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INSTALLATION

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**RETROFIT CONVERSION
TO THE
FRICK[®] QUANTUM[™] HD CONTROL**

**VILTER[®] SINGLE SCREW
INSTALLATION INSTRUCTIONS**

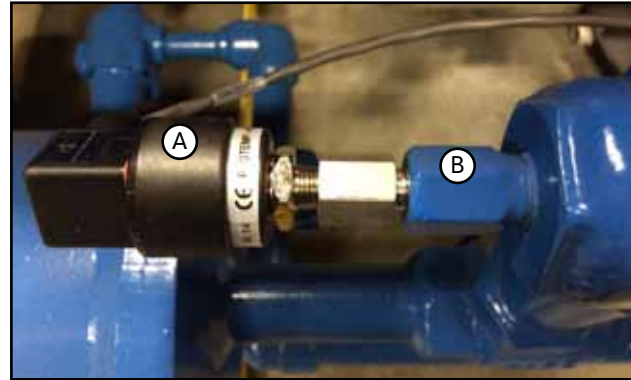
FRICK® QUANTUM™ HD RETROFIT PANELS

The *QUANTUM™HD* control panels sold under this program are designed to handle standard screw compressor package piping and instrument design. Compressors are to be electric motor driven only. Other drive lines can be accommodated through Frick® Engineering. Lubrication is accomplished by electric motor or shaft driven oil pumps, or differential pressure lube systems. If the compressor package does not meet these basic requirements, contact Frick® for engineering assistance. Frick® can make the proper changes for most applications. Additional engineering and drawing charges will be quoted. Examples of standard piping and instrument designs for both Frick and other manufacturer's designs are shown on page 3.

In some cases, even though the screw compressor package meets the basic requirements, package modifications and/or control panel modifications may be required: non-standard sensors, modified piping, additional solenoids and check valves, and additional relays into the control circuits, etc. This is the case with most vertical separators, screw chiller packages, and other specific-duty screw compressor packages. Normally, an experienced installer can handle these items in the field. Contact Frick® Engineering for assistance if a problem is encountered.

The *QUANTUM™HD* control panel will be offered in a "kit" form which will supply the panel, drawings, and the current installation, operation, and maintenance manuals. Standard pressure and temperature sensor kit includes four pressure and four temperature sensors. Pressure sensor connections are 1/4" MPT.

The standard temperature probe used with the Vilter® Single Screw is 1/4" MPT and threads into the existing 1/4" x 1/2" thermowell.



A. ICTD Temperature Sensor (1/4" MPT)
B. Existing 1/4" x 1/2" Thermowell

Figure 1. ICTD Temperature Sensor & Thermowell

Additional pressure transducers and temperature probes are available as optional items. Temperature probes are available in 3/4" and 1/2" MPT with thermowells or 1/4" without the thermowell.

See page 3 of the Order Entry Data Sheet (Publication 090.100A-P) to select these and other options.

SAFETY PRECAUTION DEFINITIONS



Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.



Indicates a potentially hazardous situation or practice which, if not avoided, will result in death or serious injury.



Indicates a potentially hazardous situation or practice which, if not avoided, will result in damage to equipment and/or minor injury.

NOTICE

Indicates an operating procedure, practice, etc., or portion thereof which is essential to highlight.

ORDERING PRESSURE AND TEMPERATURE SENSORS

When ordering pressure and temperature sensors the following sensors and cables* are provided.

*Cables ARE NOT provided for additional sensors as the distance between those sensors and the panel is unknown.

Pressure Sensors

- 1 - 0-200psia 1/4" MPT (suction)
- 3 - 0-500psia 1/4" MPT (discharge, oil & pre-filter)
- 4 - 24' 3-wire Shielded Cables with DIN Connector

Temperature Sensors

- 4 - ICTD style temperature sensors
- 4 - 24' 2-wire Shielded Cables with DIN Connector

Available Temp. Sensors (specify size when ordering)

- ICTD with 3/4" thermowell (See Fig. 2a)
 - ICTD with 1/2" thermowell (See Fig. 2b)
 - ICTD 1/4" MPT less thermowell* (See Fig. 2c)
- (*Typical for Vilter VSS retrofits. Sensor threads into existing 1/4" x 1/2" thermowell)

NOTICE

Cables ARE NOT provided for additional sensors as the distance between those sensors and the panel is unknown.

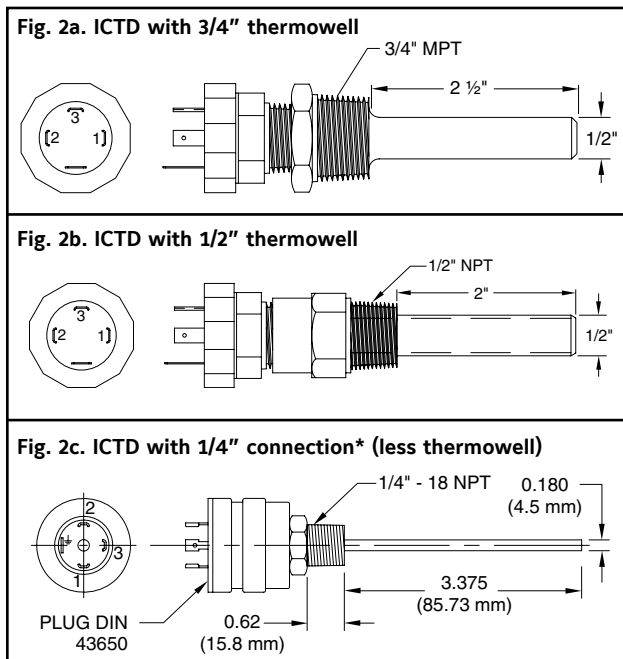


Figure 2. ICTD Sensor Options

*Note: Fig. 2c is an ICTD sensor only. Typically used with Vilter packages, the sensor threads into an existing thermowell.

INTRODUCTION

CONVERSION OF SCREW COMPRESSOR UNITS TO THE FRICK® QUANTUM™ HD CONTROL PANEL.

These instructions are based on the installer having a fundamental knowledge of refrigeration design and installation. Instructions are for conversion to the standard design unit. Special package and/or control modifications furnished on the existing unit will require deviation from these instructions.

Contact Frick® if you have any questions, concerns or problems. Frick® does not take responsibility for the suitability of these instructions, for any nonstandard installation or for consequential damages resulting from the conversion.

NOTICE

Do not initiate retrofit conversion until you have completely reviewed all instructions and checked material received for suitability and completeness.

Material supplied with this Frick® retrofit kit:

- A. A complete QUANTUM™ HD control panel.
- B. Operation, Maintenance and Retrofit Conversion manuals.
- C. Four ICTD Temperature Probes 1/4" MPT (less well).
- D. Three 0-500 PSIA Pressure Transducers 1/4" MPT.
- E. One 0-200 PSIA Pressure Transducer 1/4" MPT.

Each sensor comes with a 24' section of the proper shielded cable with DIN connector to plug onto the sensor.

A pressure transducer manifold block, with mounting brackets and service valves for four (4) pressure transducers, is available as an option. With this option, the cables on the transducers are 8'.



Figure 3. Current Optical Actuator

NOTICE

Older gear driven capacity and volume slide actuators must be replaced with the optical style actuators shown in Figure 3 before retrofitting.

MATERIAL TO BE SUPPLIED BY INSTALLER AS REQUIRED

- Pressure tubing and fittings (1/4 inch stainless steel)
- Pipe, fittings, and adaptors
- Electrical conduit, fittings, and solenoids
- Wire
- Current transformer in the compressor motor starter, control transformer, and any motor starter components or modifications.
- Labor and tools required to complete installation and start-up.

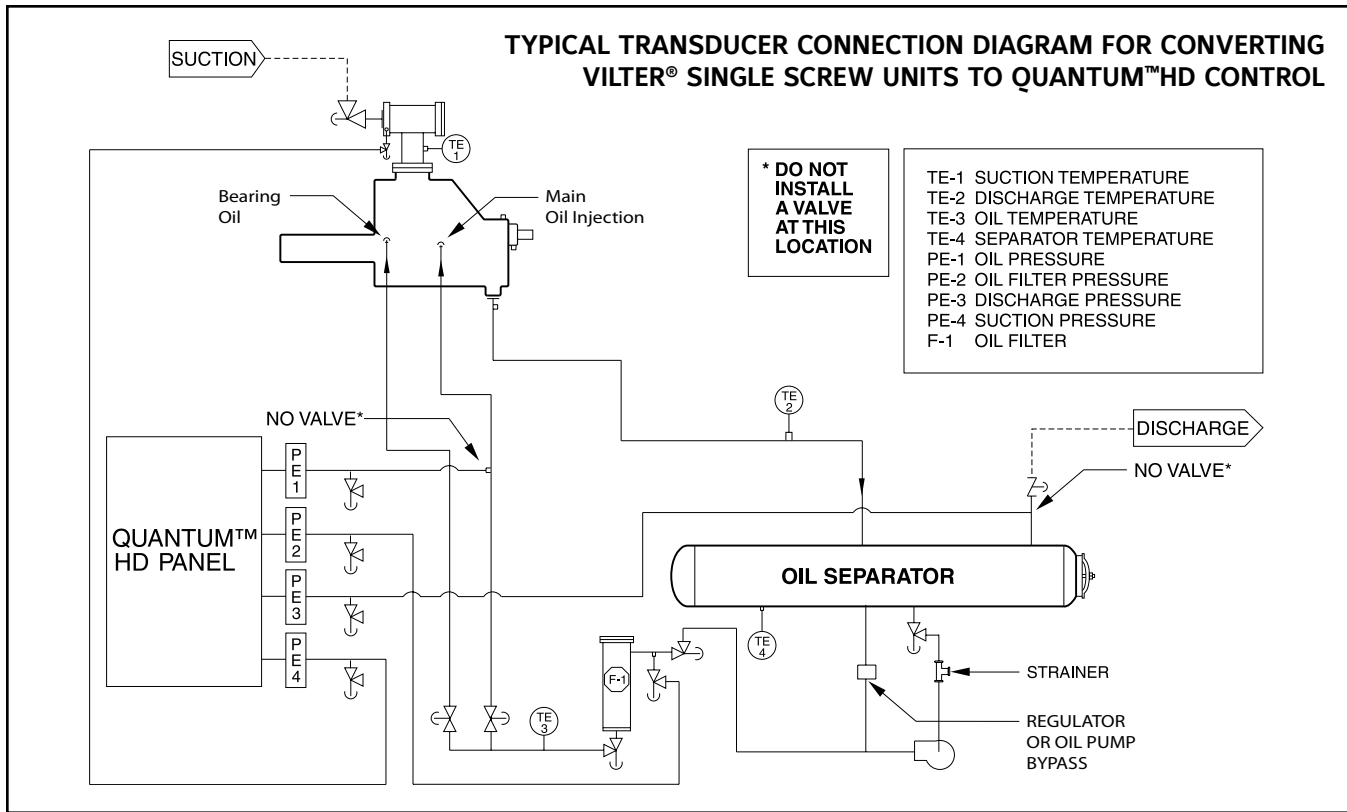


Figure 4. Transducer Connection Diagram (Typ. Conversion)

INSTRUCTIONS

NOTICE

Before proceeding, read the instructions for "Proper Installation of Electronic Equipment in an Industrial Environment" on page 8.

1. Push [STOP] key to shut down the unit. Lockout and Tagout all sources of power to the compressor package.
2. Close the discharge, and liquid injection (if applicable) service valves.
3. **SLOWLY** vent the separator to low-side system pressure using the suction check valve bypass. Close suction valve and suction check valve bypass.

NOTICE

Recover or transfer all refrigerant vapor in accordance with local ordinances before opening to atmosphere. Separator **MUST** be equalized to atmospheric pressure.

CAUTION

Refrigerant entrained in the oil may vaporize, causing a separator pressure increase. Repeat venting and recovery procedure if necessary.

4. If an oil separator temperature probe well is to be installed, drain the oil from the oil separator.
5. Take digital photographs of all internal connections of the existing controller to use as a reference when making the connections on the replacement controller. Remove the

existing panel from the compressor package. **DO NOT CUT WIRES OR TUBING LINES.** They will be used to connect to the new panel. Be sure that all wires are properly labeled by number and purpose.

6. Mount the *QUANTUM™ HD* panel on the compressor package by bolting the panel to the existing panel mounting structure. It may be necessary to weld new panel mounting brackets to the screw compressor package to accommodate the proper panel height. If so, **DO NOT WELD TO THE PRESSURE VESSEL.** Weld only to existing mounts or other structural material. **DO NOT WELD WITH THE CONTROL PANEL IN PLACE.** Welding currents may damage the electronic components. Refer to the PANEL MOUNTING HEIGHT diagram below.

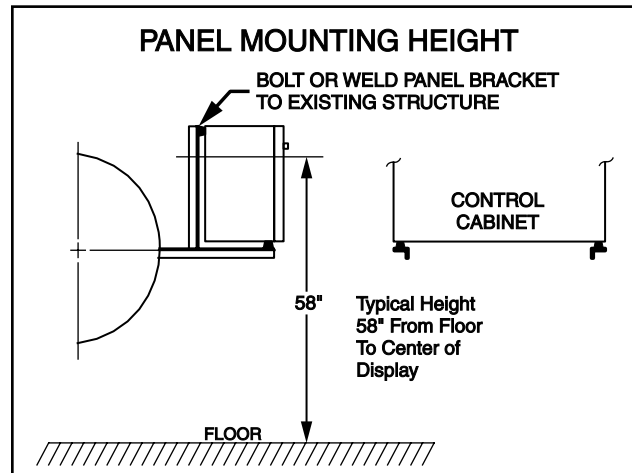


Figure 5. Panel Mounting Height

7. If the existing temperature sensors are not ICTDs or the sensor's output is NOT 4-20mA, 0-20mA, 0-5V, 1-5V, 0-10V or 2-10V, the temperature sensors must be replaced. The temperature sensor kit that comes with the *QUANTUM™HD* retrofit includes the following.

- 4 - ICTD, 1/4" MPT, temperature sensors (suction, discharge, oil and separator temperature)
Part #: 639A0361H01
- 4 - 24', 2 wire, shielded cables with integrated DIN connector
- 1 - 4-hole, 3/4" strain relief

Once each of the new temperature sensors are properly installed, plug in the cables and route back to the *QUANTUM™HD* where they will be gathered and ran through the 4-hole 3/4" strain relief provided in the kit. Use one of the 4 holes provided at the bottom left side of the enclosure for the entry of these cables.

8. Before making the final wiring connection for the temperature sensors, refer to the multipage drawing that is provided in the new controller or the panel wiring diagrams in the 090.040-M publication. Temperature probe cabling is grounded at the ground block in the panel. Cut off the shield and drain wire at the probe end and use heat shrink or electrical tape to cover the bare wire, preventing contact with ground.

9. Connect the red (or white) and black wires to the analog I/O board as shown on the on the panel wiring diagrams in the 090.040-M publication.

10. If the output of the existing pressure transducers are NOT 4-20mA, 0-20mA, 1-5V, 0-5 V, 2-10V or 0-10V, they must be replaced. The signal from the older standard Vilter® pressure transducer is not a standard sensor signal range.

The pressure transducer kit that comes with the *QUANTUM™HD* retrofit includes the following.

- 1 - 0-200psia 1/4" MPT Transducer (suction pressure)
- 3 - 0-500psia 1/4" MPT Transducer (discharge, oil & pre-filter pressure)
- 4 - 24', 3 wire, shielded cables with integrated DIN connector
- 1 - 4-hole, 3/4" strain relief

Once each of the pressure transducers are properly installed, plug in the cables and route back to the *QUANTUM™HD*. Gather the cables and run through the 4-hole 3/4" strain relief provided in the kit. Use one of the 4 holes provided at the bottom left side of the enclosure for the entry of these cables.

11. Refer to the panel wiring diagrams in the Maintenance manual (090.040-M or 090.020-M) and connect the red, black, and white wires of the pressure transducers to the *QUANTUM™HD* analog board. The shield of the transducer cable is grounded inside the transducer and should not be grounded inside the cabinet.

NOTICE

If the existing sensors are 4-20mA they can be used and need to be configured properly for signal type and range in Analog I/O Configuration.

12. The motors/actuators for the capacity and volume slides need to be the current optical actuators. If the existing motors are the old gear driven type, these will need to be replaced with the optical actuators before proceeding.

The position feedback cable from the capacity and volume slide actuators will be routed back to the *QUANTUM™HD* and through 2 of the 4 holes in the 3/4" strain relief that is provided. The capacity slide actuator is the one that is physically higher on the compressor. To avoid any incidental damage, disconnect the cables for control and signal at the optical actuators before wiring these devices to the digital and analog boards. They will be reconnected later.

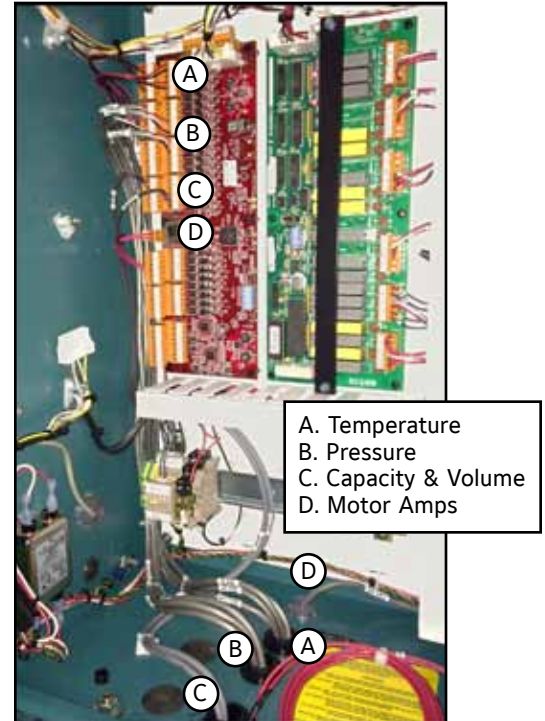


Figure 6. Analog I/O cabling entry into the enclosure and routing to the analog board (Typical).

13. Refer to the Vilter® specific drawings that come with the *QUANTUM™HD* for instruction on properly landing the power, signal and common wires of the signal cable for the capacity and volume slide position on the analog I/O board. These drawings also include connection information for the load, unload and common wire for the control cable to the digital board.

14. Before starting the AC control wiring, the following items should be checked in the compressor starter. Refer to the compressor motor starter diagrams.

- A.** The compressor requires a minimum of 2 KVA transformer for 120 VAC control and heater power.
- B.** The compressor starter must have a ground wire pulled from the three-phase source. The ground must be connected to the starter backplate and the neutral terminal (2) on the secondary side of the control transformer.
- C.** Verify that the current transformer (CT) is placed as shown on the motor starter diagram in the motor starter IOM and is sized according to the CT selection calculation.

- D. Verify that auxiliary contacts are provided on the compressor and oil pump contactor.
- E. Verify that the compressor motor overloads are sized properly.
- F. If the compressor and oil pump starters do not have interposing relays already provided, the relays must be mounted and wired as shown on the drawings.

NOTICE

The most common electronic control panel problems are due to undersized AC power wiring, poor grounds, and control power supplied from lighting panels that have other devices tied to them that generate large amounts of AC line noise. Please follow these directions carefully. (See p.8 for additional information on Installing Electronic Equipment in an Industrial Environment.)

Metal oxide varistors (MOV or surge suppressor) are recommended for the compressor starter coil, oil pump starter coil (if applicable) and liquid injection solenoid coil (if applicable). The MOVs should be placed directly at the coils of these devices. Placement of the MOVs at the control panel terminal strip negates the surge suppression effect.

15. Using 10 AWG wire, connect the control transformer in the compressor starter panel to the proper terminals in the QUANTUM™HD control panel, as shown in the IOM on the compressor motor starter diagrams and the panel wiring diagrams. These wires are: black or red (1), white (2), and green (GND). (Copper ground only. Conduit ground is not acceptable.)

The main power wiring to the QUANTUM™HD panel (line and neutral) must be 10 AWG. A separate ground wire is also required for each QUANTUM™HD panel and must also be at least a number 10 insulated copper wire.

16. Connect the remaining control wires between the starter and the control panel, as shown on the drawings that come with the QUANTUM™HD and or the compressor motor starter diagrams and the panel wiring diagrams. These control wires are typically:

- A. Compressor start (18)
- B. Compressor auxiliary (20)
- C. Current transformer (3 & 4)
- D. Oil pump start (if required) (8)
- E. Oil pump auxiliary (if required) (19)

17. Connect the remaining package control wires, including options, to the control panel, as shown on the panel wiring diagrams provided with the QUANTUM™HD for Vilter® retrofit.

18. Before applying power to the QUANTUM™HD control panel, make the following checks:

- A. Check each terminal for loose connections or damage to the circuit boards or cables.
- B. Check for wire clippings or metal drill filings on the circuit board or in the panel. Clean the QUANTUM™HD control panel thoroughly before applying the control power.

19. Make sure that the circuit breakers (CB1 and CB2) in the QUANTUM™HD control panel are in the "OFF" position. Engage the electrical disconnect at the compressor starter.

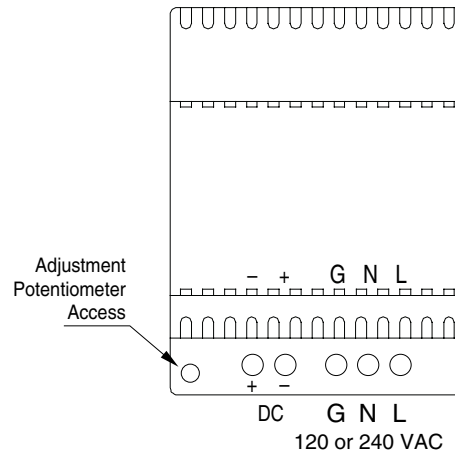
20. Using a DIGITAL VOLTMETER, verify the AC line voltage in the QUANTUM™HD control panel. The AC line voltage should be between 100 VAC and 125 VAC or 185 VAC to 254 VAC.

21. Check for AC volts (in millivolts) between AC neutral (2) and AC ground (GND). If the millivolt reading is greater than 500 millivolts, pull the electrical disconnect at the motor starter and reverify ground and neutral circuits.

22. If all is ok, turn circuit breakers CB1 and CB2 to the "ON" position.

23. POWER SUPPLY CALIBRATION

QUANTUM™ - There are three separate power supplies in the QUANTUM™ HD, and are designated from left to right as +5 VDC, +12 VDC and +24VDC.



Each power supply (5, 12, & 24 vdc) is labeled with the part number and acceptable voltage output range.

The voltages for the 5, 12, & 24 vdc supplies are as follows:

- 5 vdc range = 5.10 - 5.20 vdc
- 12 vdc range = 12.10 - 12.20 vdc
- 24 vdc range = 24.2 -24.5 vdc

The power supplies accept both 120 or 220 VAC (input range = 100 - 240 VAC)

24. At this point, the operating display on the controller should be seen.

Log in to the controller using a default login code. The default login codes for all access levels can be changed as part of the configuration process.

Quantum™ HD Default Login Access Levels

- Basic = 1
- Operation = 2
- Service = 3

25. Refer to the Operation manual (090.040-O) to ensure that all setpoints have been properly entered. The main configuration items for the Vilter® single screw are Package Type, Package Duty, Oil Pump Type, Refrigerant and Drive Type.

Go to Menu > Configuration > Package to select Package Type, Package Duty, Refrigerant and Drive Type.

Select the Oil Pump/Lubrication tab to select the oil pump type. The default oil pump selection is Full Time. If the pump operation is part time or on demand, select Demand. When Demand is selected, additional setpoints used to run the Vilter® lubrication logic are added to that page. While these are adjustable it should not be necessary to do so.

26. Before calibrating the analog devices (sensors), check the configuration of all utilized analog devices to ensure they are configured correctly with regard to sensor output and sensor range. The analog board in the *QUANTUM™HD* provides 24 vdc excitation for the sensors.

Sensor default configuration is as follows for the following sensors. Any additional sensors will also need checked for proper configuration.

Pressure Transducers		
Location	Sensor Output	Sensor Range
Suction	1-5 vdc	0 to 200 PSIA
Oil, Oil Filter & Discharge	1-5 vdc	0 to 500 PSIA

Temperature Probes		
Location	Sensor Output	Sensor Range
Suction, Oil, Separator & Discharge	ICTD (integrated circuit temperature device)	-459.3 to 463.1°F (not adjustable)

Capacity Slide, Volume Slide & Motor Amps		
Location	Sensor Output	Sensor Range
Capacity Slide	0-5 vdc	0 to 100%
Volume Slide	0-5 vdc	1.2 to 7.0 Vi
Motor Amps	CT (0-5 amp secondary)	*0 to 100 amps

*Note: The CT Range is dependent upon the primary value of the CT ratio. If the CT is a 500:5 the range would be 0 to 500.

CALIBRATION OF TEMPERATURE & PRESSURE SENSORS

1. Locate the associated temperature probe on the compressor package and pull the temperature probe from the well. Place the temperature probe in a concentrated ice water bath (80:20 ice to water) along with a quality test thermometer or sensor.
2. Wait for approximately two minutes and compare the thermometer reading with the temperature probe reading. Enter in the correction for temperature, if required.
3. Step to the next temperature to be calibrated, locate the associated temperature probe on the unit and repeat the calibration process.
4. After the temperature probe calibration is complete, re-insert the temperature probes into the wells.
5. Open the suction and discharge stop valves. If applicable, open the side load stop valve, the economizer stop valve, and the liquid injection stop valve.
6. **CHECK FOR LEAKS!**

7. To calibrate the pressure transducers, a quality test gauge is required. Go to the Pressure Calibration display and step to the suction pressure setting.

8. If available, attach the test gauge to the suction pressure service valve. Read the pressure on the test gauge and compare this reading to the displayed value. Adjust the displayed value, if necessary.

9. Step to the discharge pressure setting on the Pressure Calibration display.

10. Repeat the calibration procedure using the value from the gauge.

11. Step to the oil pressure setting on the Pressure Calibration display.

12. Repeat the calibration procedure using the value from the gauge.

13. Step to the pre-oil filter pressure setting on the Pressure Calibration display.

CAPACITY & VOLUME SLIDE CALIBRATION

Go to Menu > Calibration > Capacity / Volume

Once on this screen with the capacity and volume slides in Manual mode, you can attach the power and signal cables at the optical actuators for the capacity and volume slides.

NOTICE

When looking at the compressor the Capacity Slide actuator will always be physically higher on the compressor than the Volume Slide actuator.

Figure 7. Calibration Capacity/Volume Screen

The optical actuators used for capacity and volume slide positioning provide a 0-5vdc (0-5000mVdc) signal over the range of travel for these slides back to the *QUANTUM™HD* analog board #1 channels 14 & 15 respectively.

The rotation of the command shaft is critical for proper operation of loading and unloading for capacity control or increasing and decreasing for volume control. The correct command shaft rotation for the capacity and volume slides by compressor model number is as follows:

Vilter® Compressor Model	Command Shaft Rotation			
	Capacity Increase	Capacity Decrease	Volume Increase	Volume Decrease
71 - 451	CW	CCW	CW	CCW
501	CCW	CW	CCW	CW
601 (VSM)	CW	CCW	CCW	CW
601 (VSS)	CW	CCW	CW	CCW
701 - 3001	CCW	CW	CCW	CW

*CW - Clockwise; CCW - Counter Clockwise

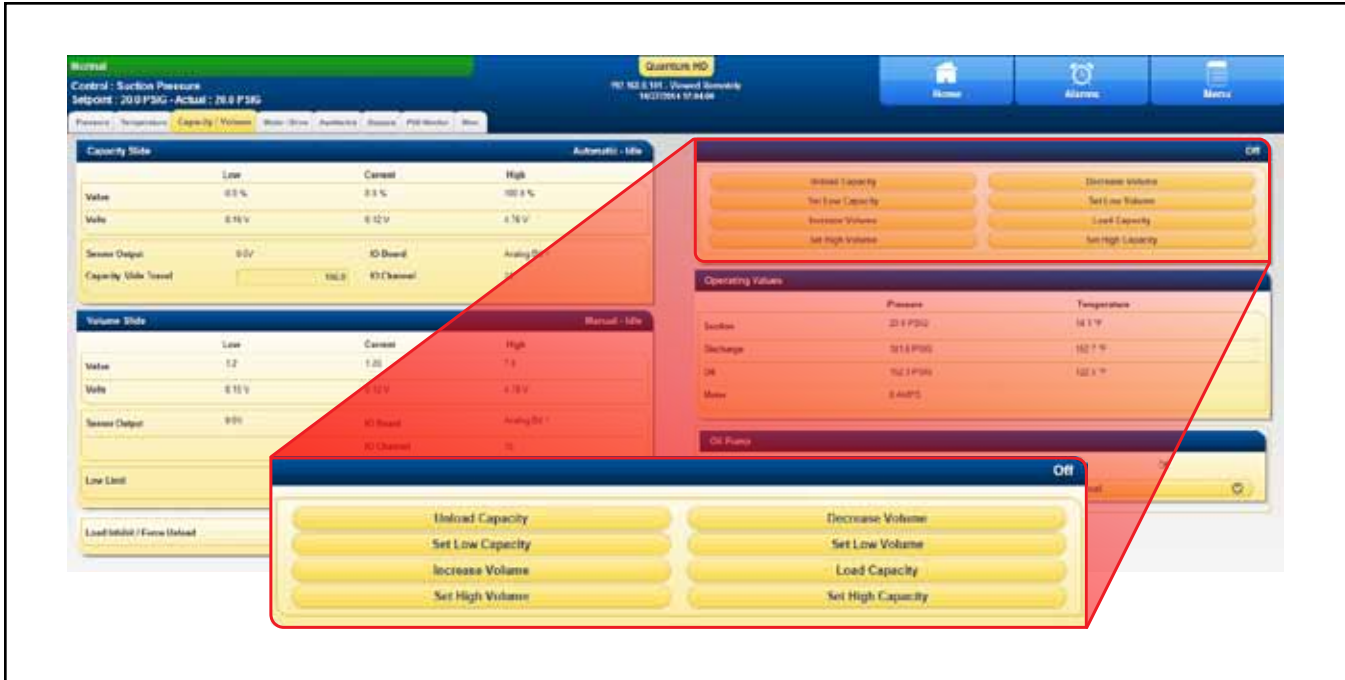


Figure 8. Calibration Capacity/Volume Screen

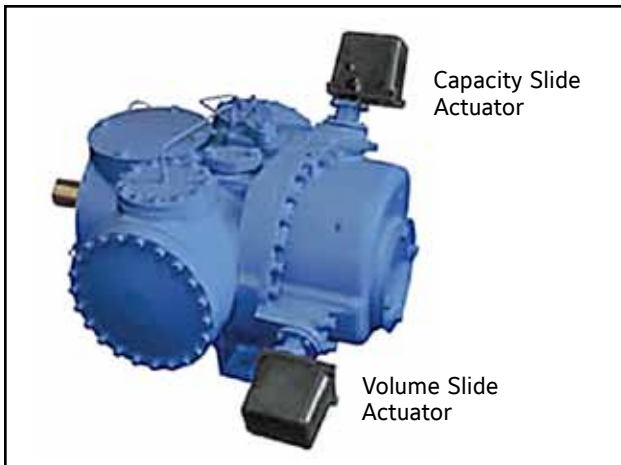


Figure 9. Capacity & Volume Slide Actuator Orientation

To check proper command shaft rotation for the capacity and volume actuators go to the calibration page for Capacity and volume. See Figure 8.

Press the load or unload capacity button for the capacity slide to check rotation. If rotation is incorrect switch the brown and blue wire for load and unload at the digital board. Use the increase or decrease volume button for the volume slide to check rotation. If rotation is incorrect switch the brown and blue wire for increase and decrease at the digital board.

Four components interact to display and calibrate the capacity and volume slides: Command Shaft, Photo Chopper, Calibration Button & Calibration LED

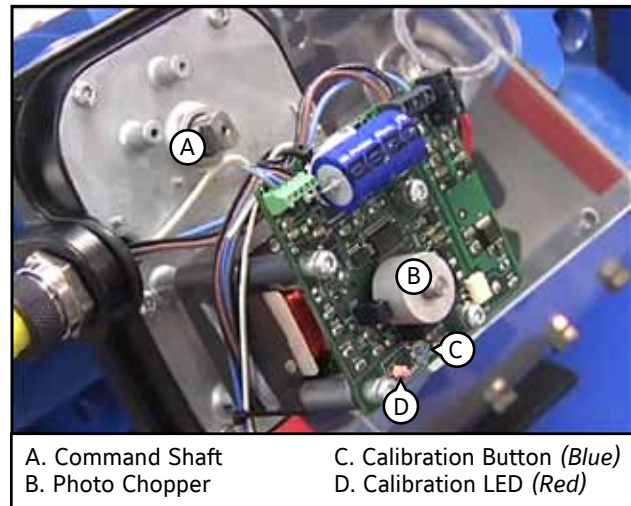


Figure 10. Actuator Control Board

Once the rotation of the capacity and volume command shafts are confirmed, go to the Capacity/Volume calibration page on the Quantum HD controller.

Capacity Slide Calibration

1. Press the Unload Capacity Slide button. The photo chopper will spin at a high rate until the low end physical stop is reached and the photo chopper winds to a stop. Quickly press the Unload Capacity Slide button again to turn of the unload output.
2. Press down on the Photo-Chopper until the tension is relieved. You may need to press down on the photo chopper a few times to fully relieve the tension.
3. Once the tension is relieved press the Blue Calibration Button on the capacity slide actuator to initiate capacity slide actuator calibration. The red calibration LED will be flashing at a rapid rate (multiple times per second).
4. Press the Blue calibration button again. The red calibration LED is now flashing at a slower rate (about once per second). The minimum capacity position output is now set on the actuator.
5. On the Capacity/Volume calibration page press the Set Low Capacity button to set the Capacity Low Value reference voltage on the Quantum HD controller. To prevent the capacity slide from hitting the low end physical stop, the reference voltage for Capacity Low Value is adjusted upward by 3% of the actuators output range of 0-5 VDC (.15 volts). The Quantum HD will not unload the capacity slide beyond the Capacity Low Value reference voltage.
6. With the red calibration LED flashing at the slower rate, press the Load Capacity Slide button. The photo chopper will spin at a high rate until the high end physical stop is reached and the photo chopper winds to a stop. Quickly press the load Capacity Slide button again to turn of the load output.
7. Press down on the Photo-Chopper until the tension is relieved. You may need to press down on the photo chopper a few times to fully relieve the tension.
8. Press the Blue calibration button again. The red calibration LED will go out. The maximum capacity position output is now set on the actuator.
9. On the Capacity/Volume calibration page press the Set High Capacity button to set the Capacity High Value reference voltage on the Quantum HD controller. To prevent the capacity slide from hitting the high end physical stop, the reference voltage for Capacity High Value is adjusted downward by 3% of the actuators output range of 0-5 VDC (.15 volts). The Quantum HD will not load the capacity slide beyond the Capacity High Value reference voltage.

NOTICE

If the signal from the actuator drops below the low end reference voltage or the above the high end reference voltage for the capacity slide, a corresponding load or unload command will be issued.

Volume Slide Calibration

1. Press the Decrease Volume Slide button. The photo chopper will spin at a high rate until the low end physical stop is reached and the photo chopper winds to a stop. Quickly press the Decrease Volume Slide button again to turn of the decrease output.
2. Press down on the Photo-Chopper until the tension is relieved. You may need to press down on the photo chopper a few times to fully relieve the tension.
3. Once the tension is relieved press the Blue Calibration Button on the volume slide actuator to initiate volume slide actuator calibration. The red calibration LED will be flashing at a rapid rate (multiple times per second).
4. Press the Blue calibration button again. The red calibration LED is now flashing at a slower rate (about once per second). The minimum volume position output is now set on the actuator.
5. On the Capacity/Volume calibration page press the Set Low Volume button to set the Volume Low Value reference voltage on the Quantum HD controller. To prevent the volume slide from hitting the low end physical stop, the reference voltage for Volume Low Value is adjusted upward by 3% of the actuators output range of 0-5 VDC (.15 volts). The Quantum HD will not decrease the volume slide beyond the Volume Low Value reference voltage.
6. With the red calibration LED flashing at the slower rate press the Increase Volume Slide button. The photo chopper will spin at a high rate until the high end physical stop is reached and the photo chopper winds to a stop. Quickly press the Increase Volume Slide button again to turn of the increase output.
7. Press down on the Photo-Chopper until the tension is relieved. You may need to press down on the photo chopper a few times to fully relieve the tension.
8. Press the Blue calibration button again. The red calibration LED will go out. The maximum capacity position output is now set on the actuator.
9. On the Capacity/Volume calibration page press the Set High Volume button to set the Volume High Value reference voltage on the Quantum HD controller. To prevent the volume slide from hitting the high end physical stop, the reference voltage for Volume High Value is adjusted downward by 3% of the actuators output range of 0-5 VDC (.15 volts). The Quantum HD will not increase the volume slide beyond the Volume High Value reference voltage.

NOTICE

If the signal from the actuator drops below the low end reference voltage or above the high end reference voltage for the volume slide, a corresponding increase or decrease command will be issued.

PROPER INSTALLATION OF ELECTRONIC EQUIPMENT IN AN INDUSTRIAL ENVIRONMENT

In today's refrigeration plants, electronic controls have found their way into almost every aspect of refrigeration control. Electronic controls have brought to the industry more precise control, improved energy savings, and operator conveniences. Electronic control devices have revolutionized the way refrigeration plants operate today.

The earlier relay systems were virtually immune to radio frequency interference (RFI), electromagnetic interference (EMI), and ground loop currents. Therefore installation and wiring were of little consequence and the wiring job consisted of hooking up the point-to-point wiring and sizing the wire properly. In an electronic system, improper installation will cause problems that may outweigh the benefits of electronic control. Electronic equipment is susceptible to RFI, EMI, and ground loop currents which can cause equipment shutdowns, processor memory and program loss, as well as erratic behavior and false readings. Manufacturers of industrial electronic equipment take into consideration the effects of RFI, EMI, and ground loop currents and incorporate protection of the electronics in their designs. However, these design considerations do not make the equipment immune, so manufacturers require that certain installation precautions be taken to protect the electronics from these effects. All electronic equipment must be viewed as sensitive instrumentation and therefore requires careful attention to installation procedures. These procedures are well known to instrumentation, networking, and other professions but may not be followed by general electricians.

There are a few basic practices that if followed, will minimize the potential for problems resulting from RFI, EMI and/or ground loop currents. The National Electric Code (NEC) is a guideline for safe wiring practices, but it does not necessarily deal with procedures used for electronic control installation. Use the following procedures for electronic equipment installation. These procedures do not override any rules by the NEC, but are to be used in conjunction with the NEC code and any other applicable codes.

With exclusion of the three phase wire sizing, Frick drawing 649D4743 should be used as a reference for properly sizing control wires and other wiring specifications.

Throughout this document the term Electronic Control Panel is used to refer to the microprocessor mounted on the compressor package or a Central Control System panel.

NOTICE

It is very important to read the installation instructions thoroughly before beginning the project. Make sure you have drawings and instructions with your equipment. If not, call the manufacturer and request the proper instructions and drawings. Every manufacturer of electronic equipment should have a knowledgeable staff, willing to answer your questions or provide additional information. Following correct wiring procedures will ensure proper installation and consequently, proper operation of your electronic equipment.

WIRE SIZING

Control power supply wires should be sized one size larger than required for amperage draw to reduce instantaneous voltage dips caused by large loads such as heaters, contactors, and solenoids. These sudden dips in voltage can cause the electronic control panel, whether it is a microprocessor,

a computer, or a PLC, to malfunction momentarily or cause a complete reset of the control system. If the wire is loaded to its maximum capacity, the voltage dips are much larger, and the potential of a malfunction is very high. If the wire is sized one size larger than required, the voltage dips are smaller than in a fully loaded supply wire and the potential for malfunction is much lower. The NEC code book calls for specific wire sizes to be used based on current draw. An example of this would be to use #14 gauge wire for circuits up to 15 amps or #12 gauge wire for circuits of up to 20 amps. Therefore, when connecting the power feed circuit to an electronic control panel, use #12 gauge wire for a maximum current draw of 15 amp and #10 wire for a maximum current draw of 20 amp. Use this rule of thumb to minimize voltage dips at the electronic control panel.

VOLTAGE SOURCE

Selecting the voltage source is extremely important for proper operation of electronic equipment in an industrial environment. Standard procedure for electronic instrumentation is to provide a clean, isolated, separate-source voltage in order to prevent EMI (from other equipment in the plant) from interfering with the operation of the electronic equipment. Connecting electronic equipment to a breaker panel (also known as lighting panels or utility panels) subjects the electronic equipment to noise generated by other devices connected to the breaker panel. This noise is known as electromagnetic interference (EMI). EMI flows on the wires that are common to a circuit. EMI cannot travel easily through transformers and therefore can be isolated from selected circuits. Use a control power transformer of the proper VA rating, usually provided in the compressor drive motor starter, to isolate the electronic control panel from other equipment in the plant that generate EMI. See Figure 11.

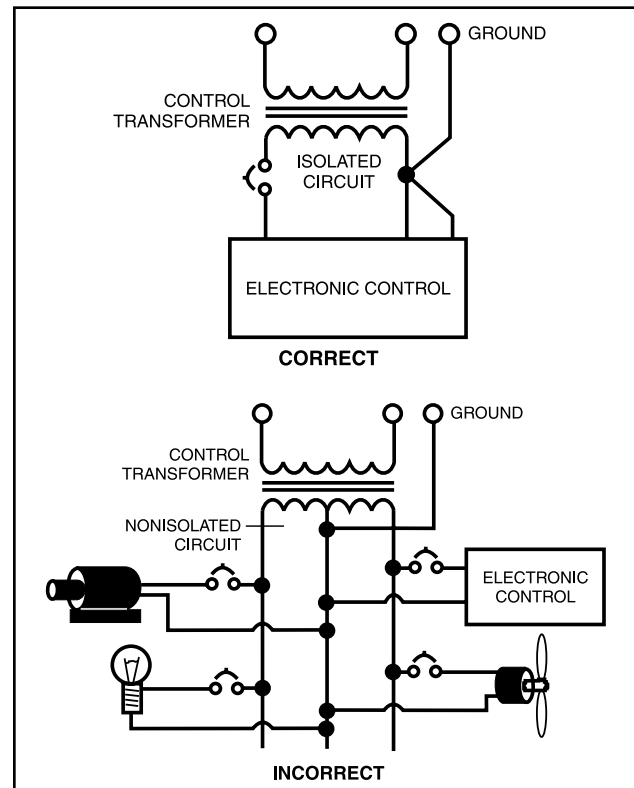


Figure 11. Voltage Source Circuit To Prevent EMI

GROUNDING

Grounding is the most important factor for successful operation and is typically the most overlooked. The NEC states that control equipment may be grounded by using the rigid conduit as a conductor. This worked for the earlier relay systems, but it is in no way acceptable for electronic control equipment. Conduit is made of steel and is a poor conductor relative to an insulated stranded copper wire. Electronic equipment reacts to very small currents and must have a proper ground in order to operate properly; therefore, stranded copper grounds are required for proper operation.

For proper operation, the control power ground circuit must be a single continuous circuit of the proper sized insulated stranded conductor, from the electronic control panel to the plant supply transformer (See Figure 12). Driving a ground stake at the electronic control may also cause additional problems since other equipment in the plant on the same circuits may ground themselves to the ground stake causing large ground flow at the electronic control panel. Also, running multiple ground conductors into the electronic control panel from various locations can create multiple potentials resulting in ground loop currents. A single ground wire (10 AWG or 8 AWG) from the electronic control panel, that is bonded to the control power neutral at the secondary side of the control power transformer in the starter and then to the 3-phase ground point, will yield the best results.

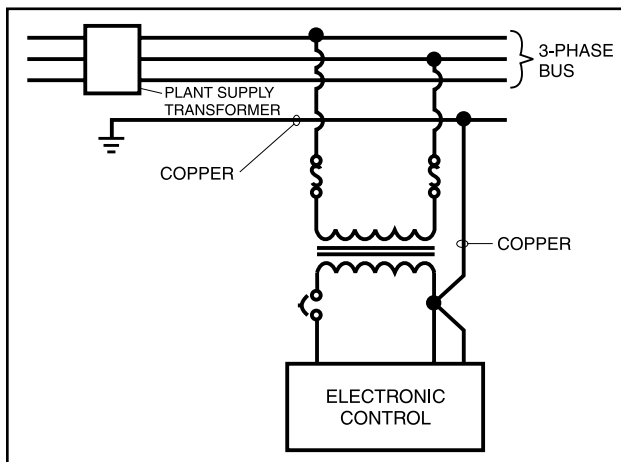


Figure 12. Control Power Ground Circuit

NOTICE

Structural grounding can also result in multiple ground potentials and is also a relatively poor conductor. Therefore, this is not an acceptable method for proper operation of electronic equipment.

There must be a ground for the three-phase power wiring. This must be sized in accordance to the NEC and any local codes relative to the highest rated circuit overload protection provided in the circuit. The manufacturer may require a larger ground conductor than what is required by the NEC for proper steering of EMI from sensitive circuits. This conductor must also be insulated to avoid inadvertent contact at multiple points to ground, which could create Ground Loops. In many installations that are having electronic control problems, this essential wire is usually missing, is not insulated, or improperly sized.

NEC size ratings are for safety purposes and not necessarily for adequate relaying of noise (EMI) to earth ground to avoid possible interference with sensitive equipment. Therefore sizing this conductor 1 – 2 sizes larger than required by code will provide better transfer of this noise.

Johnson Controls-Frick® requires that the ground conductor meet the following:

- Stranded Copper
- Insulated
- One size larger than NEC requirements for conventional starters
- Two sizes larger than NEC requirements for VFD starters
- Conduit must be grounded at each end
- This circuit must be complete from the motor to the starter continuing in a seamless manner back to the plant supply transformer (power source).

For Direct Coupled, Package Mounted Starters, the ground between the motor and the starter may need to be made externally (See Figure 13). The connection on the starter end must be on the starter side of the vibration isolators. Be certain the connection is metal to metal. Paint may need to be removed to ensure a proper conductive circuit. The use of counter-sunk star washers at the point of connection at each end will maximize metal to metal contact.

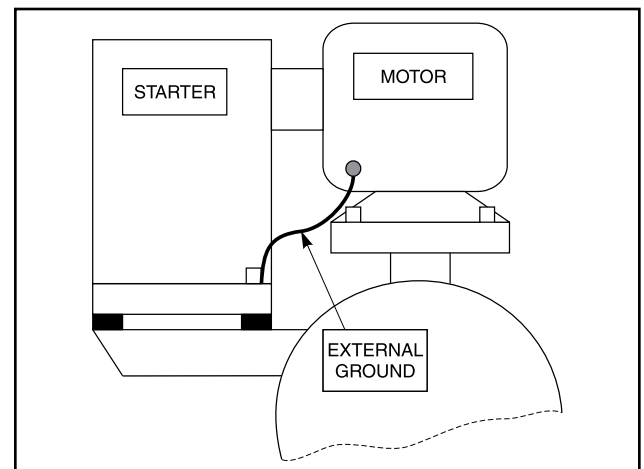


Figure 13. Motor And Starter Grounding

VFD APPLICATIONS

The primary ground conductor that accompanies the three-phase supply must be stranded copper, insulated and two sizes larger than the minimum required by the NEC or any other applicable codes. This is necessary due to the increased generation of EMI which is a characteristic of a VFD output to the motor when compared to a conventional starter.

For VFD applications, isolation of the control power, analog devices, and communications ground from the 3-phase ground within the starter and the electronic control panel may be necessary. This is due to the higher noise (RFI/EMI) levels generated between the VFD output and the motor, relative to a conventional starter. If these grounds are left coupled by a common back-plate in the starter/drive, this noise can be direct coupled to the control power, analog device, and communications grounding and may cause unexplained behavior and possible damage to components.

To install correctly, run a separate, properly sized (10 or 8 AWG typically) insulated ground along with and taken to ground with, the 3-phase ground at the 3-phase supply transformer (plant). This will require that the 3-phase ground and the control power ground be electrically isolated except for the connection at the plant supply transformer.

This style of grounding should steer the noise (EMI/RFI) to earth ground, reducing the potential for it to affect the sensitive equipment, which could occur if the grounds were left coupled.

NOTICE

If all other recommendations for grounding are followed, this process should not be necessary.

CONDUIT

All national and local codes must be followed for conduit with regard to materials, spacing and grounding. In addition, **Johnson Controls-Frick requirements must be followed where they exceed or match national or local codes. Conversely, there is no allowance for any practices that are substandard to what is required by national or local codes.**

Johnson Controls-Frick conduit requirements:

- For *variable frequency drives* (VFDs) of any type, threaded metallic or threaded PVC-coated metallic is required for both the power feed (line side) from the source and between the VFD output and the motor (load side).
- PVC conduit is acceptable **only** when *VFD rated cable* of the proper conductor size and ground is used. This applies to both the line side and load side of the drive. When VFD rated cable is not used, threaded metallic or threaded PVC-coated metallic must be used.
- When threaded metallic or threaded PVC-coated metallic is used, it must be grounded at both ends.
- When not required to be in metal or other material by national or local codes, conduits for the power feed (3-phase) of constant speed starters may be PVC.
- When not required to be in metal or other material by national or local codes, conduits between a constant speed starter and the motor (3-phase) may be PVC.
- Any unshielded control voltage, signal, analog, or communication wiring that does not maintain 12 inches of separation from any 3-phase conductors for every 33 feet (10 meters) of parallel run must be in metal conduit which will be grounded.

Separation: (0-33 feet, 0-10 meters – 12 inches, .3 meters), (33-66 feet, 10-20 meters – 24 inches, .6 meters)

- Since PVC conduit does absolutely nothing to protect lower voltage lines from the magnetic field effects of higher voltage conductors, running either the lower or the higher voltage lines in PVC, does not reduce these requirements on separation. Only running in metal conduit can relieve these requirements.
- Due to the level of EMI that can be induced onto lower voltage lines when running multiple feeders in a trench, control power, communications, analog, or signal wiring cannot be run in trenches that house multiple conduits/electrical ducts carrying 3-phase power to starters/vfd or motors.

- Control power, communications, analog, or signal wiring should be run overhead (preferred) or in a separate trench. If these lines are not in threaded metallic or threaded PVC-coated metallic, abiding by the separation requirements noted above is necessary.
- Though not recommended, if cable trays are used, *metallic* dividers must be used for separation of conductors of unlike voltages and types (AC or DC).

NOTICE

When in doubt contact the factory or use threaded metallic or threaded PVC coated metallic conduit.

WIRING PRACTICES

Do not mix wires of different voltages in the same conduit. An example of this would be the installation of a screw compressor package where the motor voltage is 480 volts and the electronic control panel power is 120 volts. The 480 volt circuit must be run from the motor starter to the motor in its own conduit. The 120 volt circuit must be run from the motor starter control transformer to the electronic control panel in its own separate conduit. If the two circuits are run in the same conduit, transients on the 480 volt circuit will be induced onto the 120 volt circuit causing functional problems with the electronic control panel. Metallic dividers must be used in wire way systems (conduit trays) to separate unlike voltages. The same rule applies for 120 volt wires and 220 volt wires. Also, never run low voltage wires for DC analog devices or serial communications in the same conduit with any AC wiring including 120 volt wires. See Figure 14.

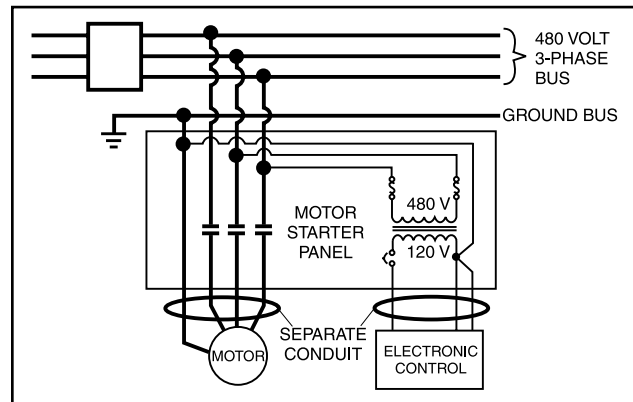


Figure 14. Separation Of Different Voltage Circuits

Never run any wires through an electronic control panel that do not relate to the function of the panel. Electronic control panels should never be used as a junction box. These wires may be carrying large transients that will interfere with the operation of the control panel. **An extreme example of this would be to run 480 volts from the starter through the electronic control panel to an oil pump motor.**

When running conduit to the electronic control panel, use the access holes (knockouts) provided by the manufacturer. These holes are strategically placed so that the field wiring does not interfere with the electronics in the panel. Never allow field wiring to come in close proximity with the controller boards since this will almost always cause problems.

Do not drill into an electronic control panel to locate conduit connections. You are probably not entering the panel where the manufacturer would like you to since most manufacturers recommend or provide prepunched conduit connections. You may also be negating the NEMA rating of the enclosure. Drilling can cause metal filings to land on the electronics and create a short circuit when powered is applied. If you must drill the panel, take the following precautions:

- First, call the panel manufacturer before drilling into the panel to be sure you are entering the panel at the right place.
- Take measures to avoid ESD (electrostatic discharge) to the electronics as you prep the inside of the Electronic control panel. This can be done by employing an antistatic wrist band and mat connected to ground.
- Cover the electronics with plastic and secure it with masking or electrical tape.
- Place masking tape or duct tape on the inside of the panel where you are going to drill. The tape will catch most of the filings.
- Clean all of the remaining filings from the panel before removing the protective plastic.

When routing conduit to the top of an electronic control panel, condensation must be taken into consideration. Water can condense in the conduit and run into the panel causing catastrophic failure. Route the conduit to the sides or bottom of the panel and use a conduit drain. If the conduit must be routed to the top of the panel, use a sealable conduit fitting which is poured with a sealer after the wires have been pulled, terminated, and the control functions have been checked. A conduit entering the top of the enclosure must have a NEMA-4 hub type fitting between the conduit and the enclosure so that if water gets on top of the enclosure it cannot run in between the conduit and the enclosure. This is extremely important in outdoor applications.

NOTICE

It is simply NEVER a good practice to enter through the top of an electronic control panel or starter panel that does not already have knockouts provided. If knockouts are not provided for this purpose it is obvious this is not recommended and could VOID WARRANTY.

Never add relays, starters, timers, transformers, etc. inside an electronic control panel without first contacting the manufacturer. Contact arcing and EMI emitted from these devices can interfere with the electronics. Relays and timers are routinely added to electronic control panels by the manufacturer, but the manufacturer knows the acceptable device types and proper placement in the panel that will keep interference to a minimum. If you need to add these devices, contact the manufacturer for the proper device types and placement.

Never run refrigerant tubing inside an electronic control panel. If the refrigerant is ammonia, a leak will totally destroy the electronics.

If the electronic control panel has a starter built into the same panel, be sure to run the higher voltage wires where indicated by the manufacturer. EMI from the wires can interfere with the electronics if run too close to the circuitry.

Never daisy-chain or parallel-connect power or ground wires to electronic control panels. Each electronic control panel must have its own control power supply and ground wires back to the power source (Plant Transformer). Multiple electronic control panels on the same power wires create current surges in the supply wires, which may cause controller malfunctions. Daisy-chaining ground wires, taking them to ground at each device, allows ground loop currents to flow between electronic control panels which also causes malfunctions. See Figure 15.

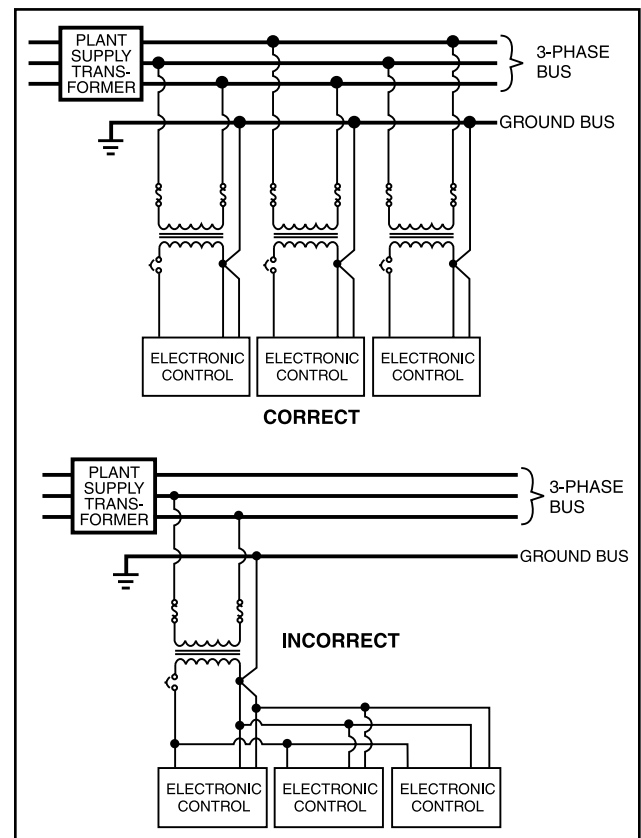


Figure 15. Electronic Control Panel Power Supplies

COMMUNICATIONS

The use of communications such as serial and ethernet in industrial environments are commonplace. The proper installation of these networks is as important to the proper operation of the communications as all of the preceding practices are to the equipment.

Serial communications cable needs to be of the proper gauge based on the total cable distance of the run. Daisy-chaining is the only acceptable style of running the communications cable. While Star Networks may use less cable, they more often than not cause problems and interruptions in communications, due to varying impedances over the varying lengths of cable. Ground or drain wires of the communications cable are to be tied together at each daisy-chain connection and only taken to ground in the central control system panel.

It is important to carefully consider the type of cable to be used. Just because a cable has the proper number of conductors and is shielded does not mean it is an acceptable cable. Johnson Controls-Frick recommends the use of Belden #9829 for RS-422 communications and Belden # 9841 for RS-485 up to 2000 feet (600 Meters) total cable length. Refer to Frick drawing 649D4743 for more detail

Comm Port Protection: Surge suppression for the comm ports may not be the best method, since suppression is required to divert excess voltage/current to ground. Therefore, the success of these devices is dependent on a good ground (covered earlier in this section). This excess energy can be quite high and without a proper ground, it will access the port and damage it.

Isolation or Optical Isolation is the preferred comm port protection method. With optical isolation, there is no continuity between the communications cable and the comm port. There is no dependence on the quality of the ground. Be sure to know what the voltage isolation value of the optical isolator is before selecting it. These may range from 500 to 4000 Volts.

Frick® Optical Isolation Kits are offered under part number 639C0133G01. One kit is required per comm port.

UPS POWER AND QUANTUM™HD PANELS

Johnson Controls, Inc. does not advise nor support the use of uninterrupted power supply systems for use with the Quantum™HD panel. With a UPS system providing shutdown protection for a Frick Quantum panel, the panel may not see the loss of the 3-phase voltage on the motor because the UPS may prevent the motor starter contactor from dropping out. With the starter contactor still energized, the compressor auxiliary will continue to feed an "okay" signal to the Quantum™HD panel. This may allow the motor to be subjected to the fault condition on the 3-phase bus.

A couple of fault scenarios are: 1. The 3-phase bus has power "on" and "off" in a continuous cycle manner which may cause the motor to overheat due to repeated excessive in-rush current experiences. 2. The motor cycling may damage the coupling or cause other mechanical damage due to the repeated high torque from rapid sequential motor "bumps." 3. Prolonged low voltage may cause the motor to stall and possibly overheat before the motor contactor is manually turned off.

Under normal conditions, the loss of 3-phase power will shut down the Quantum™HD panel and it will reboot upon proper power return. If the panel was in "Auto," it will come back and return to running as programmed. If the unit was in "Remote," the external controller will re-initialize the panel and proceed to run as required. If the panel was in "Manual" mode, the compressor will have to be restarted manually after the 3-phase bus fault/interruption has been cleared / restored.

If the local power distribution system is unstable or prone to problems there are other recommendations to satisfy these problems. If power spikes or low or high line voltages are the problem, then a constant voltage (CV) transformer with a noise suppression feature is recommended. Johnson Controls, Inc. can provide these types of transformers for this purpose. Contact Johnson Controls for proper sizing (VA Rating) based on the requirement of the job. If a phase loss occurs, then you will typically get a high motor amp shutdown. If the problem continues, an analysis of the facility's power supply quality may be necessary.

NOTICE

It is very important to read the installation instructions thoroughly before beginning the project. Make sure you have drawings and instructions for the equipment being installed. If not, call the manufacturer to receive the proper instructions and drawings. Every manufacturer of electronic equipment should have a knowledgeable staff, willing to answer your questions or provide additional information. Following correct wiring procedures will ensure proper installation and consequently, proper operation of your electronic equipment.

Notes

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