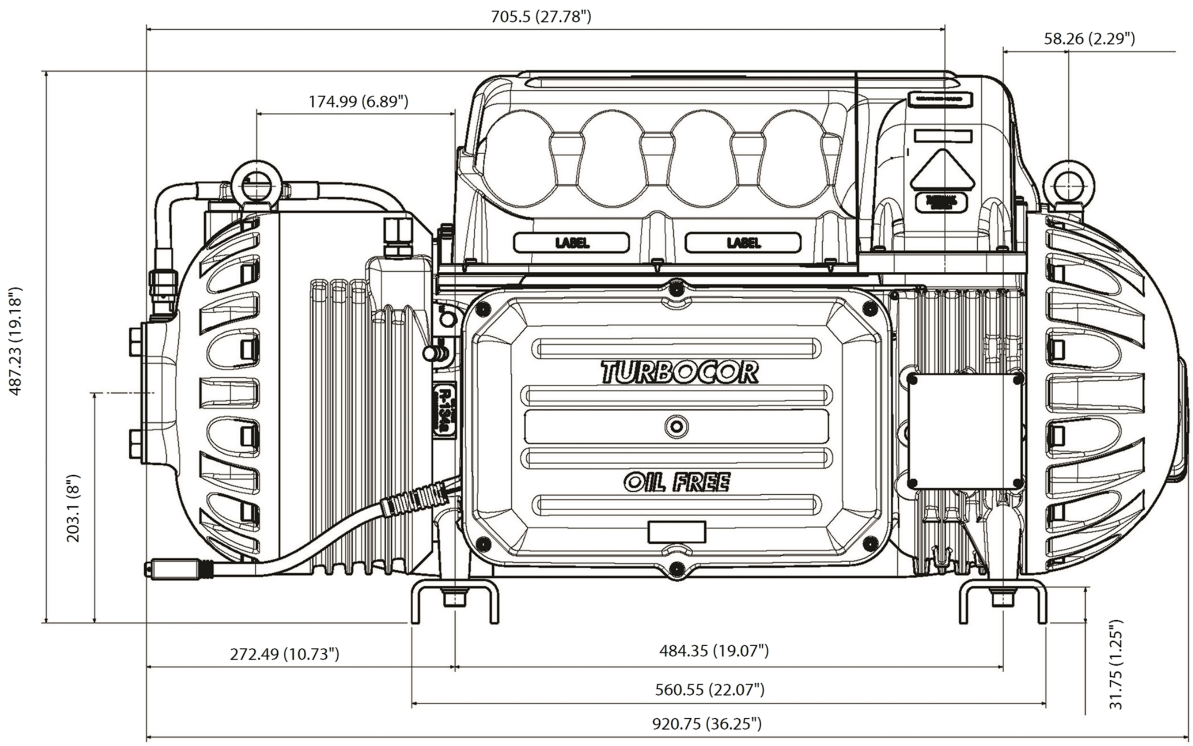


Figure 16-6 TTH/TGH Second Stage Housing View

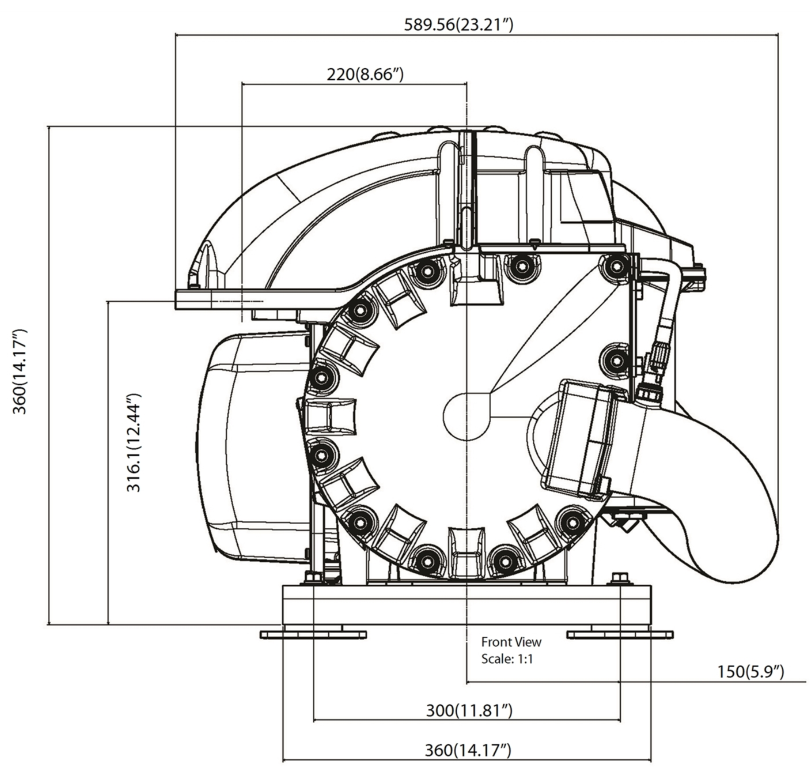


Figure 16-7 TTH/TGH Discharge Side View

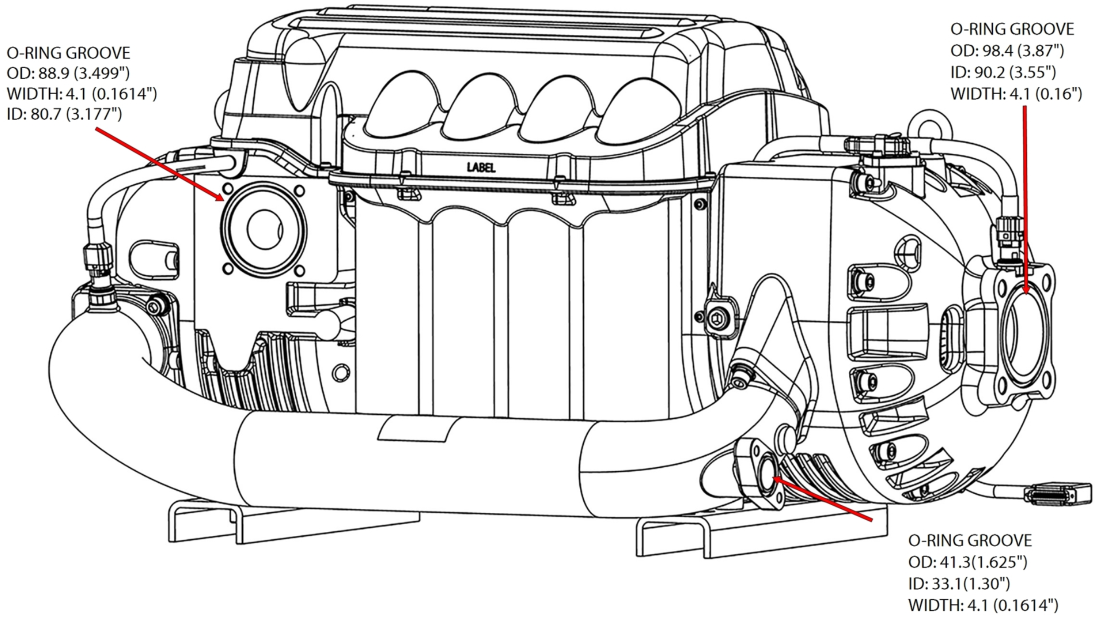


Figure 16-8 Center of Gravity Capacitor Side View (Excluding TTH/TGH Compressors)

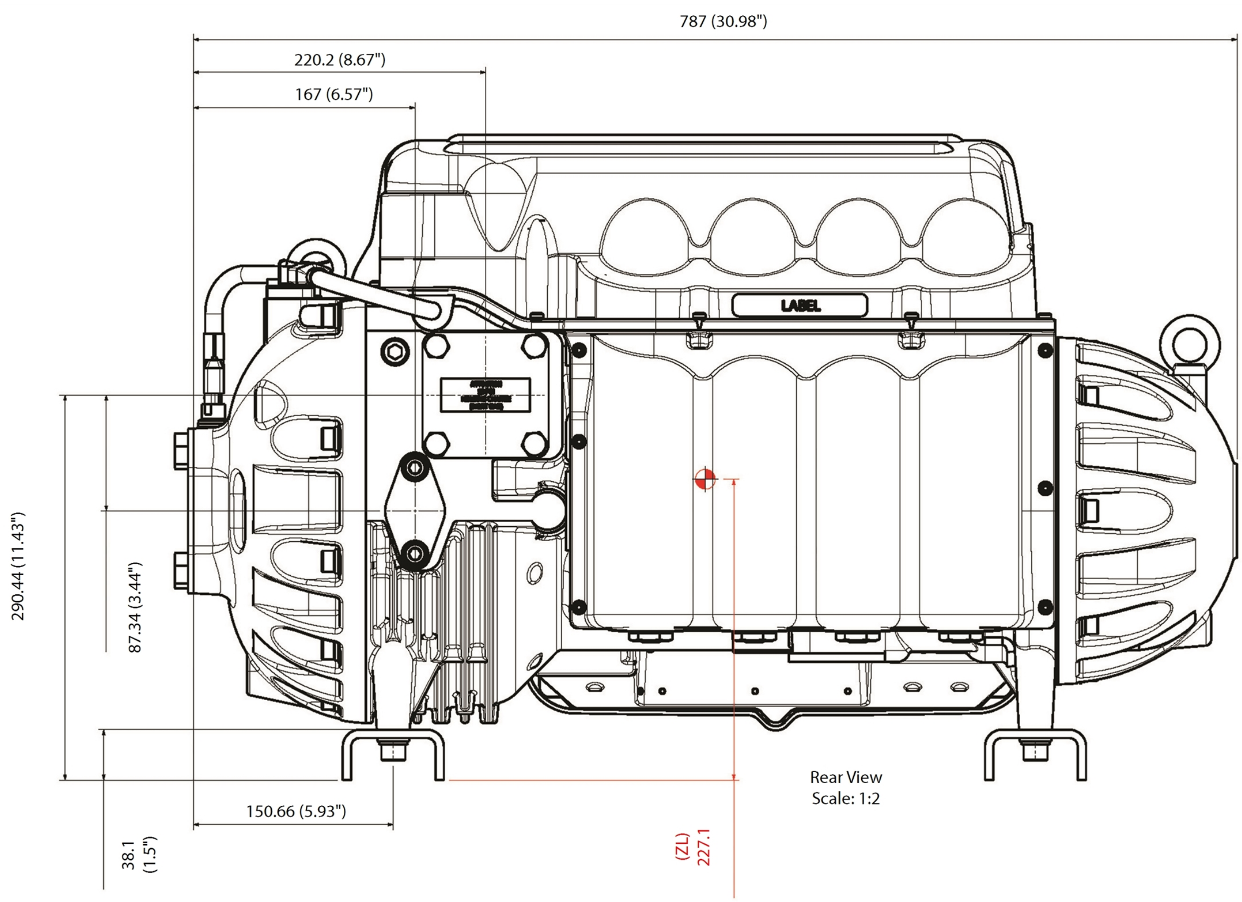


Figure 16-9 Center of Gravity Top View (Excluding TTH/TGH Compressors)

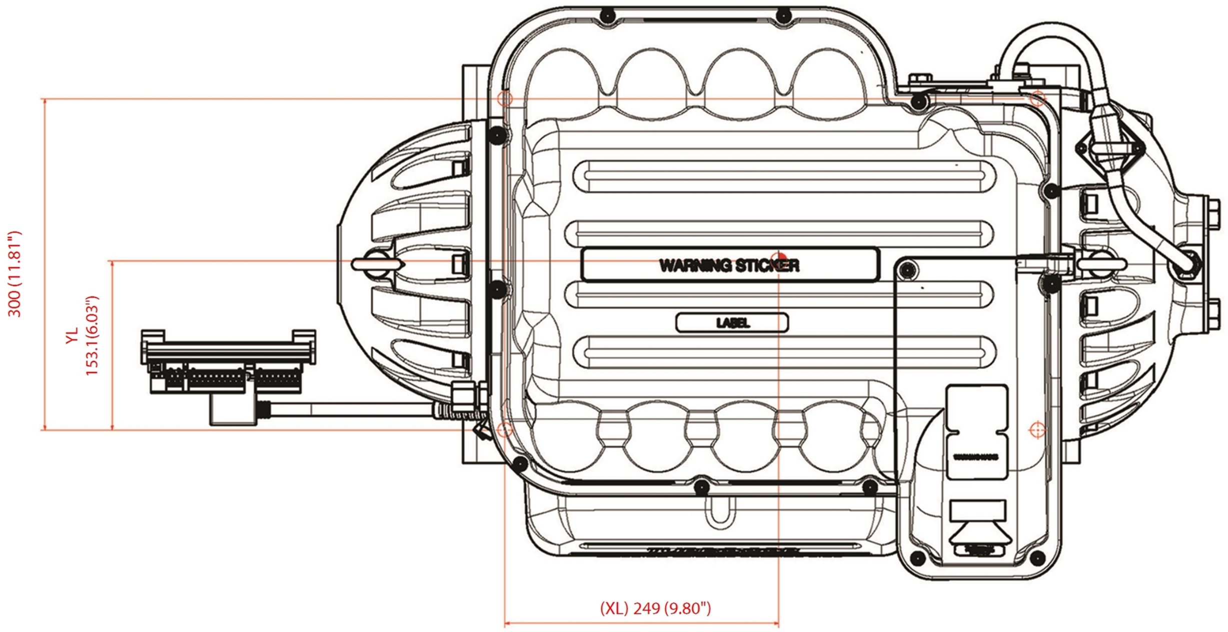


Figure 16-10 TTH/TGH Center of Gravity Capacitor Side View

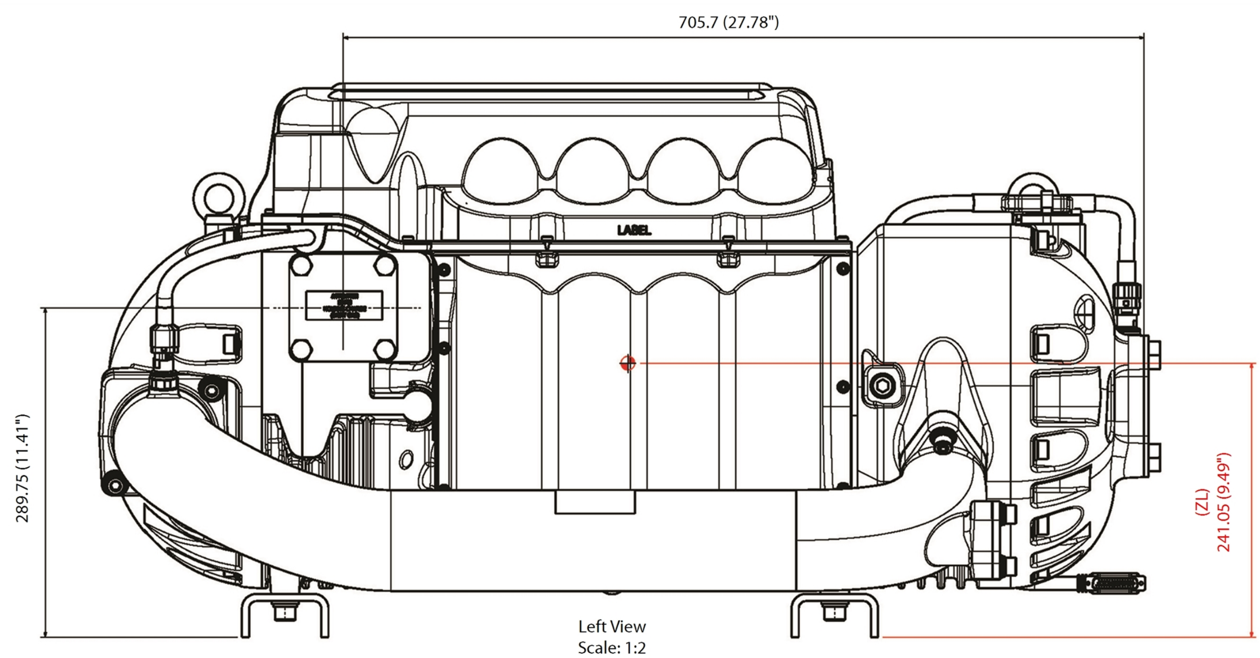


Figure 16-11 TTH/TGH Center of Gravity Top View

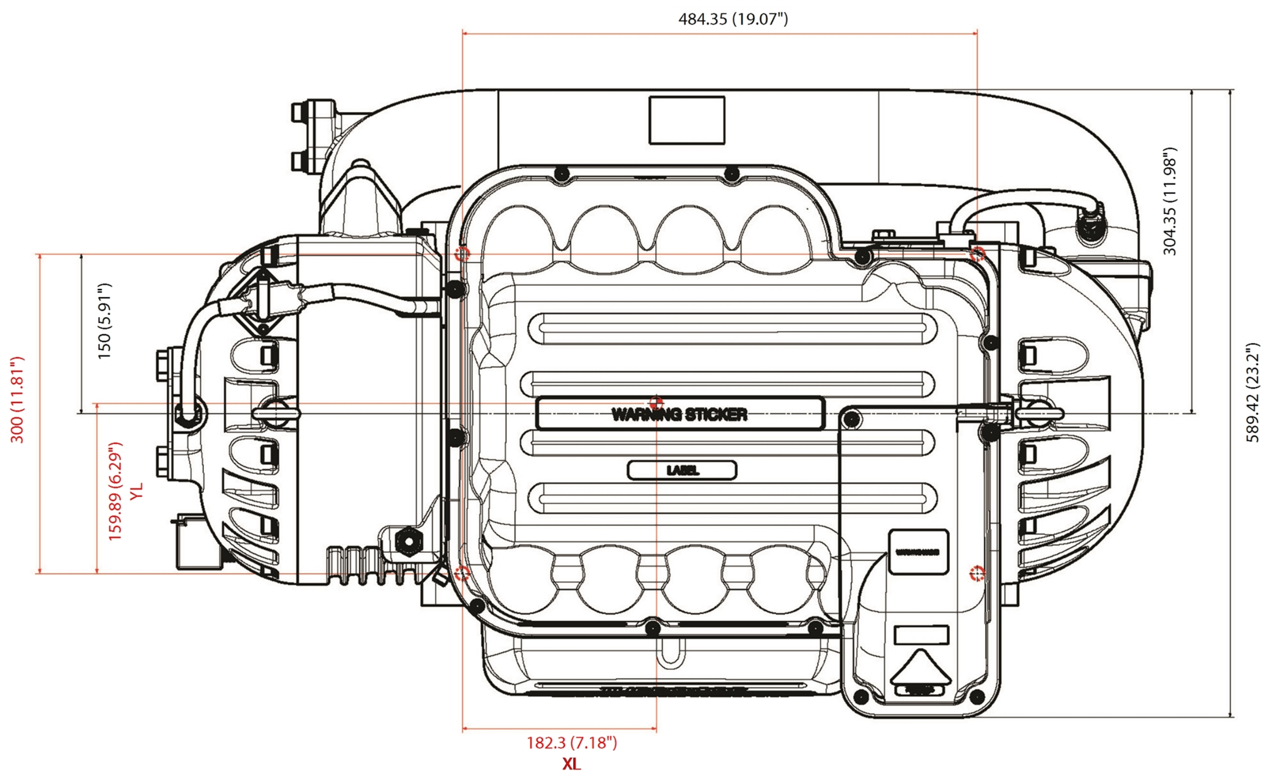


Table 16-2 Center of Gravity X-Y Coordinates

	Description	Parameter	TTS300/ TGS230	TGS490/ TTS350/ TGS310	TTS400/ TGS390	TTS700/ TGS520	TTH375/ TGH285
CG Line	Length of Center of Gravity m (in)	XL	257 mm (10.13")	249 mm (9.80")	247 mm (9.74")	251mm (9.87")	182.3 mm (7.18")
	Width of Center of Gravity m (in)	YL	151 mm (5.95")	153.1 mm (6.03")	152 mm (5.97")	150 mm (5.91")	159.9 mm (6.29")
	Height of Center of Gravity m (in)	ZL	215 mm (8.464")	227.1 mm (8.94")	227 mm (8.94")	227 mm (8.94")	241.05 mm (9.49")

Compressor valve flange details are shown in Figure 16-12 Discharge Port Detail (TTS300 and TGS230) through Figure 16-22 TTS700, TGS490, and TGS520 Flange Footprint Details." Refer to the product specifications in the Spare Parts Selection Guide for further details.

Figure 16-12 Discharge Port Detail (TTS300 and TGS230)

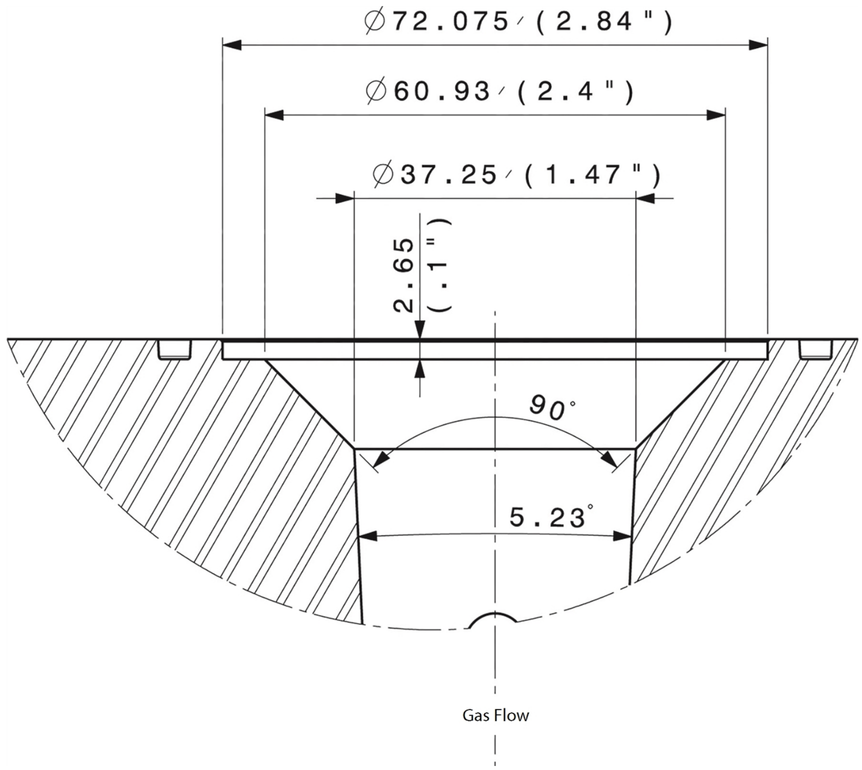


Figure 16-13 Discharge Port Detail (TTS350 and TGS310)

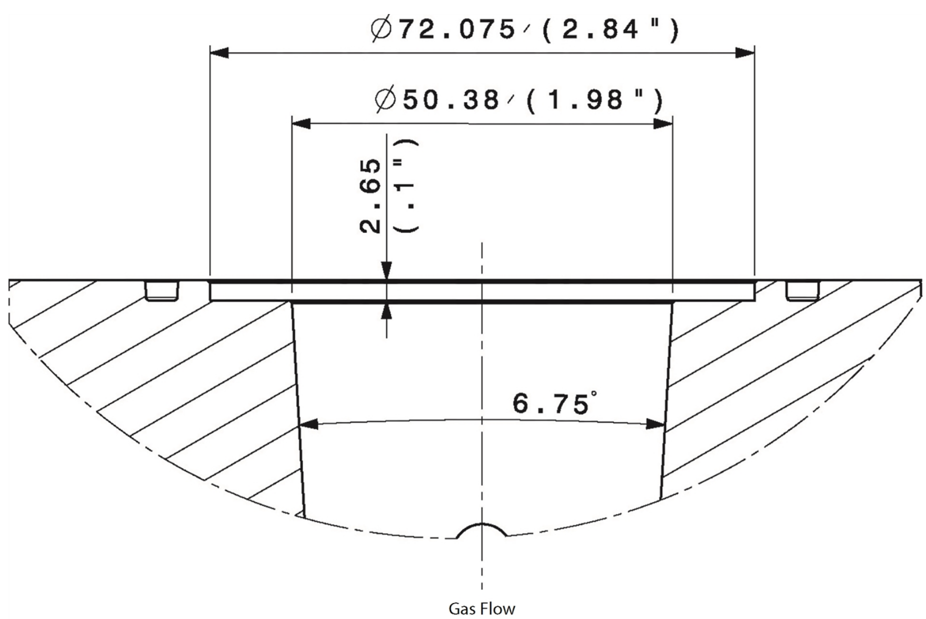


Figure 16-14 Discharge Port Detail (TTS400 and TGS390)

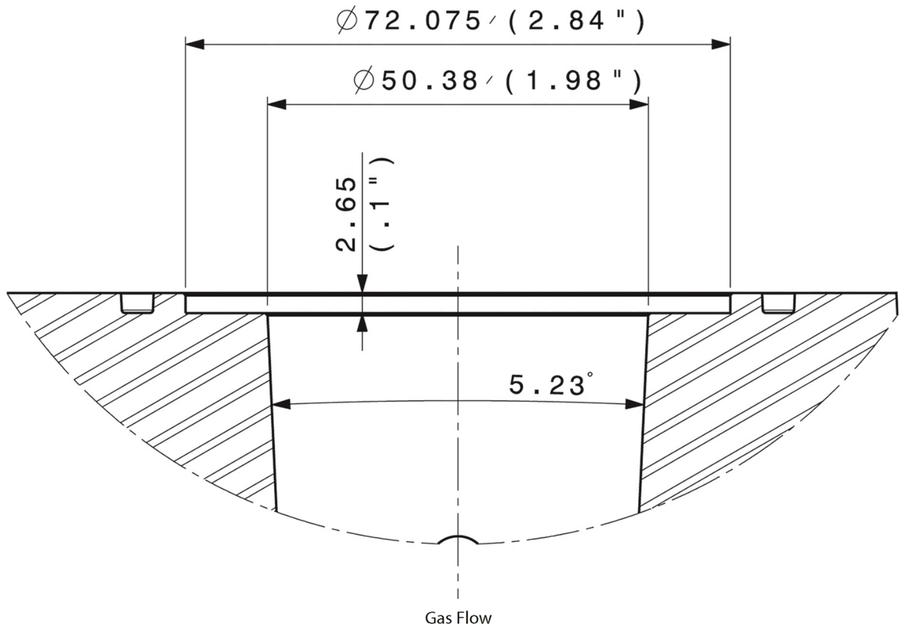


Figure 16-15 Discharge Port Detail (TTS700, TGS490, and TGS520)

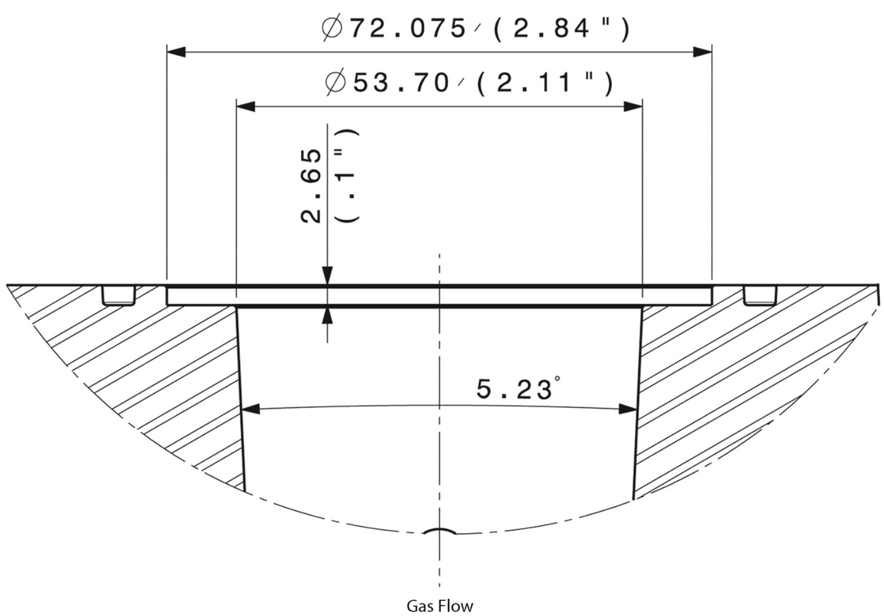


Figure 16-16 Discharge Port Detail (TTH375 and TGH285)

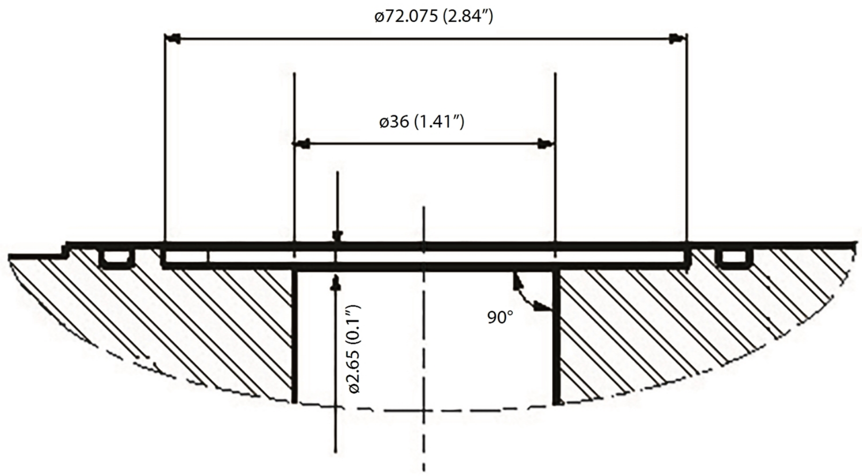
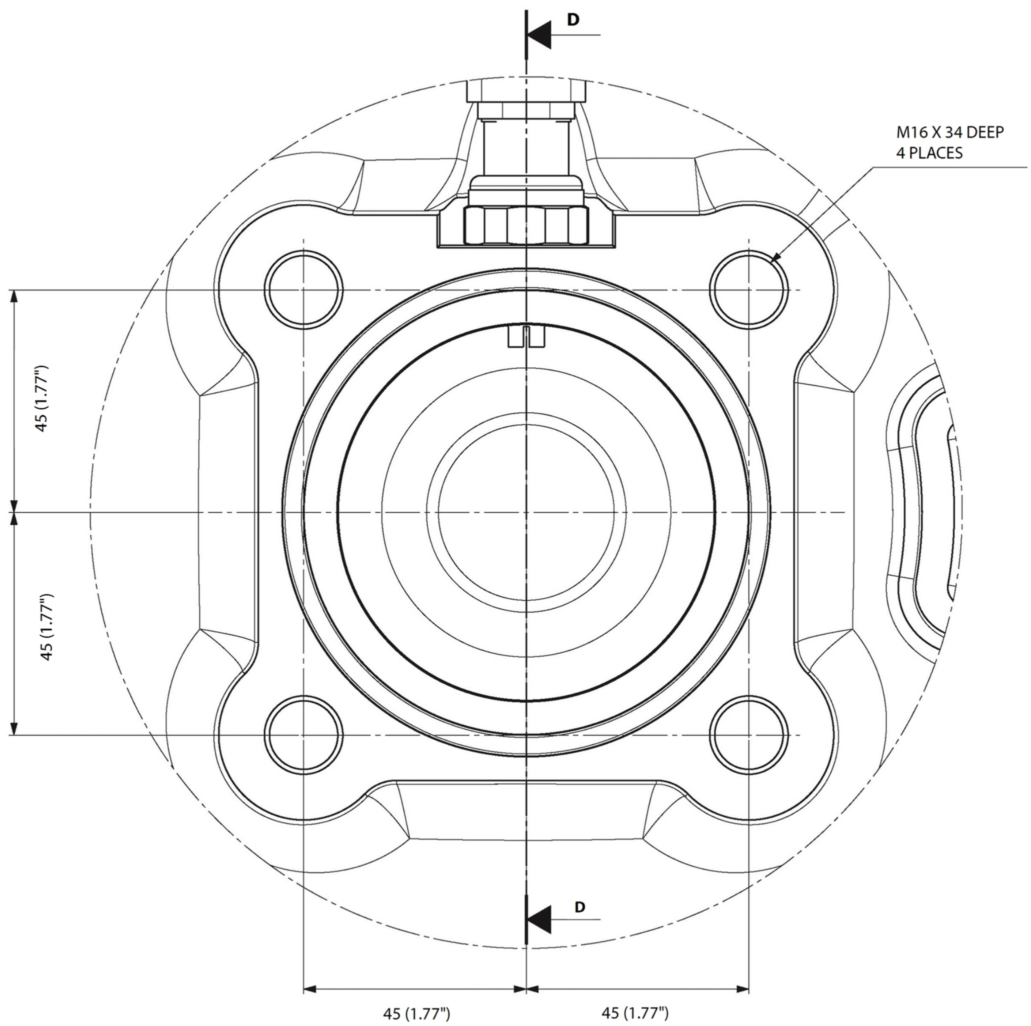


Figure 16-17 Suction Port (All Models)



Suction Port - Scale 1:1

Figure 16-18 Suction Port Detail (All Models Excluding TTS700, TGS490, and TGS520)

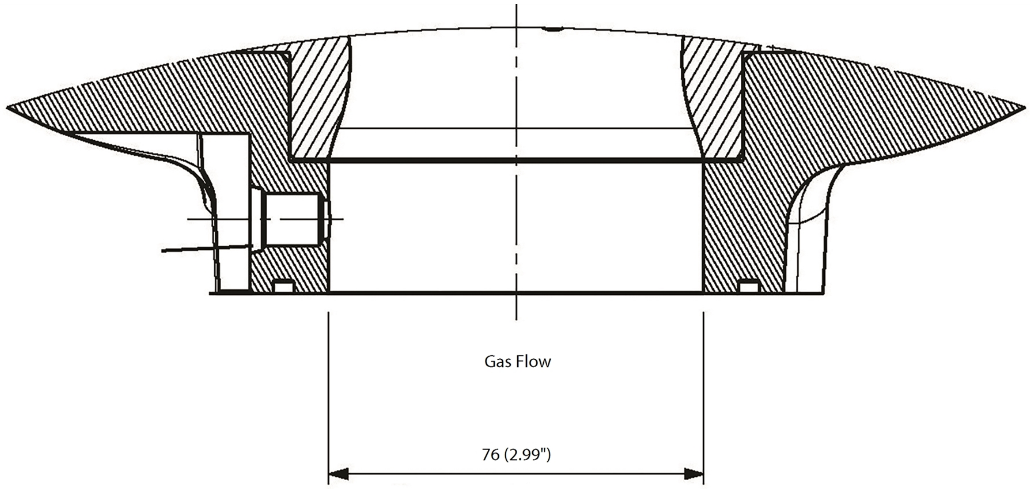


Figure 16-19 Suction Port Detail (TTS700, TGS490, and TGS520)

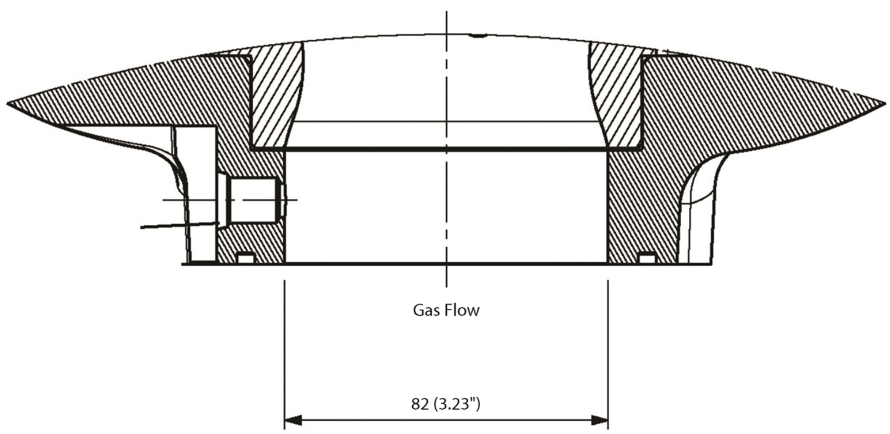


Figure 16-20 TTS300 and TGS230 Flange Footprint Details

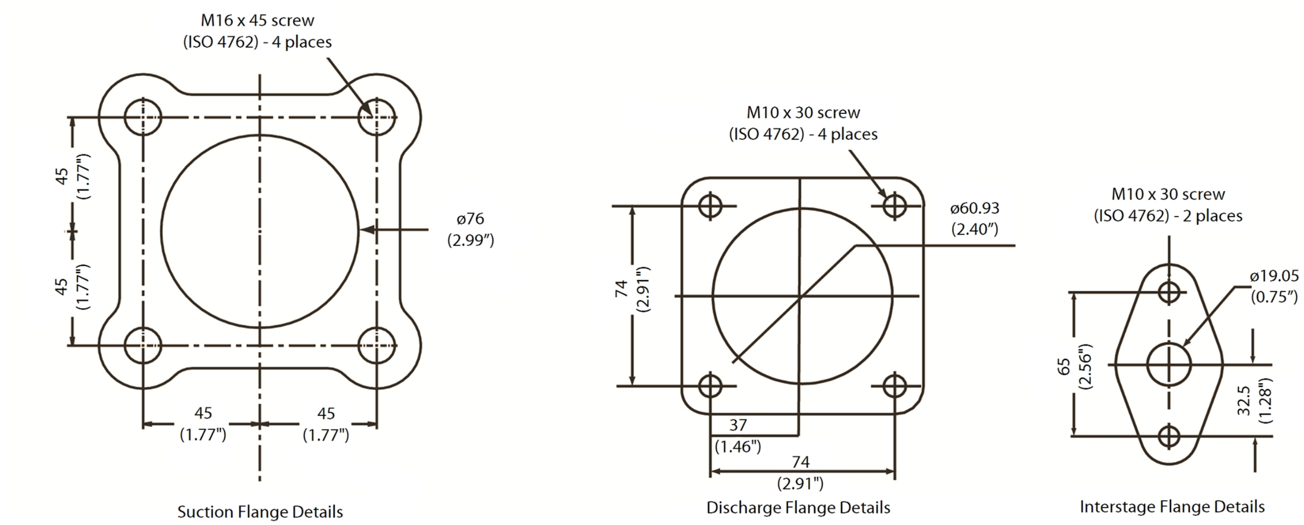


Figure 16-21 TTS350, TGS310, TTS400, TGS390, TTH375, and TGH285 Flange Footprint Details

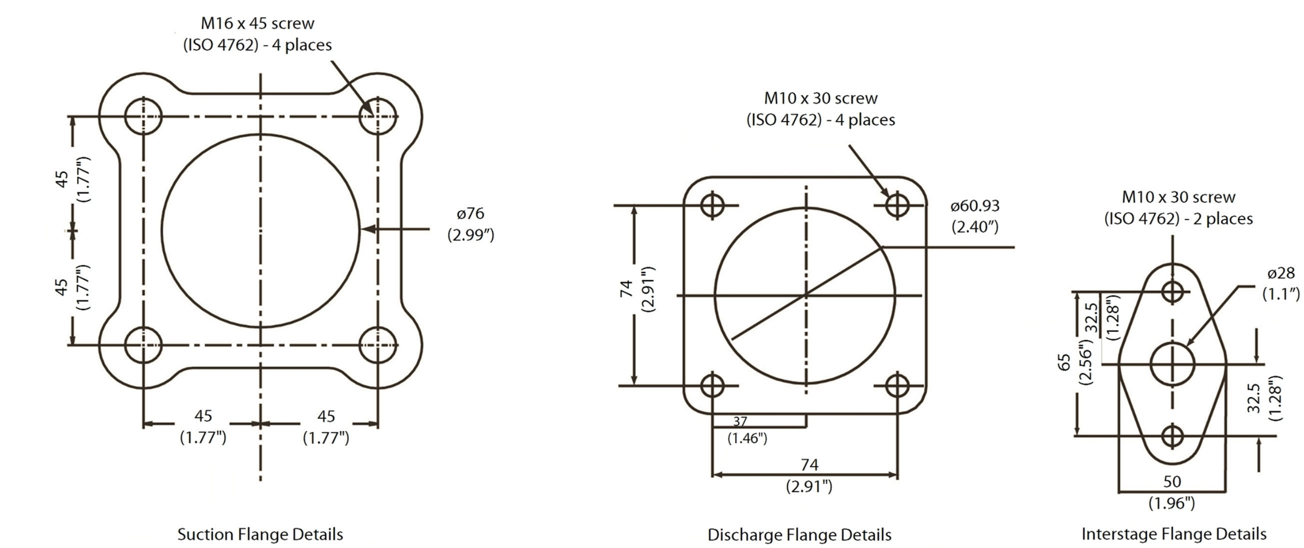


Figure 16-22 TTS700, TGS490, and TGS520 Flange Footprint Details

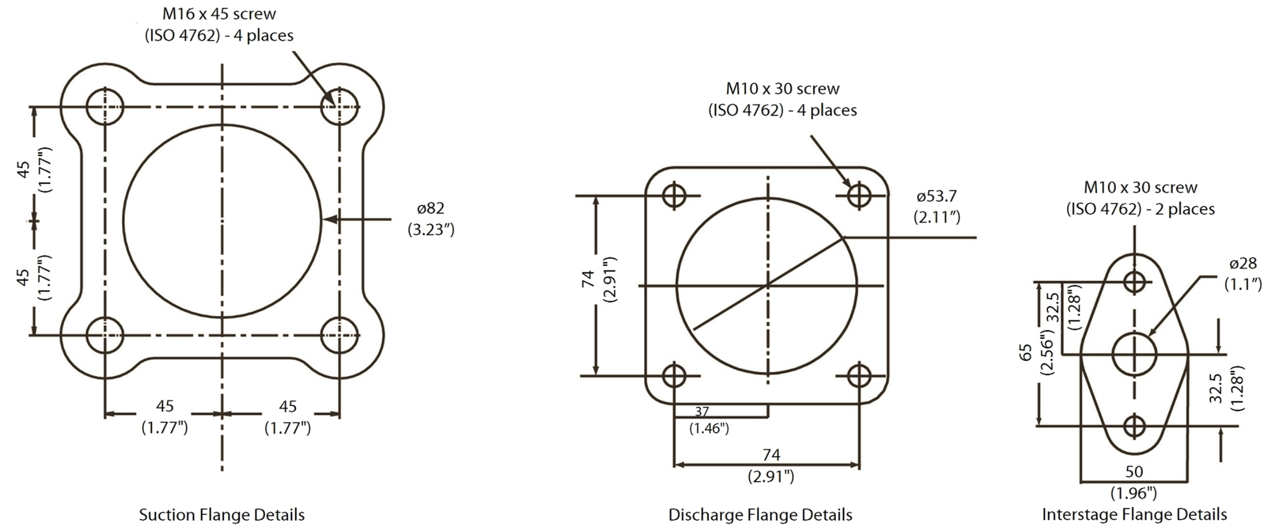


Table 16-3 Screw Hole Specifications

Port	Fastener Thread Spec	Thread Depth (mm)	Recommended Torque (Nm)
Suction	M16	34.5	75
Discharge	M10	20	32
Economizer	M10	20	32

• • • CAUTION • • •

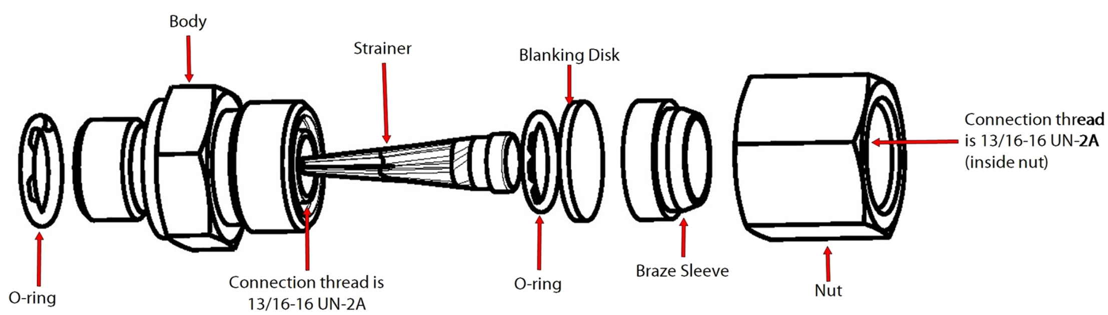
Refer to the manufacturer fastener specifications and torque as required, but do not exceed the torque values listed in Table 16-3 Screw Hole Specifications." If this value is exceeded, damage to compressor housing threads may occur.

Table 16-4 Torque Specifications

Description	Nm	Ft.Lb.	In.Lb
IGV and End Bell Fasteners	25	18	221
Pressure/Temp Sensor	10	7	89
IGV Power Feedthrough	5	4	44
Bearing Power and Sensor Feedthroughs	5	4	44
Cavity Sensor E-Housing and Later	13	10	115
SCR Mounting Fasteners	7	5	62
A/C Bus Bars	6	4	53
DC Capacitors and Bleed Resistors	2	1	18
Inverter Mounting Fasteners	6	4	53
Schaeder Valves	13	10	115
Motor Cooling Body (Body Nut), E-Housing and Later*	25	18	221
Motor Cooling Compression Nut, E-Housing and Later*	11	8	97
Cover Plate	13	10	115
Hermetic Feedthrough	22	16	195
Motor Cooling Brass Orifice	7	5	62
Motor Cooling Plunger	4	3	35
TT300 Mains Termination	31	23	274

***Check figure below for details**

Figure 16-23 Motor Cooling Fitting



Chapter 17.0 Piping Considerations

Care should be exercised when selecting pipe sizes as they will vary according to their application. Chapter 14.0 Sample Refrigeration Circuits provides examples of compressor piping arrangements for the most common applications.

The motor-cooling line should be channeled from the liquid line; refer to Section 13.1 General Requirements for more information. Danfoss LLC Applications requires the installation of a sight glass and full-flow liquid dryer in the motor-cooling line.

NOTE
Some applications may require alternative arrangements. Contact Danfoss LLC Applications for further assistance, if required.

• • • CAUTION • • •

The discharge line must be fitted with a non-return valve to prevent reverse flow into the discharge port, which can cause damage to compressor components.

All pipe work should be carried out in accordance with industry standards. Brazing without the use of nitrogen will result in debris being deposited in the pipes, potentially leading to blockage or damage.

Discharge piping should contain a caution label from system manufacturers or compressor installers that the surface is hot.

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Chapter 18.0 Environmental Considerations

18.1 Humidity

If the compressor is installed in a humid environment, drip trays may be required to collect condensate. Insulation should be installed on the suction valve/piping and the end cap as this is where condensation is most likely to form.

It is recommended to fit an End Cap insulator in a humid environment.

NOTE
The End Cap insulator is not available for TGH/TTH compressors.

18.2 Vibration

External copper piping should be braced to minimize the transfer of vibration to the compressor.

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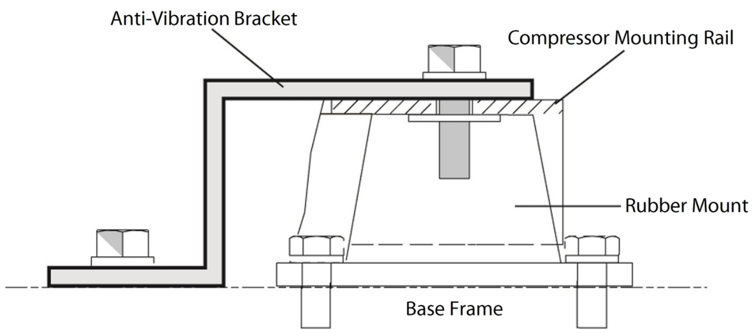
Chapter 19.0 Shipping Considerations

19.1 Vibration

When shipping the compressor as an integral part of a chiller unit, precautions should be taken to protect the compressor motor cooling line from excessive vibration. Due to the flexibility of the compressor's isolation mounts, compressor vibration during transit can fracture the motor cooling line's rigid piping. Danfoss LLC Applications suggests the temporary installation of an anti-vibration bracket between the compressor's base frame and mounting rail during transit, as shown in Figure 19-1 Anti-Vibration Bracket.

Figure 19-1 Anti-Vibration Bracket



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Chapter 20.0 Installation

20.1 Unpacking and Inspection

The compressor should be carefully inspected for visible signs of damage. Check for loose bolts and damage to covers or the outer casing. Damage should first be reported to the carrier, not Danfoss LLC. You can contact Danfoss LLC Product Support to assist in determining the extent of damage or if the compressor should be returned to Danfoss LLC. Damage should be specified on the Bill of Lading or transportation/freight forwarder documentation. Open all containers and verify all parts against the packing list. Report any shortages to Danfoss LLC Customer Service. Contact Danfoss LLC Customer Service to conduct report actions via the Incident Report form.

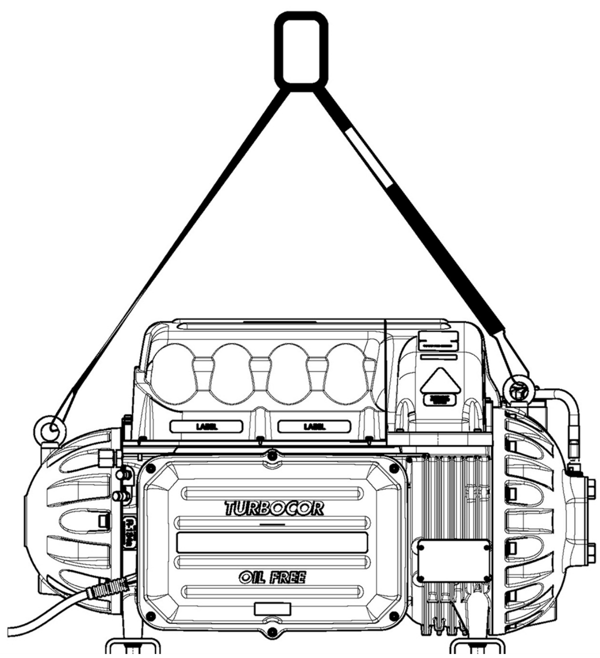
20.2 Rigging Requirements

Care must be exercised at all times when rigging or handling the compressor to protect it from damage. Two eyebolts (one at each end) are provided for compressor rigging. A spreader bar should be used to safely position the compressor into its final location (refer to Figure 20-1 Rigging Set-up).

20.3 Unit Placement

1. If mounting the compressor with the Danfoss LLC mounting kit, refer to 20.4 Mounting Base; if not, install four isolation pads in accordance with the footprint dimensions given in Figure 20-2 Mounting Base (TTS/TGS/TTH/TGH) Series.
2. Mount the compressor onto the isolation pads. Ensure the compressor mounting rails are properly isolated from the base frame once the attaching hardware is secured; for example, the screw should not extend from the compressor mounting rails to the base frame Figure 20-3 Incorrect Compressor Mounting Pad Installation and Figure 20-4 Correct Compressor Mounting Pad Installation.
3. Check that the compressor mounting rails are level ± 5 mm (3/16") in the lateral and longitudinal planes.

Figure 20-1 Rigging Set-up



20.4 Mounting Base

The compressor must be mounted on a rigid surface of sufficient structural integrity to support the weight of the compressor and valves. Refer to the following figures and table for further details.

- Figure 16-10 TTH/TGH Center of Gravity Capacitor Side View
- Figure 1-9 Center of Gravity Top View (Excluding TTH/TGH Compressors
- Figure 16-10 TTH/TGH Center of Gravity Capacitor Side View
- Figure 1-11 TTH/TGH Center of Gravity Top View
- Table 1-2 Center of Gravity X-Y Coordinates

A mounting kit is available to isolate the compressor from the supporting structure and to minimize vibration from other rotating equipment. The compressor mounting rails should be level ± 3/16" (5 mm) in the lateral and longitudinal planes.

NOTE

If isolation pads are used at the four mounting base points, the overall height of the compressor will change. Be sure to measure accordingly based on the insulator used.

1. If isolation pads are used, install four pads in accordance with the footprint dimensions given in Figure 20-2 Mounting Base (TTS/TGS/TTH/TGH) Series.
2. Mount the compressor onto the isolation pads. Ensure the compressor mounting rails are properly isolated from the base frame once the attaching hardware is secured; for example, the screw should not extend from the compressor mounting rails to the base frame Figure 20-3 Incorrect Compressor Mounting Pad Installation and Figure 20-4 Correct Compressor Mounting Pad Installation.
3. Check that the compressor mounting rails are level ± 5 mm (3/16") in the lateral and longitudinal planes.

Figure 20-2 Mounting Base (TTS/TGS/TTH/TGH) Series

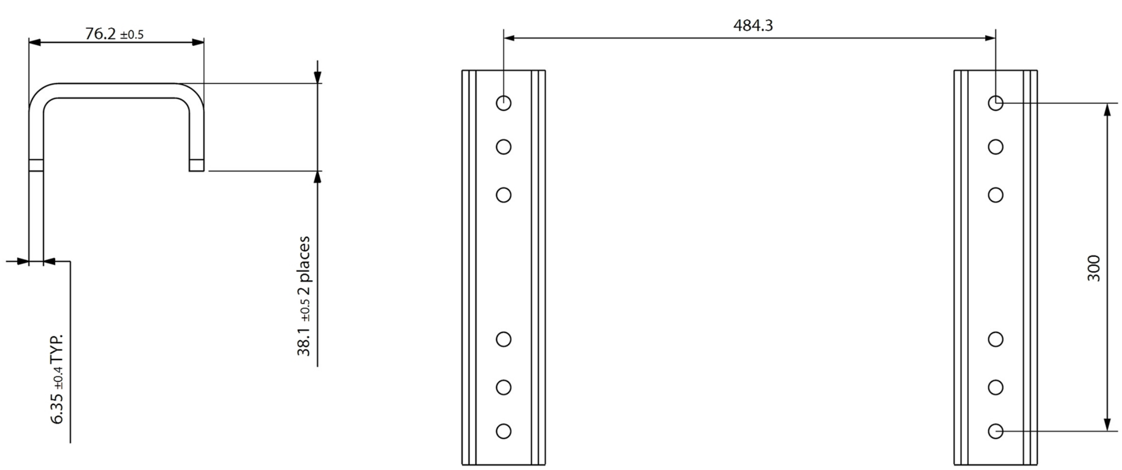


Figure 20-3 Incorrect Compressor Mounting Pad Installation

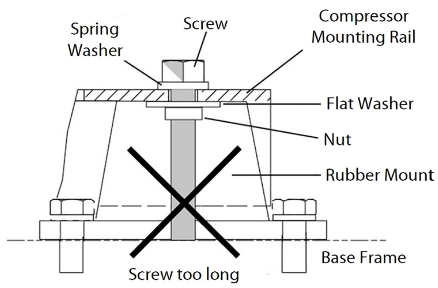
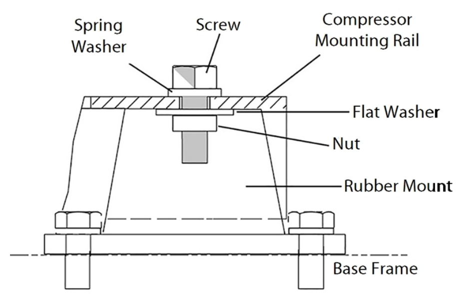


Figure 20-4 Correct Compressor Mounting Pad Installation



In the event the mounting base is not used and the compressor is secured directly to the chiller, refer to the fastener specifications in Table 20-1 Mounting Base Screw Hole Specifications.

Table 20-1 Mounting Base Screw Hole Specifications

Fastener Thread Spec	Thread Depth (mm)	Recommended Torque (Nm)
M12	24	22

20.5 Piping Connections

• • • CAUTION • • •

Install new O-rings when attaching flanges to the compressor. The OEM must make sure all sealing materials and equipment on the unit are compatible with the appropriate refrigerant.

• • • DANGER • • •

The motor-cooling line should be channeled from the liquid line (Figure 20-5 Motor-Cooling Connection and Access Port

The motor-cooling line requires the installation of a service valve (not included) to enable refrigerant isolation during compressor servicing.

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. Isolation and recovery of the refrigerant must be performed by a qualified technician. Always wear proper safety equipment when handling refrigerants (Figure 20-5 Motor-Cooling Connection and Access Port).

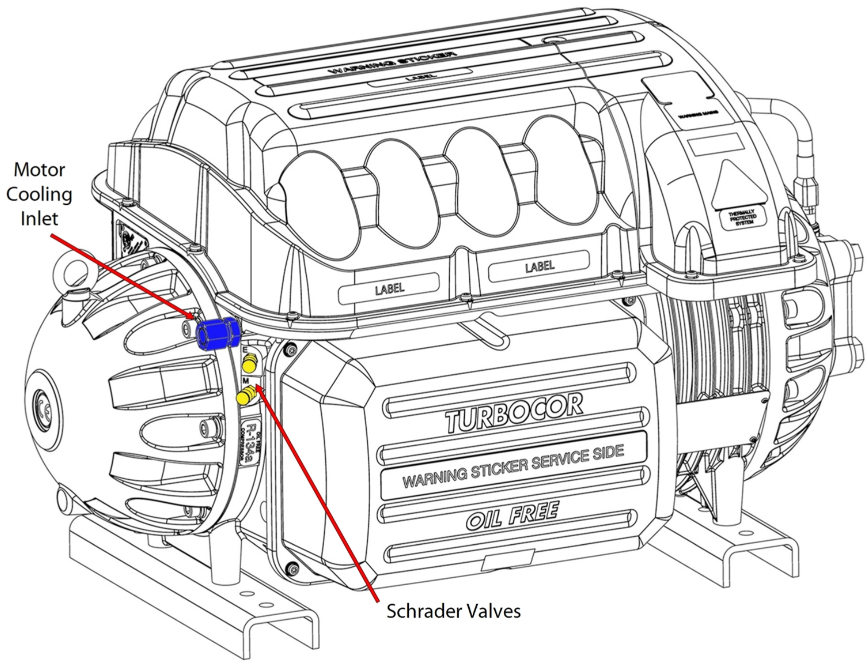
1. After releasing the pressure, remove the suction and discharge connection blanking plates from the new compressor.
2. Attach the suction, discharge, and economizer (if applicable) connections. Solder all joints according to approved practice ensuring that dry nitrogen is used at all times.
3. Ensure flange surfaces are clean and free from debris. Install new O-rings.

• • • CAUTION • • •

Ensure the discharge line is fitted with a non-return valve. During a surge condition or shutdown, the non-return valve prevents reverse flow into the discharge port, which can cause damage to compressor components. Dry-fit the pipework to the valves and verify the connections are aligned and there is no strain on the joints.

4. Attach the motor-cooling connection at the rear of the compressor. This connection is a 1/2 inch O-ring face seal connection (Figure 20-5 Motor-Cooling Connection and Access Port).
5. Perform a leak test, evacuation, and charge according to industry standards.

Figure 20-5 Motor-Cooling Connection and Access Port



20.6 Control Wiring

The compressor I/O board enables communication of control and status signals between the compressor controller and external equipment. These signals include, among others, cooling demand, input, stepper motor control inputs and outputs, alarm and interlock contacts, and Modbus protocol communications.

20.6.1 Control Wiring Connections

Figure 4-1 Typical Control Wiring shows the control wiring connections to the compressor I/O board. Table 4-1 Control Wiring Details provides details for the module terminal connections.

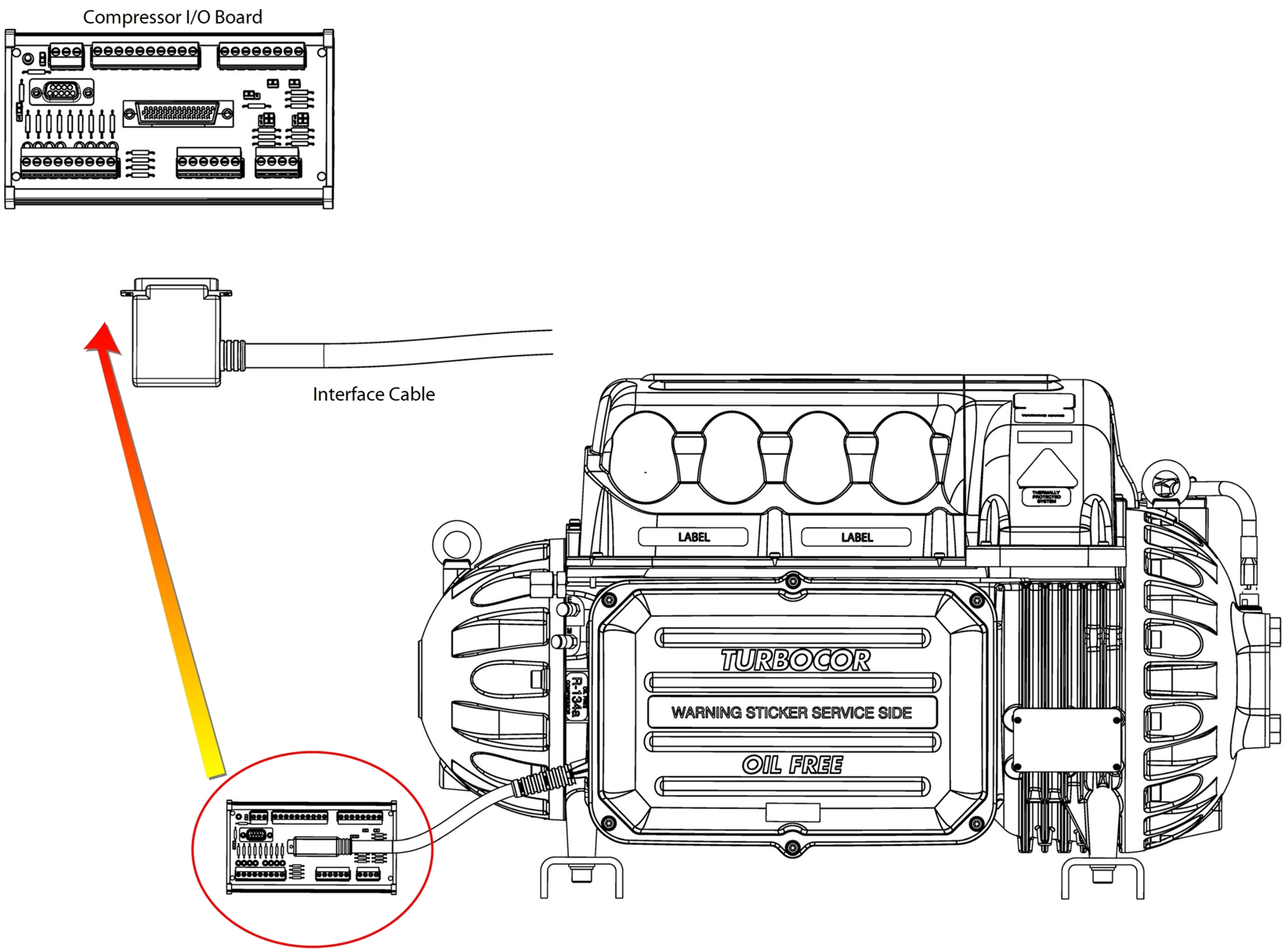
• • • CAUTION • • •

Incorrect wiring of the terminals can severely damage the module and other components.

The interface cable connects the compressor to the compressor I/O board. To connect the cable:

1. Plug the cable connector into connector J6 on the compressor I/O board.
   - For RS-485 communication, the total length of the interface cable and control wiring can be extended up to 100 meters (328 feet) (refer to Figure 1-1 Typical Control Wiring Figure 4-3 I/O Wiring Specifications. If the compressor is going to be monitored over an RS-232 line, the total cable length between the compressor and the PC should not exceed 15 meters (50 feet). Refer to Figure Interface Cable.

Figure 20-6 Compressor I/O Board Connections

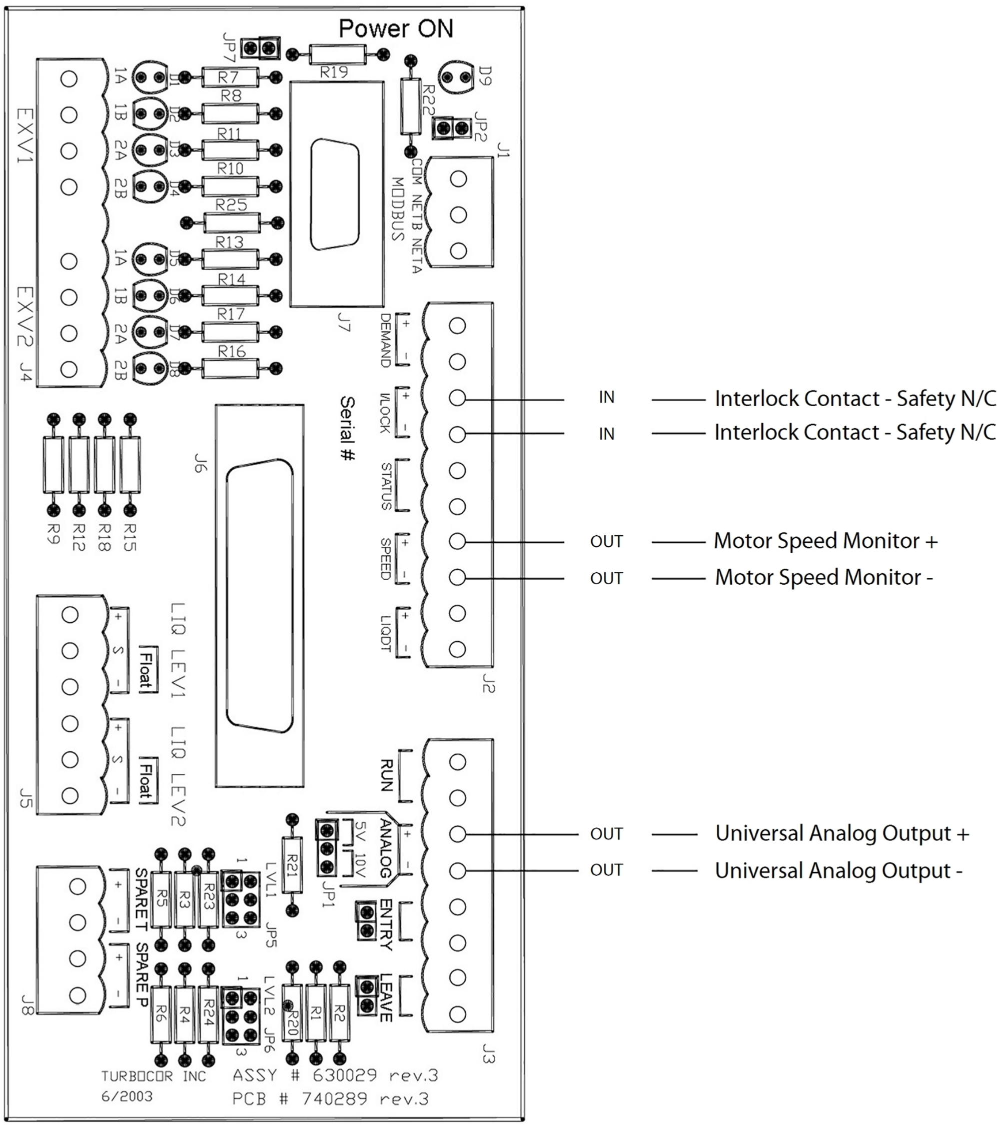


20.6.2 Circuit Grounding

Improper grounding or voltage in circuits connected to the compressor I/O board can lead to component failures. In particular, the interlock and analog output circuits are sensitive to improperly connected external circuits (refer to Figure 20-7 Interlock and Motor Speed Connections

Prior to connecting the control wiring to the compressor I/O board, check for improper grounding. Improper grounding can be identified by measuring the voltage between the customer's negative terminals and the ground (J1 COM or Modbus shield) terminal on the compressor I/O board (refer to Figure 20-7 Interlock and Motor Speed Connections If the measured voltage is not zero (0), determine the source of the voltage. The most likely cause of voltage is insufficient insulation of the external circuit. In case of uncertainty of the grounding, connect the negative terminals of the external circuit to a ground and then connect the external ground to the ground on the compressor I/O board.

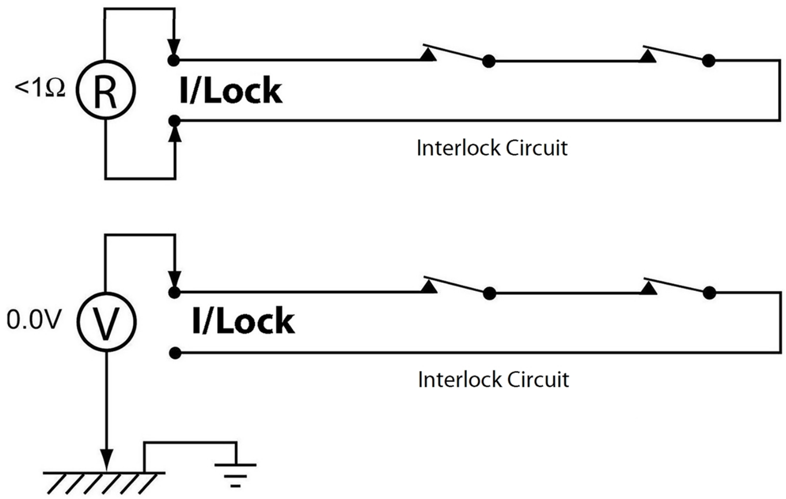
Figure 20-7 Interlock and Motor Speed Connections



20.6.3 Voltage-Free Contacts

Prior to connecting the interlock terminals of the compressor I/O board, measure the resistance across the customer's interlock terminals (refer to Figure 20-8 Interlock Circuit Tests). Ensure that the interlock contacts are closed. The measured value should be less than 1Ω.

Figure 20-8 Interlock Circuit Tests



Measure the voltage between each customer interlock terminal and the frame ground while the interlock contacts are open and closed. In either contact state, if the measured voltage is not zero (0), verify the source of the voltage. Do not connect the interlock terminals until the voltage source is removed (refer to Figure 20-9 Typical Electrical Connections).

20.7 Power Wiring

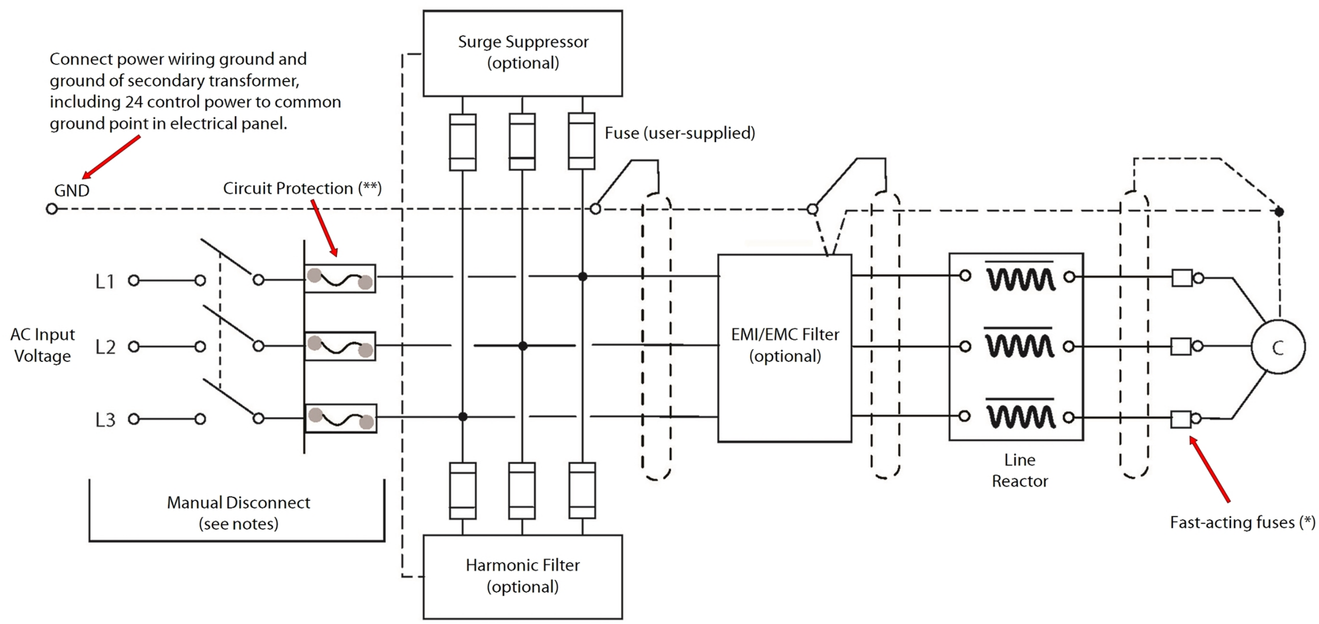
This section describes the connection of the power wiring to the compressor.

NOTE

- The AC input cable should be CSA, UL, or CE approved, 3-wire with a common shield and single ground. It is recommended that the cable be double-jacketed; for example, a teck cable type. The cable must be rated for 90° C (194° F) minimum with a maximum current rating corresponding to the LRA value on the compressor nameplate.
- Keep power cables and control interface cables in separate conduits. Use metal cable glands for shielded cables to ensure good grounding.
- If you are installing a line reactor or EMI or harmonic filter in the mains input circuit, refer to Figure 20-9 Typical Electrical Connections for the proper placement within the input power wiring.

Figure 20-9 Typical Electrical Connectionsshows a typical schematic for the compressor’s electrical connections.

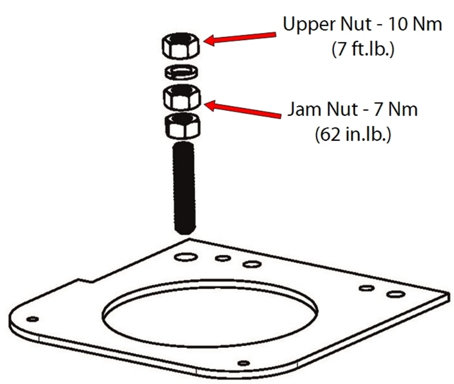
Figure 20-9 Typical Electrical Connections



NOTE
• **(*)** Class T 600 VAC fast-acting fuses must be installed for all models except for TGS230 and TTS300 compressors.
• **(**)** Circuit protection is required - refer to local electrical requirements.

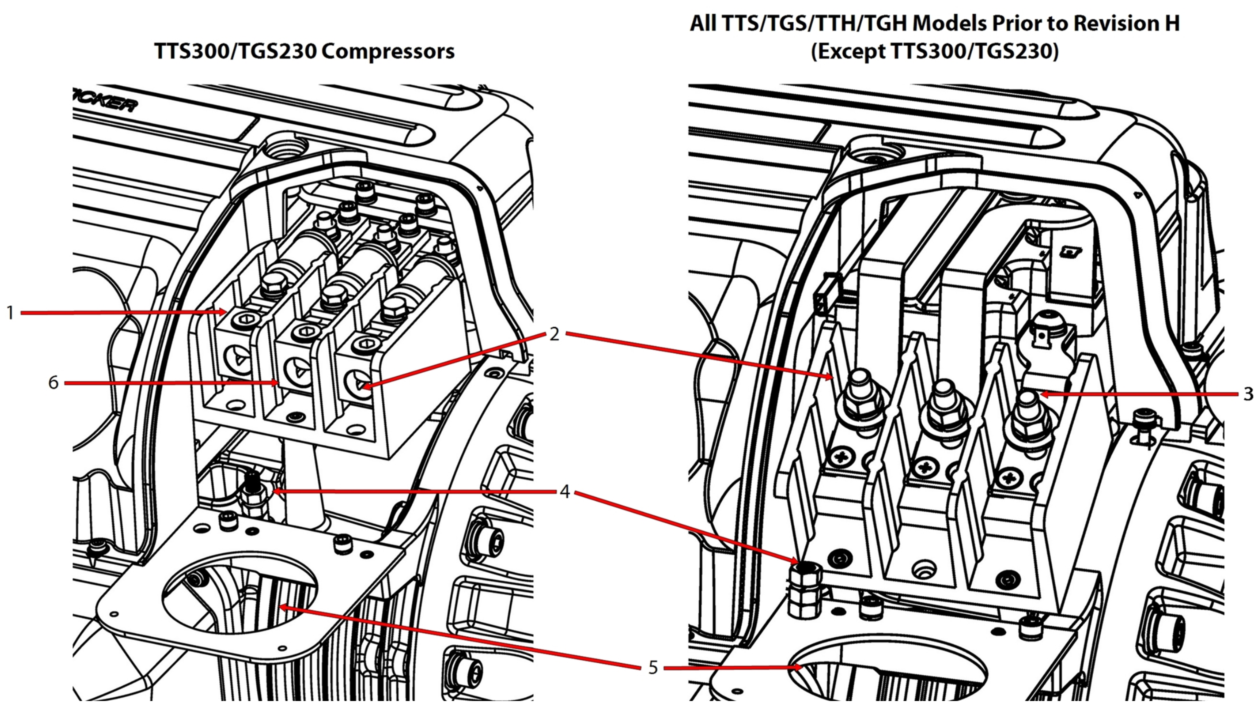
1. Remove the fasteners that secure the cover and set the cover aside.
2. Insert a cable gland (customer-supplied) into the opening in the mains input bracket.
3. Fasten the cable gland to the bracket with the locknut
4. Feed the AC input cable through the cable gland.
5. Attach the ground cable to the ground post on the compressor housing.
6. Attach and secure the upper nut and jam nut to the ground post (refer to Figure 20-10 Ground Post Nuts).
7. Attach the three main power cables to the compressor terminals (refer to Figure 20-11 Compressor AC Input Terminals). Continue to Step 8 for TT300/TG230 compressors. For all other TTS/TGS compressors, continue to Step 9.

Figure 20-10 Ground Post Nuts



8. The three compression lugs on the TTS300/TGS230 compressors need to be torqued to 20 Nm (15 ft-lbs).

Figure 20-11 Compressor AC Input Terminals

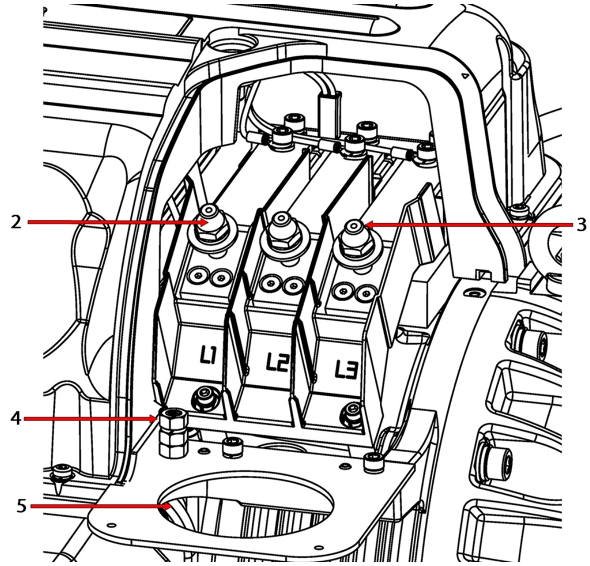


Refer to Table 20-2 Compressor AC Input Terminals for the descriptions of the items shown in Figure 20-11 Compressor AC Input Terminals and Figure All TTS/TGS/TTH/TGH Models, Revision H (Except TTS300/TGS230).

Table 20-2 Compressor AC Input Terminals

No.	Description	No.	Description
1	Mains Input Pressure Screw	4	Upper Jam Nut
2	AC Input Connection	5	Seal Bracket Opening
3	Mains Stud - 3/8-16 - 1.5" long	6	Terminal Block Adapter

Figure 20-12 All TTS/TGS/TTH/TGH Models, Revision H (Except TTS300/TGS230)



9. The three 3/8”-16 nuts on all other compressors (excluding TTS300/TGS230 compressors) will need to be torqued to 21 Nm (15 ft-lbs).

NOTE
The bore size of the Terminal Block Adapter (TTS300 and TGS230 only) is 18 mm, therefore the maximum wire diameter must not exceed that size.

10. Tighten the gland nut to secure the cable to the mains input bracket.
11. Seal any gaps between the cabling and the mains input bracket to minimize any dust ingress into the compressor.
12. Replace the Mains Input Cover and secure it with the fasteners.

![Danfoss logo]

Appendix A

A.1 Line Reactor Installation Instructions

These instructions apply to the installation of the line reactor kit in a main supply panel. Refer to the Spare Parts Selection Guide for product specifications.

A.1.1 AC Line Cable Connection (From External Disconnect)

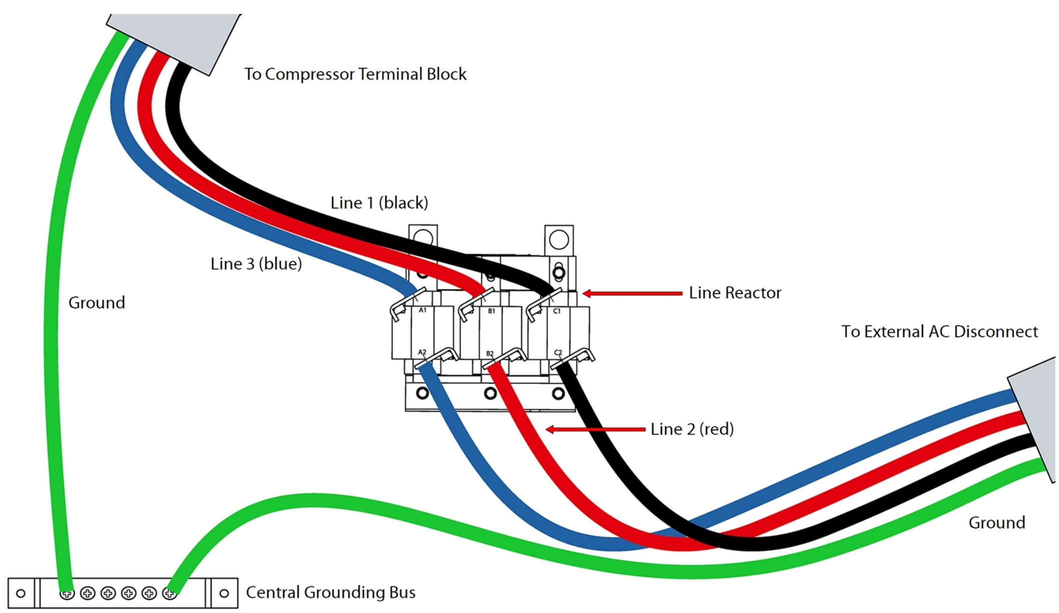
NOTE
The customer is responsible for supplying the mounting hardware for the line reactor.

1. Figure A-1 Line Reactor Connections shows a schematic of the main input circuit and connections to the line reactor. Use this schematic as a guide for choosing the location of the line reactor.
2. Feed the AC line cable through the opening in the side of the main supply panel.
3. Attach the AC line wires to the line reactor terminals as shown in Figure A-1 Line Reactor Connections.
4. Attach the ground cable to the mounting block on the panel wall. Ensure there is good electrical/mechanical contact between the ground cable and the panel wall.
5. Secure the AC line cable to the main supply panel using approved methods (e.g., cable gland).

A.1.2 AC Line Cable Connection (to Compressor Terminal)

1. Feed the AC line cable through the opening in the side of the main supply panel.
2. Attach the AC line wires to the line reactor output terminals as shown in Figure 1-1 Line Reactor Connections.
3. If a harmonic filter is being installed, attach its AC line wires to the line reactor output terminals.
4. Attach the ground wire to the mounting block on the panel wall. Ensure there is good electrical/mechanical contact between the ground wire and the panel wall.
5. Secure the AC line cable to the main supply panel using approved methods (i.e., cable gland).
6. Refer to Section 20.7 Power Wiring for instructions on completing the AC input connection to the compressor.

Figure A-1 Line Reactor Connections



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Appendix B

B.1 EMI/EMC Filter Installation Instructions

1. Mount the filter on the floor or on a wall in a vertical position.
2. Ensure there is a minimum of 60mm (2 3/8”) of space for the cooling slots.

B.1.1 Line Side Connection

Input and output filter leads should be separated by a maximum practical distance within the enclosure and should be routed separately in interconnecting conduits when used (refer to Figure B-1 Interconnection Layout).

1. Insert the line wires into the terminals labeled "L1," "L2," and "L3" on the "Line" side of the filter. Tighten the terminal screws.
2. Attach the ground lug to the main ground bus and tighten the nut (refer to Figure B-2 Grounding Diagram).

NOTE
A short, heavy, stranded conductor from the filter chassis to the main ground bus is recommended for top performance. A battery braid, litz wire, or flexible welding cable with many fine strands is recommended for best grounding performance.

B.1.2 Load Side Connection

1. Insert the load wires (instead of the line side of the line reactor) into the terminals labeled "L1," "L2," and "L3" on the "Load" side of the filter. Tighten the terminal screws.
2. Attach the ground lug to the main ground bus and tighten the nut.

B.1.3 Harmonic Filter

1. If a harmonic filter is to be installed, follow the manufacturers instructions.
2. Connection of a harmonic filter should be made on the Load side of the Line Reactor (refer to Figure 20-9 Typical Electrical Connections).

Figure B-1 Interconnection Layout

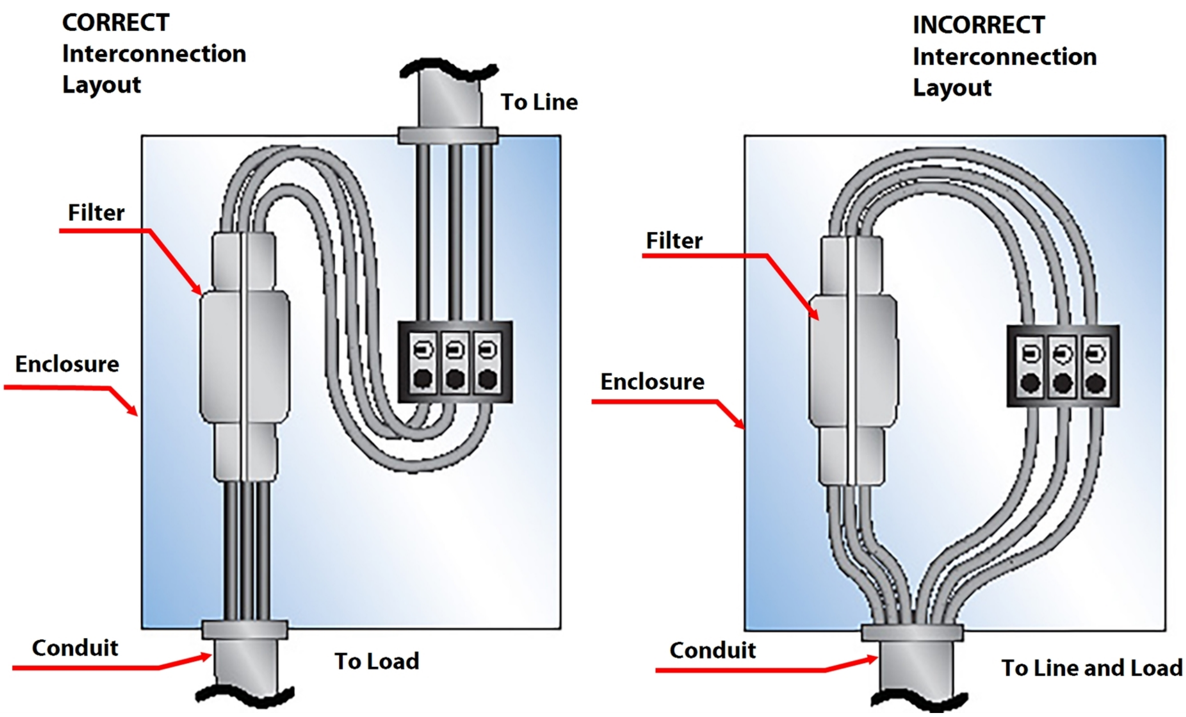
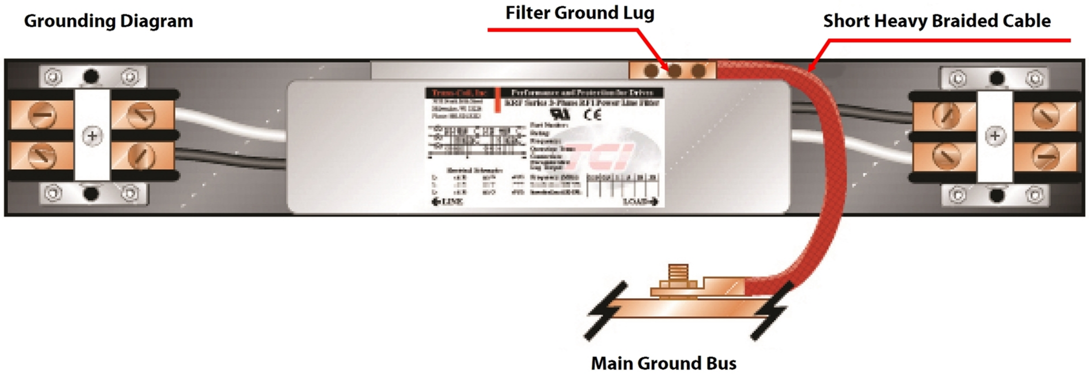


Figure B-2 Grounding Diagram



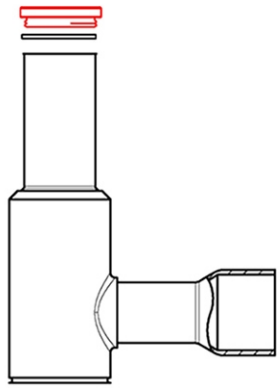
Appendix C

C.1 Pressure Regulating Valve Installation Instructions

When installing the KVP 22, certain steps must be performed to ensure no internal valve damage occurs.

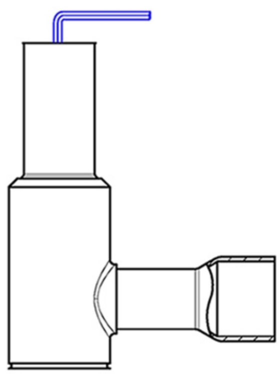
1. Remove the KVP 22 adjustment cap as shown in Figure C-1 Adjustment Cap Lift.

Figure C-1 Adjustment Cap Lift



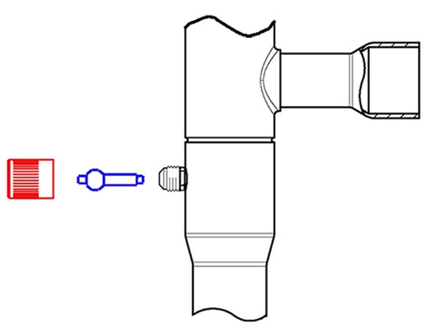
2. Use an appropriately sized hex wrench to turn the setting screw. Turn three (3) complete revolutions counterclockwise.

Figure C-2 Hex Wrench



3. Remove the Schrader valve cap and then the Schrader valve.

Figure C-3 Schrader Valve Removal



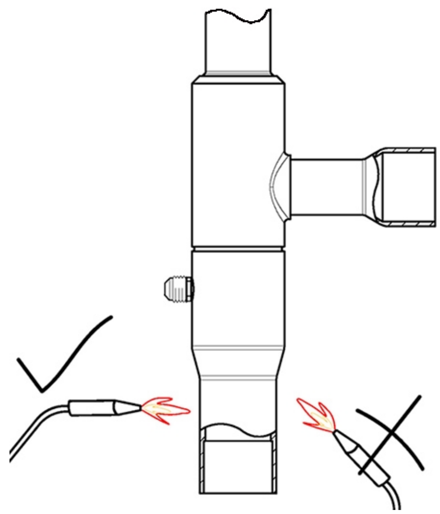
4. Clean all connections with a sanding cloth and then apply soldering flux to the exterior of the clean copper tube. Do the same to the mating copper pipe that will connect to the valve.

5. Slide both pipes over the stubs of the valve ensuring a minimum of a 9.5 mm (3/8”) connecting joint.
6. Wrap the valve in cool wet towels to help prevent excessive heat from damaging the valve.
7. Heat the two (2) sections of pipe and apply a (6% silver 94% tin) type solder ensuring the two (2) pipe connections are properly sealed.

• • • CAUTION • • •
Ensure the body of the valve gets no hotter than 285°F (140°C).

• • • CAUTION • • •
To prevent damaging the internal components of the valve, do not point the flame towards the center (body) portion of the valve. Refer to Figure C-4 Brazing Connections.

Figure C-4 Brazing Connections



8. Once cooled, Re-install the Schrader valve. Finger tight plus a ½ turn (3Nm). Then install the Schrader valve cap.

9. Leak test the cooled joint to ensure there are no leaks.

10. Use an appropriately sized hex wrench to turn the setting screw. Set the valve according to Table C-1 KVP Setting.

Table C-1 KVP Setting

Setting KVP for 30°F		
Refrigerant	**Pressure @ 30°F**	**360° Rotations for 30°F**
R134a	26	4.3
R513A	30	5.0
R1234ze	15	2.5
R515B	30	5.0

11. Install the KVP 22 cap. Finger tight plus a ¼ turn (3Nm).

• • • DANGER! • • •
It is important to properly tighten the Schrader valve and the top cap. This is especially important when used with flammable refrigerants.

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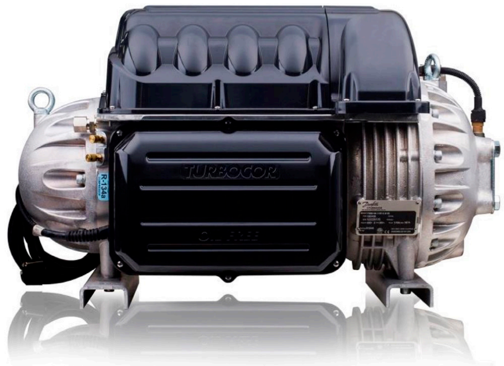
ENGINEERING
TOMORROW



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

78

years of combined service and applications knowledge

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

Join us for the next **Turbocor® Training** class. Scan the code to see our schedule and **register today!**

www.turbocor.danfoss.com | TURBOCOR®

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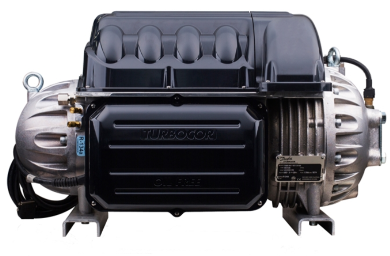
ENGINEERING TOMORROW
Danfoss
TurboTool®
Quick access to Danfoss Turbocor® compressor troubleshooting.
The new version of the Danfoss TurboTool® 2.0 app for all your full service Danfoss Turbocor® compressor needs.
24/7
Access to Danfoss Turbocor® compressor troubleshooting on site
The TurboTool® app 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
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.
Spare Parts
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®

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.



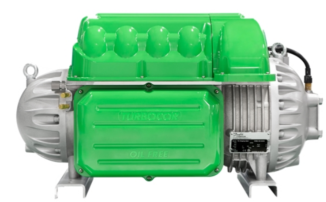
TTS Compressors

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