Sumitomo
(SHI) CRYOGENICS OF AMERICA, INC.

FA-40H and FA-40L Air-Cooled Helium Compressors

Operating Manual

Sumitomo (SHI) Cryogenics of America, Inc.
1833 Vultee Street
Allentown, PA 18103-4783
U.S.A.

Revision A: March 2017 **268317A**

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SAFETY

GENERAL

SCAI equipment is designed to operate safely when the installation, operation and servicing are performed in accordance with the instructions in this technical manual. For Service Center locations, see the Service section of this manual.

SPECIAL NOTICES

Three types of special notices -- **WARNINGS, CAUTIONS** and **NOTES** are used in this technical manual.

⚠ WARNING

WARNINGS call attention to actions or conditions that can result in serious injury or death.

CAUTION

CAUTIONS call attention to actions or conditions that can result in damage to the equipment or in abnormal performance.

NOTE

NOTES give important, additional information, explanations or recommendations related to the appropriate topic or procedure.

WARNINGS and **CAUTIONS**, like other safety instructions, appear within rectangles in the text where they are applicable. Because of their importance, they are summarized in this Safety section and in the General Technical Manual, and should be read first.

NOTE

Changes to this manual since the previous issue are identified by parallel lines (||) in the right margins.

WARNINGS

AVOID ELECTRIC SHOCK. All electrical supply equipment must meet applicable codes and be installed by qualified personnel.

Disconnect the power to the compressor before troubleshooting the electrical components.

Permit only qualified electrical technicians to open electrical enclosures, to perform electrical checks or to perform tests with the power supply connected and wiring exposed. Failure to observe this warning can result in serious injury or death.

AVOID INJURY. Never use compressed helium gas from a cylinder without a proper regulator. Overpressure can cause serious injury if the system equipment ruptures.

During operation, some surfaces under the compressor's cover become hot. Allow the compressor to cool for 1/2 hour after shutdown before removing the cover for maintenance.

Always wear eye protection when handling pressurized gas lines and other pressurized equipment. Never apply heat to a pressurized gas line or other pressurized components.

Disconnect gas lines only when the compressor is stopped. Disconnecting the cold head while it is cold can create excessively high internal pressure as the gas warms. Material failure and uncontrolled pressure release can cause serious injury.

Use two wrenches when disconnecting a gas line coupling to avoid loosening the cold head or compressor coupling. Gas pressure can project the coupling with enough force to cause serious injury.

The compressor is charged with helium gas. Except when disconnecting the adsorber or the gas lines, vent both supply and return Aeroquip couplings to atmospheric pressure before disassembly. Uncontrolled pressure release can cause serious injury.

Always vent a gas-charged component before beginning to disassemble its couplings. Gas pressure can launch a loose coupling with enough force to cause serious injury.

The adsorber is charged with helium gas. Follow the used adsorber venting procedure for safe disposal of the used adsorber.

Do not touch heat exchanger fins. Fins are sharp and may cause injury.

CAUTIONS

PRESERVE YOUR WARRANTY. Modification to equipment without the consent of the manufacturer will void the warranty.

Specifications require the use of 99.999% pure helium gas. Using a lesser quality of helium can damage the system and void the warranty.

AVOID GAS LEAKS. Check the condition of the gasket face seal on the male half of each Aeroquip coupling. Be sure the gasket face seal is in place and the sealing surfaces on both the male and female halves are clean before connecting. Replace the gasket face seal if it is damaged or missing.

Keep the gas line couplings aligned when making or breaking a coupling connection. Leaks can occur due to the weight of the gas line or due to a sharp bend near the connection.

CAUTIONS (continued)

AVOID CONTAMINATION. When checking the compressor for shipping damage, do not connect the gas lines and the cold head. The components may become contaminated with compressor oil.

Follow the charging or venting procedures to prevent reversed flow of system gas. Do not charge through the supply coupling. Do not vent through the return coupling. Reversed flow can contaminate the system with compressor oil.

A leaking coupling on an adsorber should not be repaired in the field. Consult a Service Center. Venting the adsorber will introduce contaminants to the system, which cannot be removed in the field.

PREVENT EQUIPMENT DAMAGE. Damage to gas lines can result from crimping by repeated bending and repositioning.

If the compressor is wired for 380/400/415 V3~ electrical service, connecting to a higher voltage may damage the control circuit. Similarly, if it is wired for 460-480 V3~, it can be damaged by connecting to 380/400/415 V3~.

Never pull a vacuum on the compressor or on the cold head. The motors will short circuit if started.

Do not insert object or admit fluids through fan guard under any circumstances. Injury or malfunction may occur.

AVOID A MALFUNCTION. Repeatedly charging the system with helium gas rather than locating and repairing gas leaks can cause a malfunction. Impurities are introduced at an abnormal rate and can freeze in the cold head.

Do not allow air to get into the helium gas refrigerant of the system. Moisture from the atmosphere can seriously degrade cold head performance.

AVOID EQUIPMENT FAILURE, CONTAMINATION OR A NUISANCE SHUTDOWN. Do not tip the compressor greater than 5 degrees from horizontal, to avoid flowing oil into unwanted places.

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SERVICE

HEADQUARTERS

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INTRODUCTION

Helium Compressors, Models FA-40H and FA-40L

The compressors are designed to deliver high-pressure, oil-free, helium gas to cryogenic refrigerators. Cold head cables are used with the compressor to supply electrical power to cold heads. Self-sealing gas couplings allow for easy connection to and disconnection from the rest of the closed-cycle cryogenic refrigeration system.

The information in this manual pertains only to the FA-40H (high voltage model) and the FA-40L (low voltage model) Air-Cooled Compressors. Other components used to form an operating system are described in separate technical manuals.

Pressures are stated as gauge, not absolute. Pressure units are bar and pounds per square inch (psig). For reference:

1 bar = 14.5 psig.
1 MPa = 10 bar

Definition of Symbols used in this manual and on equipment

	Mains Disconnect On		Protective Earth (Ground)
	Mains Disconnect Off		Dangerous Voltage
	Refer to Manual	V3~	Volts, AC, 3 phase
		AT	Amps, Time delay, to describe the fuse rating

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PRINCIPLES of OPERATION

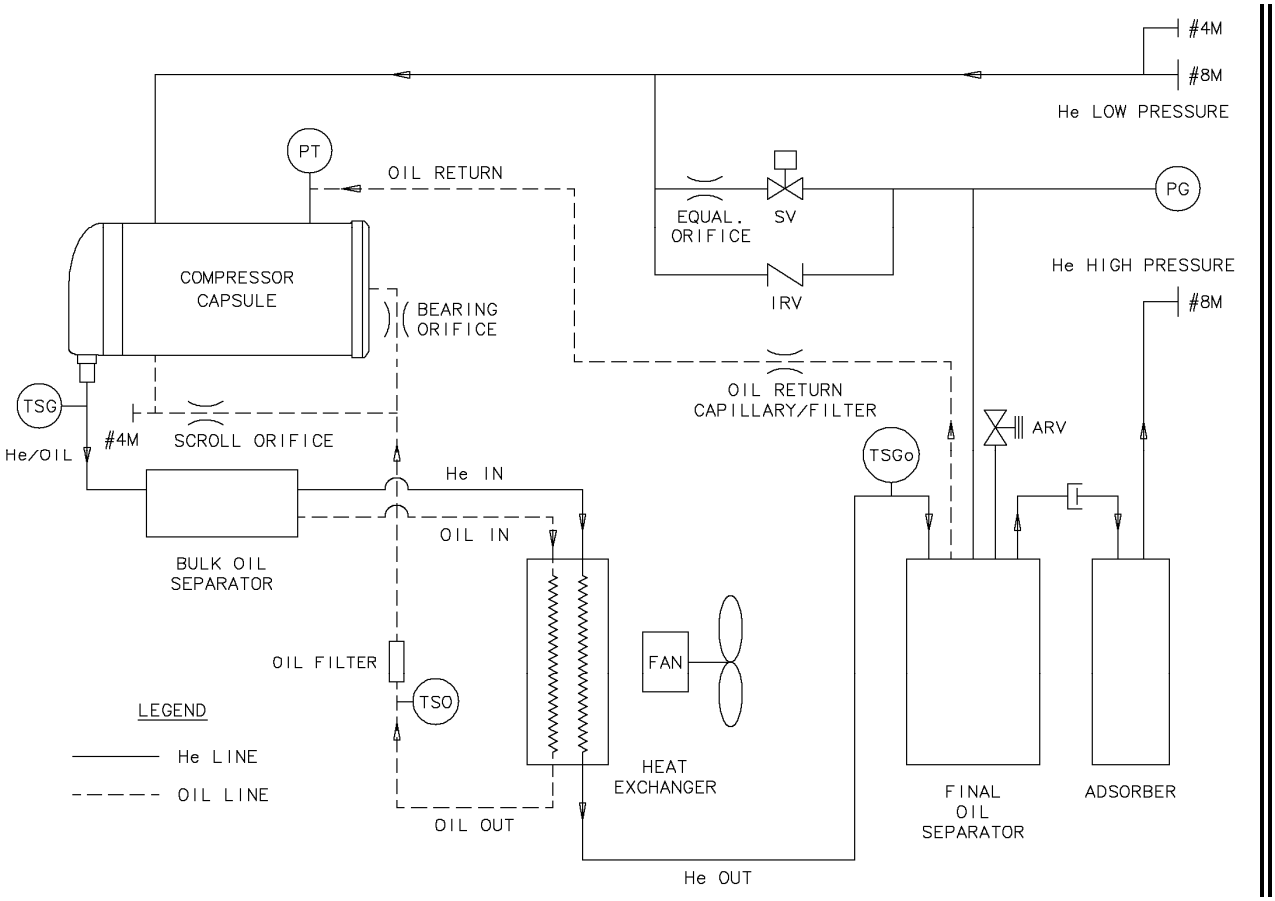

Figure 1 Compressor Flow Diagram

Key	
TSG	Helium discharge temperature thermistor
TSO	Oil Hx outlet temperature thermistor
TSGo	Helium Hx outlet temperature thermistor
ARV	Atmospheric relief valve
IRV	Internal relief valve
SV	Solenoid valve
PT	Pressure transducer
PG	Pressure gauge

The compressor continuously draws low-pressure helium from the system return line. It compresses, cools and cleans the gas, then delivers it through the system gas supply line to the cold head. See Figure 1.

When helium gas leaves the compressor capsule, the gas contains heat and compressor lubricant. Both must be removed. From the compressor capsule, the hot gas with its entrained oil flows out of the shell and through the bulk oil separator. The gas next flows through one circuit of a two-circuit, air cooled, heat exchanger, where it is cooled. Next, the gas passes through the final oil separator and the adsorber for oil and moisture removal. From the adsorber, the high-pressure helium gas flows to the cold head through the gas lines.

Through the system gas return line, low-pressure gas from the cold head flows into the compressor.

A gas line containing an internal relief valve (IRV) connects the high-pressure line to the low-pressure line. The relief valve will open to prevent overloading the motor when the system gas lines are not connected to the compressor.

Oil is separated from the gas in three stages. The first stage is by gravity when the gas passes through the bulk oil separator. The second stage is in the final oil separator whose element collects oil mist from the gas; oil is agglomerated and returned to the compressor. The third stage is the adsorber that removes any remaining oil the gas is carrying.

Oil collected in the oil separators flows back to the compressor capsule through capillary tubes and orifices. The differential gas pressure across the system is the moving force, and the restriction size limits the amount of gas bypassed. The small amount of oil collected in the adsorber remains there and is removed only by replacing the adsorber.

Before being returned to the compressor capsule, the oil separated in the bulk oil separator flows through the heat exchanger where it is cooled. It is then injected into the low pressure side of the compressor capsule to adsorb heat and lubricate the compressor capsule.

DESCRIPTION

Components

Adsorber - The adsorber removes any oil and moisture the gas is carrying which did not drop out in the separator. The adsorber has a finite life and must be replaced at regular intervals.

Atmosphere Relief Valve [ARV] – The pressure relief valve prevents the compressor from operating at an unsafe pressure by venting to the atmosphere.

Bulk Oil Separator - Removes much of the entrained oil from the gas stream. This unit needs no servicing or replacement

Cold Head Power Receptacle - Mounted on the front panel for connecting a cable to supply electrical power from the compressor to the cold head.

Compressor Capsule - Helium, scroll compressor with a hermetically sealed motor.

Compressor High Temperature Motor Protector Switch - Located inside the compressor motor, the switch senses compressor motor temperature and stops the motor if the temperature is too high. The switch resets after cool down.

Electrical Chassis - The electrical box contains electrical components and connections and distributes power to all system circuits.

Fan – Moves air through the heat exchanger to cool helium and oil streams.

Final Oil Separator - Removes most of the remaining entrained oil from the gas stream. This unit needs no servicing or replacement.

Fuses – Three (3) time delay, class CC fuses, located inside the electrical chassis box, protect the transformer. Three (3) time delay, 5x20 mm fuses, located inside the electrical chassis box, protect the cold head supply circuit, the fan motor circuit and the control circuits.

Heat Exchanger - Uses air to cool the high-pressure helium refrigerant and the compressor's lubricating oil.

Helium Charge - A size 4, male (4M), Aeroquip coupling located on the front of the compressor is used for charging or venting helium gas refrigerant.

Helium Discharge High Temperature Thermistor [TSG] - Senses discharge gas temperature. It causes the compressor to shut down if the temperature of the high-pressure helium from the compressor is too high.

Helium Hx Outlet Temperature Thermistor [TSGo] – Senses helium temperature downstream of the heat exchanger. It causes the compressor to shut down if the helium out temperature is too high. A warning is provided if the temperature is higher than normal operating temperature, but not yet high enough to cause shutdown.

Helium Supply and Helium Return Pressure Couplings – Both supply (high pressure) and return (low pressure) are self-sealing, size 8, male (8M), Aeroquip, bulkhead couplings and are the points of connection on the front panel for the gas lines.

Internal Relief Valve [IRV] - The internal relief valve opens to allow the compressor to be operated in the stand-alone mode or when the system gas lines are disconnected, to avoid overloading the motor.

Mains Power Switch - Mounted on the front panel, it provides a means to disconnect power and it protects the compressor from electrical overload. This device is labeled Main Power.

Oil Capillary - The capillary returns oil collected in the oil separator sump to the compressor for recycling.

Oil Filter - Filters in the oil lines protect the oil return capillary and the orifices.

Oil Hx Outlet Temperature Thermistor [TSO] - Senses oil temperature downstream of the heat exchanger.

Oil Injection Orifices - These orifices are installed in the oil return lines and control the flow rate of oil returned to the compressor.

Pressure Gauge - Indicates gas pressure in the supply line. When the compressor is not running, the gauge located on the compressor's front panel shows the equalization pressure.

SPECIFICATIONS

FA-40H Compressor (high voltage model) 460-480 (±10%) V3~, 60 Hz or 380/400/415 (±10%) V3~, 50 Hz

FA-40L Compressor (low voltage model) 200 (±10%) V3~, 50/60 Hz

Electrical Characteristics

Service required: Delta connected, 4 wires (3 phase plus protective ground or earth.)

Power Connection, FA-40H and FA-40L:

A screw-mounted, rectangular industrial connector is provided on the electrical front panel for connecting power to the compressor.

FA-40H (high voltage model) Transformer Voltage Tap Selection: The proper transformer voltage tap must be selected to match the incoming supply voltage by proper position of the transformer supply connector located behind the voltage selection access panel on the electrical front panel. See the section Transformer Voltage Tap Selection.

Power consumption:

	Equalization Pressure	Operation	Startup
RDK-305D Cold Head	12.2 bar (177 psig)	3.6 – 3.8 kW @ 50 Hz 4.6 – 4.8 kW @ 60 Hz	<4.8 kW @ 50 Hz <5.6 kW @ 60 Hz
RDK-408D2 Cold Head	1.52 MPa (220 psig)	4.0-4.4 kW @ 50 Hz 5.0-5.4 kW @ 60 Hz	<5.4 kW @ 50 Hz <6.4 kW @ 60 Hz

Rated load current:

For the FA-40H compressor, 9 amperes
For the FA-40L compressor, 19 amperes

Locked rotor current:

For the FA-40H compressor, 50 amperes at 50/60 Hz
For the FA-40L compressor, 91 amperes at 50/60 Hz

Internal circuit protection

Transformer: (3) 1.0 ampere, time delay, class CC fuses (FA-40H) (FU-1, 2 and 3)
(3) 2.0 amperes, time delay, class CC fuses (FA-40L) (FU-1, 2 and 3)
Fan, control and cold head motor: (3) 0.8 ampere, time delay, 5x20 mm fuses (FU-4, 5 and 6)
Control circuit: (2) 0.75 ampere, resettable, poly fuses (not replaceable).

Fuses are located inside the electrical chassis box, for service by qualified electrical technician only**.** See Figure 4.

Cold head power requirement: 200 V3~, 0.4 amperes, supplied from the compressor.

Cold head power supply: A cable connects the cold head to the compressor.

Class I: Grounded equipment

Ingress protection: 2X

See the Compressor Wiring Diagrams, Figures 13, 14, 15 and 16.

Compressor Control

Control options

1. Front Panel ON and OFF buttons
2. Control through the Diagnostic Interface
3. Control through the Serial (RS232) Interface

Control functions

- System ON and OFF
- Front panel LCD display (16 characters) of elapsed time and system status.
- (2) Push buttons, up and down arrows, to scroll the LCD display
- Cold head only run (front panel control only)
- Compressor only run (Diagnostic Interface and RS232 control only)
- Interlock to prevent starting the compressor and the cold head if the main power phase sequence is incorrect.
- Automatic restart after power interruption.
- Automatic shutoff for the following system faults. Operator correction is required before restart.
  - High helium discharge temperature (TSG), when thermistor reads >93° C (200° F).
  - High helium Hx outlet temperature (TSGo), when thermistor reads > 60° C (140° F).
  - High compressor motor windings temperature, switch opens at 145° C (293° F), resets at 60° C (140° F).
  - High compressor motor current draw: FA-40H trips at 10 amperes
    FA-40L trips at 20 amperes.
  - Open cold head (valve motor) fuse(s)
  - Low gas return pressure, < 1.03 bar (15 psig)
  - Incorrect DB-25 configuration compared to continuity value of DB-25 pins 7 and 8
- Error warning displayed for the following system fault:
  - High helium Hx outlet temperature (TSGo), > 50° C (122° F).

Front Panel Connections (See Figure 2.)

- Helium gas connections: size 8, male (8M) Aeroquip couplings, high-pressure supply (red) and low-pressure return (green).
- Helium fill port: size 4, male (4M) Aeroquip coupling.
- Cold head cable receptacle: Amphenol 97-3102A-14S-2S
- Mains power connection: Screw-mounted rectangular industrial connector
- Diagnostic interface connector: Dsub-25, for control and to indicate error condition
  - Proper Dsub-25 configuration mode must be selected at installation. See Diagnostic Interface Connector in the Compressor Control Preparation section of this manual.
- Serial connector/RS232: Dsub-9, for control and to indicate error condition

Front Panel Mounted Items (See Figure 2.)

- Supply pressure gauge (0-40 bar, 0-600 psig, 0-4000 kPa)
- LCD display (Elapsed time meter display is the default position)
- ON and OFF buttons
- (2) Display buttons (to scroll the LCD display)
- Main power switch
- Voltage selection access panel (FA-40H)
- Configuration mode selector switch
- Diagnostic Interface Connector (DB-25)
- Optional DB-25 to DA-15 adapter
- Serial Connector

Environmental Requirements

	Operating	**Storage**
Ambient Temperature	4° C to 38° C (40° F to 100° F)	-20° C to 65° C (-4° F to 150° F)
Relative Humidity	25% to 85%	10% to 90% (non-condensing)
Magnetic Field Limits	≤ 50 Gauss	
Atmospheric Pressure	70 kPa to 110 kPa	20 kPa to 110 kPa

NOTE

Operating the equipment out of specifications may void the warranty.

Heat Rejection to Room

60 Hz: 5.6-6.4 kW
50 Hz: 4.8-5.4 kW

Make sure room ventilation or air conditioning can properly handle this amount of heat.

Mounting Position

Compressor must be mounted base down and level within 5 degrees of horizontal.

Helium Gas Pressures

Application	**Equalization Pressure at 20° C (68° F) for 12 to 20 m long gas lines**	**Operating (Supply) Pressure ***
RDK-305 Cold Head, 50/60 Hz	1.2 – 1.25 MPa {12.2 bar (177 psig) nominal}	1.5 – 1.9 MPa (218-276 psig)
RDK-408 Cold Head, 50/60 Hz	1.52 MPa (220 psig)	1.85 – 2.1 MPa (268-305 psig)

*The operating pressure varies according to the heat load of cold head and ambient temperature.

Refrigerant Quality

Refrigerant is 99.999% pure helium gas with a dew point temperature less than -60° C (-76° F) at 20.7 bar (300 psig).

CAUTION

PRESERVE YOUR WARRANTY. Specifications require the use of 99.999% pure helium gas. Using a lesser quality of helium can damage the system and void the warranty.

Color Codes

The compressor helium connections are color-coded to match color labels provided with the gas lines.

SUPPLY (red) - Helium high-pressure gas supply from the compressor to the cold head.
RETURN (green) - Helium low-pressure gas return to the compressor from the cold head.

Required Spacing for Airflow

See Figure 5.

Optional Spacing

Allow 300 mm (12") space in front of the compressor for access to electrical and gas connections. Allow 600 mm (24") space on the left side (when facing the front) of the compressor for maintenance of the adsorber.

Maintenance Intervals

Compressor adsorber: 30,000 operating hours

Noise Level

< 67 dB(A) at 1m

Dimensions

See Figure 3.

Weight (approximate)

Compressor: 110 kg (242 pounds)

General Operating Conditions

Normal pressure and temperature data are listed above. User should record monthly the operating conditions in a logbook. Keep this record of data for reference and later comparisons.

Supplier Name and Address

Sumitomo (SHI) Cryogenics of America, Inc.
1833 Vultee Street
Allentown, PA 18103-4783
U.S.A.

(610) 791-6700

Product End of Life Instructions

1. Depressurize helium refrigerant gas to atmospheric pressure.
2. Drain oil.
3. Dispose used equipment in accordance with local laws and requirements.

Regulatory Compliance

EU Declaration of Conformity

Manufacturer's Name	Sumitomo (SCAI) Cryogenics of America
Manufacturer's Address	1833 Vultee Street Allentown, PA 18103 U.S.A.
Authorized Representative's Name	Sumitomo (SHI) Cryogenics of Europe Limited
Authorized Representative's Address	3 Hamilton Close Houndmills Industrial Estate Basingstoke, Hants RG21 6YT England
Type of Equipment	Cryogenic Refrigeration Systems

We declare under our sole responsibility that the following product(s)

FA-40H and FA-40L Series Compressors

are in conformity with the relevant Union harmonization legislation

CE

Application of Council Directives:

- **Machinery Directive 2006/42/EC**
- **EMC Directive 2014/30/EU**
- **RoHS Directive 2011/65/EU**

Product complies with
UL 471: 10th Ed., cUR Mark

I, the undersigned, hereby declare that the products specified above conform to the above Directives.

By: _____

Robert Deobil
President, SCAI

February 2017

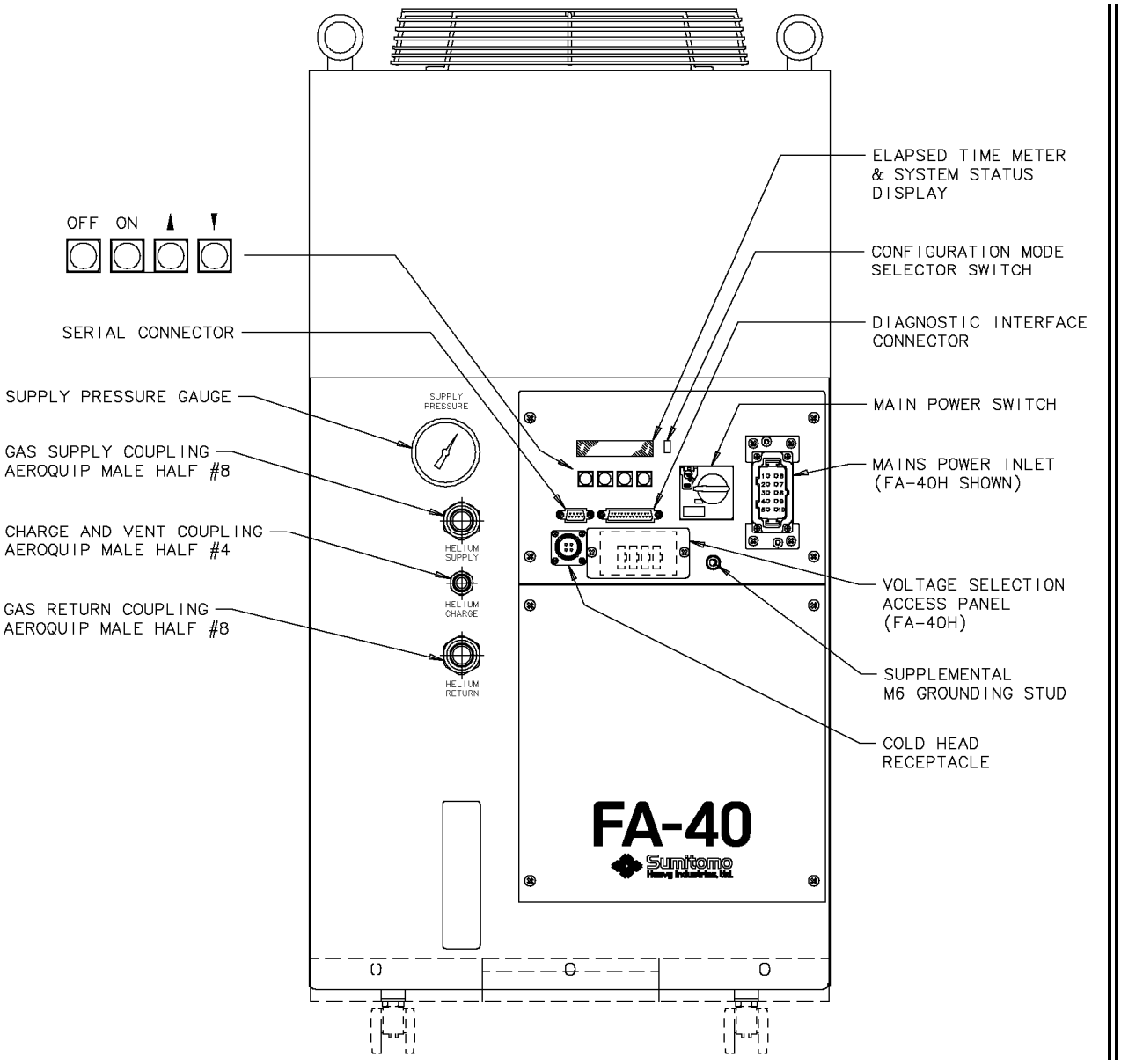

Figure 2 FA-40H and FA-40L Compressors, Front View

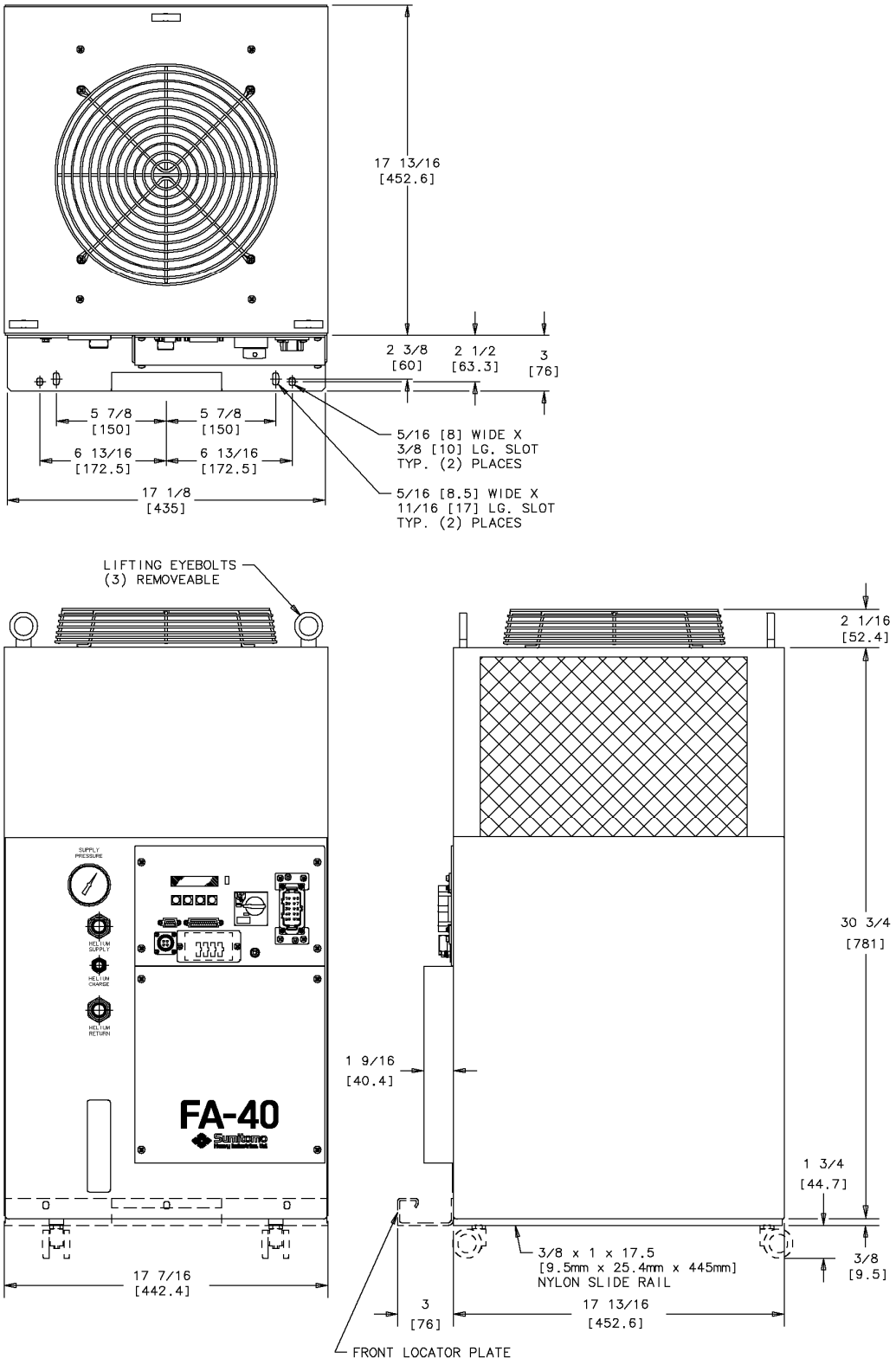

Figure 3 FA-40H and FA-40L Compressors, Dimensions

Dimensions are in inches and [mm].

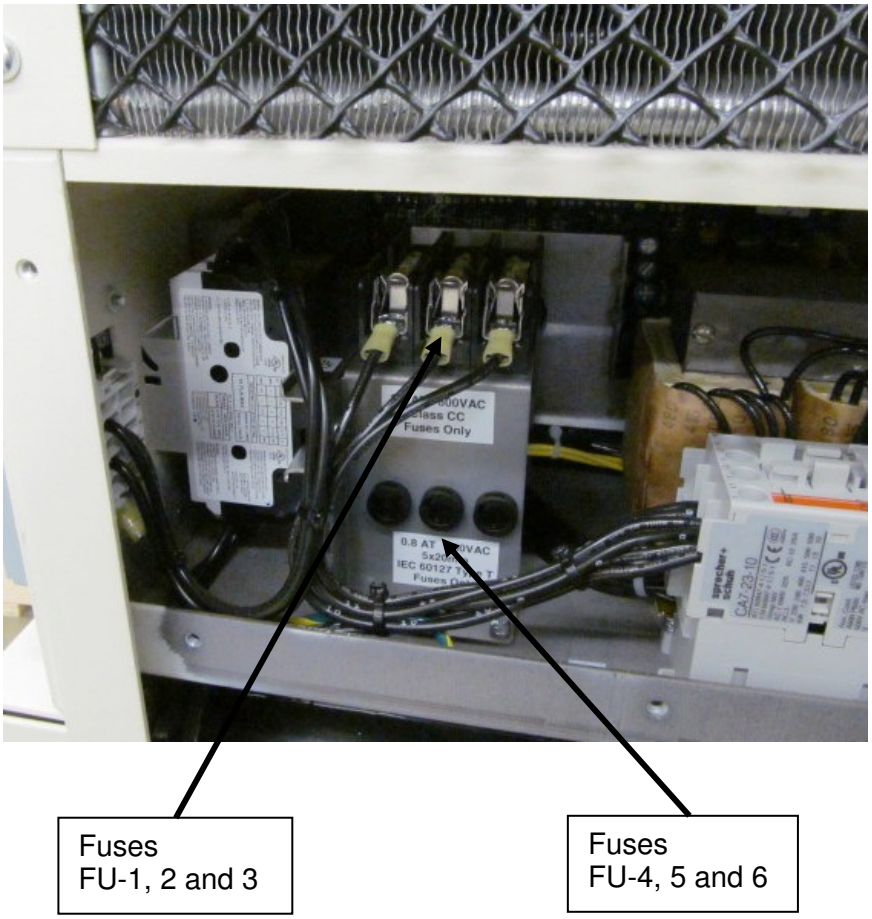

Figure 4 Fuse Locations in the Electrical Chassis

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INSTALLATION

Introduction

Install the FA-40H or the FA-40L Compressor, Gas Lines and Cold Head Cable, and configure the Compressor Control according to the following procedures.

The following installation procedures are based on standard arrangements of equipment, using SCAI standard components.

To prevent contaminating the components or the system, it is important to follow the procedures in this manual step by step.

NOTE

Be sure to have 99.999% pure helium gas available for installation of the system. See Refrigerant Quality in Specifications.

Receipt Inspection Instructions

CAUTION

AVOID EQUIPMENT FAILURE, CONTAMINATION OR A NUISANCE SHUTDOWN. Do not tip the compressor more than 5 degrees from horizontal to avoid flowing oil into unwanted places.

CAUTION

AVOID CONTAMINATION. When checking the compressor for shipping damage, do not connect gas lines and cold head. The components may become contaminated with compressor oil.

1. Upon receipt, inspect the shipping container and the compressor for damage.

1.1. If there is any evidence of external damage to the container, be sure the carrier's driver sees the damage. Note it on the shipping documents and have the driver acknowledge it by his initials on the delivery receipt.

1.2. Remove the compressor from its shipping container and inspect for damage. If there was external damage to the compressor, remove its covers and check for internal damage. Notify the carrier immediately and take photographs of the damage to document your claim to the carrier. Keep the damaged shipping container.

NOTE

Retain the shipping containers, if reusable, for returning the components to the factory if reconditioning is required. If internal damage is suspected, retain the shipping container for proof to the carrier.

2. Inspect for Proper Charge Pressure

2.1 The Charge Pressure of the Compressor Unit can be checked from the outside of the shipping container without removing the packaging.

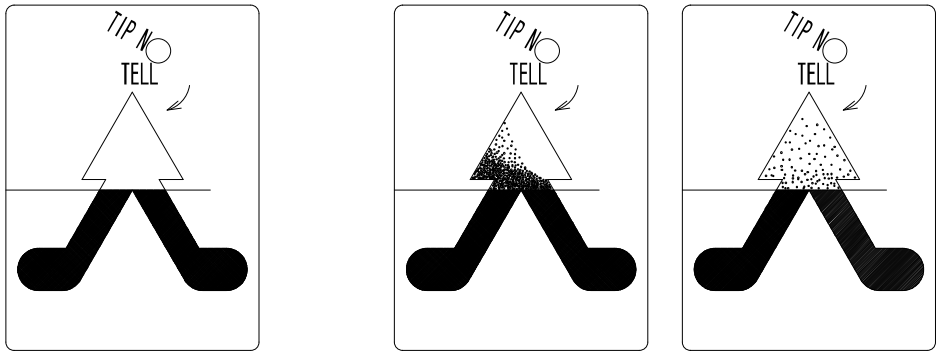
2.2 Look through the "peep hole" on the container. View the pressure gauge on the Compressor Unit front panel. The pressure gauge should indicate 174 – 179 PSIG at 68°F (1200 – 1230 kPa at 20°C).

2.3 If the gauge indicates 0 PSIG (0 MPa), the Compressor Unit cannot be used. Contact the nearest SHIG Service Center.

3. Upon receipt, inspect Tip-N-Tell Sensor on Package for Activation

3.1 The Tip-N-Tell sensor mounted on the shipping container package surface should be checked upon receipt and before unpackaging to verify the "Compressor Unit shipping container" was NOT tipped or mishandled during transport.

3.2 If activated, Tip-N-Tell sensor turns blue in the arrow as shown below. Proceed with internal inspection.



Non-Activated (Good) Activated (Not Good)

Unpackaging and Product Inspection Instructions

1. Unpackaging Instructions

1.1 Remove the straps around the package.

1.2 Remove the Packaging Cover Shell and Top Inside Cushions.

1.3 Insert and tighten the three (3) furnished eyebolts into the top of the compressor. See Figure 3.

1.4 Carefully lift the compressor off the wooden base.

1.5 Retain the reusable shipping container parts for possible reuse. This includes the wooden base with Ethafoam cushion blocks, the packaging cover shell and the top inside cushions.

2. Inspect the Tip-N-Tell Sensor on Compressor Unit for Activation.

2.1 Check the Tip-N-Tell sensor mounted on the compressor rear panel. If the Tip-N-Tell sensor shows no mishandling and there is no apparent physical damage, skip Steps **2.2** and 2**.3** and proceed to the section Compressor Location.

If the Tip-N-Tell sensor indicates mishandling (arrow point is blue), proceed to either Step **2.2** or **2.3**:

2.2 The equalization pressure is within specifications:

If the compressor has been momentarily tipped (less than one hour) and the equalization pressure is within specifications, allow it to stand upright for two hours before performing this step

⚠ WARNING

AVOID ELECTRIC SHOCK. All electrical supply equipment must meet applicable codes and be installed by qualified personnel.

⚠ WARNING

AVOID ELECTRIC SHOCK. Permit only qualified electrical technicians to open electrical enclosures, to perform electrical checks or to perform tests with the power supply connected and wiring exposed. Failure to observe this warning can result in serious injury or death

CAUTION

PREVENT EQUIPMENT DAMAGE. If the FA-40H compressor is wired for 380-415 V3~ electrical service, connecting to a higher voltage may damage the control circuit. Similarly, if it is wired for 460-480 V3~, it can be damaged by connecting to 380/400/415 V3~.

Connect power to the compressor. See the next sections Compressor Location, Electrical Supply Connection, and Compressor Checkout. Test run the compressor for two (2) hours minimum. If there are no problems during this time, stop the compressor and proceed to assemble the system.

If the compressor shuts down during the two- (2) hour test, contact the nearest SCAI Service Center.

2.3 If the equalization pressure is outside the specified range or there is physical damage to the compressor enclosure or the compressor has been on its side or upside down for an extended period of time (more than one hour), contact the nearest SCAI Service Center and notify the delivering carrier of the damage.

NOTE

When checking the compressor for shipping damage, do not connect gas lines and cold head. The components may become contaminated with compressor oil.

3. Inspect for Visible Damage of Compressor Unit.

3.1 Inspect the exterior panels of the Compressor Unit for evidence of damage.

3.2 If there was external damage to the compressor, remove the compressor unit panels and check for internal damage. Notify the carrier immediately and take photographs of the damage to document your claim to the carrier.

3.3 If any irrecoverable damage is found (e.g. oil Leakage, panel deformation), contact the nearest SCAI Service Center.

Compressor Location

Place the compressor in a location that is protected from the elements and where the ambient temperature will always be within the range of 4° C to 38° C (40° F to 100° F).

The compressor must be installed base down, within 5 degrees of horizontal.

The compressor must be installed in a location allowing proper airflow. Proper airflow prevents warm discharge air from entering the heat exchanger. Minimum spacing requirements are shown in Figure 5.

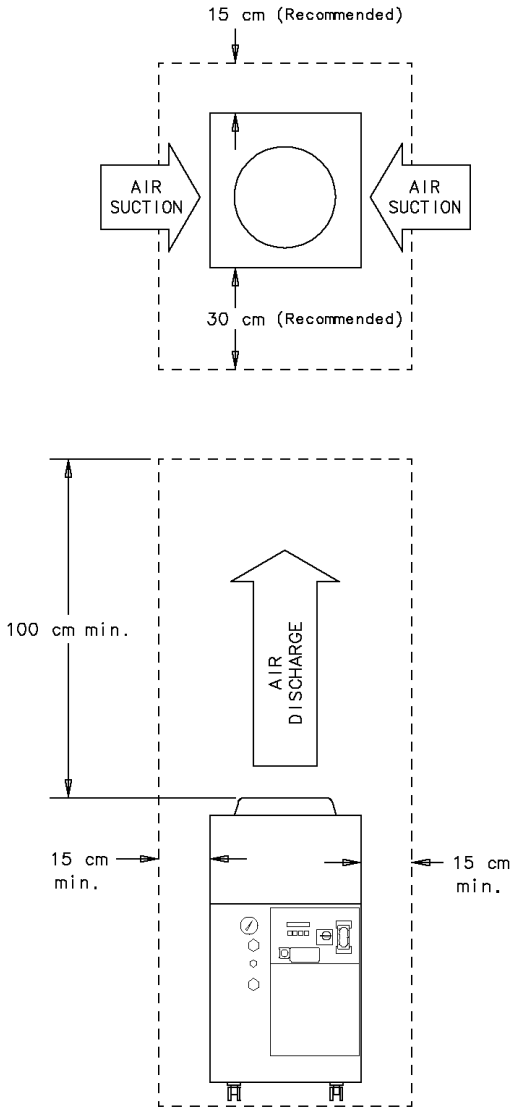


Figure 5 Required Space for Compressor Unit

Allow 300-mm (12”) space in front of the compressor for access to electrical and gas connections. A 600-mm (24”) space is recommended on the left side (when facing the front) of the compressor for maintenance of the adsorber.

Transformer Voltage Tap Selection for FA-40L

The FA-40L Compressor is permanently configured for 200 V3~, 50/60 Hz. No changes are required for this model.

Transformer Voltage Tap Selection for FA-40H

There are four (4) possible voltage taps: 380 V, 400 V, 415 V and 460-480 V (labeled “480”). The compressor is factory set for 400 V3~. Select voltage tap closest to mains power supply:

Mains Voltage Supply	Voltage Tap
342-418 VAC, 50 Hz	380 V
360-440 VAC, 50 Hz	400 V
374-456 VAC, 50 Hz	415 V
414-528 VAC, 60 Hz	480 V

Before power is supplied, the following procedure must be applied only if the wires need to be changed to another supply voltage.

CAUTION

PREVENT EQUIPMENT DAMAGE. If the FA-40H compressor is wired for 380-415 V3~ electrical service, connecting to a higher voltage may damage the control circuit. Similarly, if it is wired for 460-480 V3~, it can be damaged by connecting to 380/400/415 V3~.

⚠ WARNING

AVOID ELECTRIC SHOCK. Permit only qualified electrical technicians to open electrical enclosures, to perform electrical checks or to perform tests with the power supply connected and wiring exposed. Failure to observe this warning can result in serious injury or death.

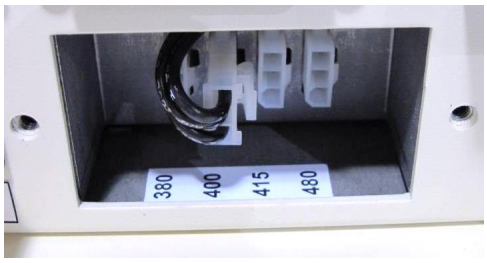
Tool required: #2 Phillips screwdriver

1. Disconnect the mains power supply to the compressor (if connected).
2. At the voltage selection access panel on the front of the compressor, remove the clear plastic cover to expose the voltage selection connectors. See Figure 6.
3. Move the exposed connector half from the incorrect voltage tap connector to the voltage tap connector labeled for the correct supply voltage. Use the tap labeled “480” for nominal supply voltages 460 V and 480 V. Make sure the connector latches in place. See Figure 7.
4. Replace the clear plastic window.

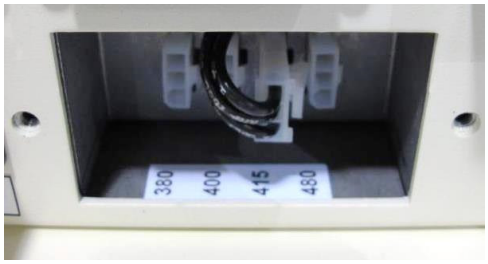
5. Reconnect the compressor's main power.

Figure 6 Voltage Selection Connectors

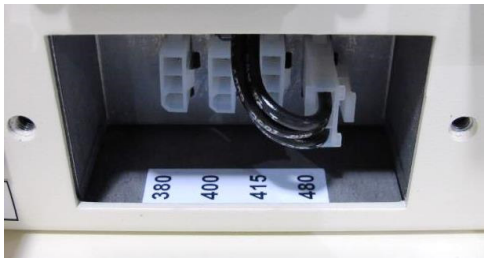
380V Connection



400V Connection



415V Connection



460-480V Connection

Figure 7 Voltage Tap Configurations

Electrical Supply Connection

Tools required: #3 Phillips screwdriver
5 mm Hex driver

The FA-40 compressor must be installed in a circuit capable of supplying the specified voltage and power. The wiring method used for connection to the front panel power connector must meet applicable codes.

⚠ WARNING

AVOID ELECTRIC SHOCK. All electrical supply equipment must meet applicable codes and be installed by qualified personnel. Permit only qualified electrical technicians to open electrical enclosures, to perform electrical checks or to perform tests with the power supply connected and wiring exposed. Failure to observe this warning can result in serious injury or death.

FA-40H and FA-40L:
Connect mains power supply cable into the mains power receptacle on the front panel and fasten cover with attached screws. See Figure 8.

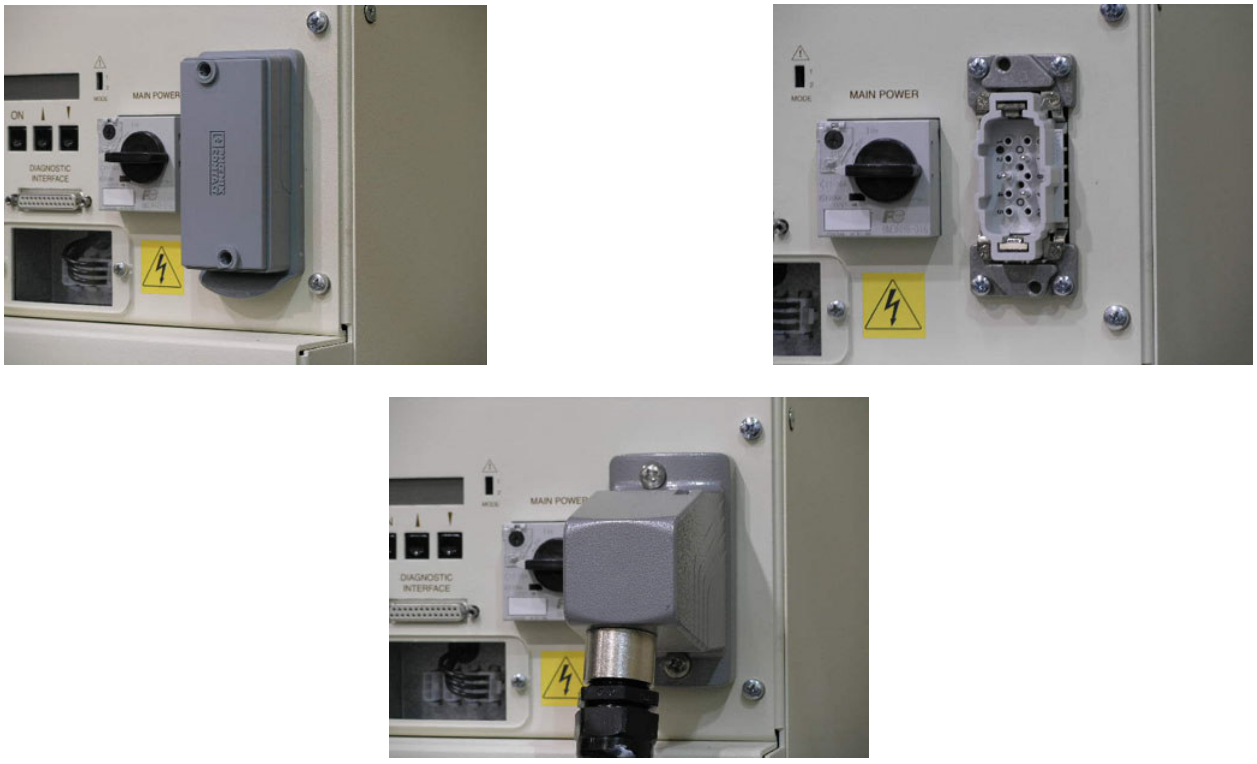


Figure 8 Connect Mains Power Supply Cable to Mains Power Receptacle

Compressor Checkout

The compressor should be operated before being connected to the other system components.

1. For the FA-40H (high voltage model) Compressor only, be sure that the transformer voltage taps are correctly selected to match the supply voltage.
2. Supply power to the compressor. Set the compressor's Main Power switch to on. Push the ON button. Run the compressor for ten (10) minutes and then stop.

NOTE

The compressor has reversed-phase protection to prevent it from running in reverse. If it does not start and the LCD displays "Phase/Fuse – ERR", disconnect the power and interchange any two mains supply wires (except ground). Refer to the Troubleshooting section in this manual.

NOTE

If the compressor starts but does not build pressure, turn it off immediately. It could be running in reverse despite the above-mentioned phase monitor relay. Contact a Service Center if this occurs.

This completes the checkout of the compressor.

Install the Gas Lines

Tool required: Open-end wrenches, 1", 1 1/8", 1 3/16"

Gas lines are shipped with protective dust plugs. Do not remove the plugs until the gas lines are ready to be attached. All bending and routing of gas lines should take place with plugs in place.

⚠ WARNING

AVOID INJURY. Always wear eye protection when handling pressurized gas lines and other pressurized equipment. Never apply heat to a pressurized gas line or other pressurized components.

CAUTION

PREVENT EQUIPMENT DAMAGE. Damage to gas lines can result from crimping by repeated bending and repositioning.

NOTE

Be sure to have 99.999% pure helium gas available at the installation site in case gas needs to be added to the system. See Refrigerant Quality in Specifications in this manual.

1. Identification labels are furnished with the gas lines. Before installing the gas lines, identify each with an appropriate label, SUPPLY (high pressure, color-coded red) or RETURN (low pressure, color-coded green) by applying the label adjacent to each Aeroquip coupling. See Figure 9.

NOTE

Supply and return gas lines are identical. Labels are used to prevent making a wrong connection at installation or at reassembly following maintenance.

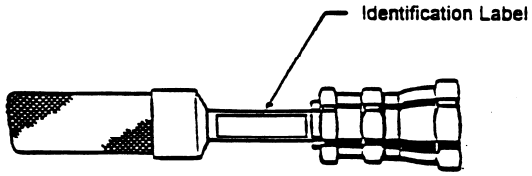


Figure 9 Attach Identification Label

2. Arrange the system components so that the gas lines will be protected from stress and traffic. Observe the minimum bend radius of 180 mm (7") when routing gas lines. Provide supports where needed.

3. Remove the dust caps from the compressor's supply and return gas couplings.

4. Connect the gas lines to the compressor's high-pressure (supply) and low-pressure (return) couplings. Use two wrenches to tighten the coupling. Torque all couplings to 47 ± 7 Nm (35 ± 5 ft. lbs.) See Figure 10. Tighten each coupling before proceeding to the next one.

CAUTION

AVOID GAS LEAKS. Check the condition of the gasket seal on the male half of each Aeroquip coupling. Be sure the gasket seal is in place and the sealing surfaces on both the male and female halves are clean before connecting. Replace the gasket seal if it is damaged or missing.

Keep the gas line couplings aligned when making or breaking a coupling connection. Leaks can occur due to the weight of the gas line or due to a sharp bend near the connection.

NOTE

Retain the dust caps and plugs to re-cover the couplings when they are not in use. They protect the couplings from damage and prevent the entry of contaminants.

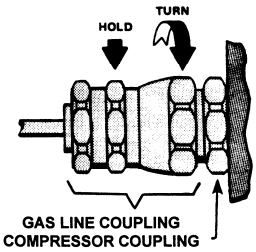


Figure 10 Connect Gas Line to Compressor or Cold Head

5. Using two wrenches, connect the RETURN gas line to the RETURN coupling on the cold head. Tighten the coupling to 47 ± 7 Nm (35 ± 5 ft. lbs.).

6. Using two wrenches, connect the SUPPLY gas line to the SUPPLY coupling on the cold head. Tighten the coupling to 47 ± 7 Nm (35 ± 5 ft. lbs.).

The system equalization pressure, shown by the compressor gauge after all components have been connected, will determine if charging or venting is required. System equalization pressure should equal the value provided in the system level manual or the Specification section of this manual.

Install the Cold Head Cable(s)

1. Be sure the compressor is not running by pressing the OFF button.
2. Connect the cold head cable to the cold head cable receptacle on the compressor front panel. Connect the other end of the cable to the electrical receptacle on the cold head.

Compressor Control Preparation

Tool required: Small, flat blade screwdriver

The FA-40 model compressors can be controlled from the front panel ON and OFF buttons or remotely through either the Diagnostic Interface or Serial Interface connections.

Error and data reporting is available simultaneously through the front panel display, the Diagnostic Interface connection, and the Serial Interface connection.

Front Panel Button Control Preparation:

1. Set the front panel Configuration Mode Selector Switch to mode 1 (see below).

Diagnostic Interface Control Preparation:

1. The front panel Configuration Mode Selector Switch must be set to either mode 1 or mode 2 (see below), depending on the desired signal characteristics and control function.

   See signal descriptions in Tables 1, 2 and 3 in the Troubleshooting section of this manual.

   Mode 1 allows Diagnostic Interface, front panel and Serial Interface control, with Diagnostic Interface control taking priority. Mode 2 allows Diagnostic Interface control only, and specifically disables both front panel and Serial interface control except for limited display and data reporting functions.

   Mode 1 allows an FA-40's Diagnostic Interface to replace an HC-10's Remote Control interface. Mode 1 with DA15-to-DB-25 signal adapter allows an FA-40's Diagnostic Interface to replace a CNA or a CSW model compressor's External Connector (JR) interface or an F-50's Diagnostic Interface. Mode 2 allows an FA-40's Diagnostic Interface to replace a CSW-71TW's External Connector (JR) interface.

2. Securely connect a control cable providing the necessary operating signals to the front panel Diagnostic Interface DB-25 connector. If used, install the DA15-to-DB-25 signal adapter (SCAI P/N 268121A) between the cable and the DB-25 Diagnostic Interface Connector.

Serial Interface (RS232) Control Preparation:

1. The front panel Configuration Mode Selector Switch must be set to mode 1 (see below).
2. Securely connect a control cable providing the necessary RS232 communications as described in the RS232 Protocol and Pin-Outs section of this manual.

The Configuration Selector Switch must be set for either Configuration Mode 1 or Configuration Mode 2 when the Main Power Switch is in the OFF position.

Switch position changes after power is supplied to the controller will change DB-25 electrical characteristics but will not be recorded by the controller. Loss of control and incorrect indications will result.

The selector switch handle is accessible on the front panel of the electrical chassis. See Figure 2. Move the switch handle up or down with a flat blade screwdriver. Handle up sets the switch for Configuration Mode 1. Switch handle down sets the switch for Configuration Mode 2. See Figure 11.

Figure 11 Set the Configuration Mode Selector Switch

Prestart Check

1. Check that all electric connections are made:
   - **a.** Power to the compressor
   - **b.** Cold head cable
   - **c.** Diagnostic interface cable (if used)
2. Check that the diagnostic interface selector switch is properly set (if used).
3. Check that the electrical power supply is switched on.
4. Check that the equalization pressure is as specified when the compressor is at room temperature, 20° C (68° F). A change in temperature, higher or lower, will cause a small change, higher or lower, in the equalization pressure. If the pressure is far from the specified equalization pressure, the gas charge is incorrect and may indicate a leak or incorrect filling.

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OPERATION

Starting

Supply power to the compressor, turn the knob of the main power switch on the front of the compressor to ON, then:

For Front Panel Button Control: Press the ON button located on the front panel under the LCD. The compressor and cold head will start.

Note: The ON/OFF buttons do not function when Configuration Mode is set for Mode 2 (see Compressor Control Preparation in the Installation section of this manual)

For Diagnostic Interface Control: Provide the necessary run signal as identified in Table 1, 2 or 3 in the Troubleshooting section of this manual. The compressor and cold head will start.

For Serial Interface (RS232) Control: Provide the ON command as identified in the RS232 Protocol and Pin-Outs section of this manual. The compressor and cold head will start.

Note: The RS232 ON/OFF commands do not function when the Configuration Mode is set for Mode 2 (see Compressor Control Preparation in the Installation section of this manual).

Stopping

For Front Panel Button Control: Press the OFF button located on the front panel under the LCD. The compressor and cold head will stop.

Note: The ON/OFF buttons do not function when Configuration Control is set for Mode 2 (see Compressor Control Preparation in the Installation section of this manual)

For Diagnostic Interface Control: Remove the run signal as identified in Table 1, 2 or 3 in the Troubleshooting section of this manual. The compressor and cold head will stop.

For Serial Interface (RS232) Control: Provide the OFF command as identified in the RS232 Protocol and Pin-Outs section of this manual. The compressor and cold head will stop.

Note: The RS232 ON/OFF commands do not function when the Configuration Mode is set for Mode 2 (see Compressor Control Preparation in the Installation section of this manual).

As desired, turn the main power switch on the front of the compressor to OFF and remove power to the compressor.

Cold Head Only Run

For running the cold head only to perform a maintenance procedure, the cold head receptacle can be energized without running the compressor by:

1. While the system is off, scrolling the display until “Cold Head Run” is shown
2. While “Cold Head Run” is displayed, press the ON button.

The cold head will run until the OFF button is pressed or until 30 minutes of running has occurred.

Restarting after a Power Failure

When the power comes on, the microprocessor will determine if the last shutdown was due to a power outage. If the operator turns off the system by the main power switch, it will be detected as a power outage.

If the compressor power was interrupted by a power outage, the compressor and the cold head, after a slight delay, will restart automatically when power is restored.

If the compressor stops for other reasons, compressor troubleshooting is required.

System Status Display

Normal conditions: When all systems are operating normally, with no system errors, the following lines are displayed on the LCD in the order listed below by scrolling the display. Press the DISPLAY buttons (up and down arrows) to scroll the LCD. Scrolling past the bottom of the display will start back at the top and repeat. If the DISPLAY button is pressed and not pressed again after 30 seconds, the display will return to the first line (ET).

Elapsed time in hours to one decimal place and control state
Helium Temp-OK
He Out Temp-OK
Oil Temp-OK
Motor Temp-OK
Phase/Fuse-OK
Return Press-OK
DB-25 Config (switch configuration)-OK
Rtn Press (current return pressure)
Firmware Version
Cold Head Run (When in OFF state only)

Error conditions: If a system error occurs that causes an alarm or shutdown condition, the monitor point as listed above will change from “OK” to “ERR” and that monitor point will be scrolled to the top for display.

Any point that has not failed will continue to display OK if the operator manually scrolls the display.

If additional points fail before the operator resets the first error(s), the latest point to fail will change from “OK” to “ERR” and will be placed at the top for display. In this way, the operator will see the most recent fault displayed on the LCD and, by manually scrolling the display, can see other error conditions that lead up to the latest.

If a monitoring sensor is disconnected, the display for that monitor point will change from “OK” to “FAIL”.

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Adsorber Replacement

Part required: Adsorber, P/N F300138A

Tools required: #2 Phillips screwdriver
Open-end wrenches, 1", 1 1/8", 1 3/16"
Snoop®

CAUTION

AVOID EQUIPMENT FAILURE OR CONTAMINATION. Use SHIG adsorber P/N F300138A only. Use of non-SHIG spare parts will void the warranty.

The compressor's adsorber should be replaced every 30,000 operating hours (40 months). The used adsorber has no salvage or repair value. Venting the compressor is not required when replacing the adsorber because the gas couplings are self-sealing.

Adsorber Removal

1. Stop the compressor and disconnect the power to the compressor.
2. Using two wrenches, disconnect the high pressure (supply) gas line from the helium high pressure coupling on the compressor. Screw a dust plug into the disconnected gas line.

NOTE

Always hold the stationary nut on the gas line coupling with one wrench while turning the moveable coupling with the other wrench.

3. Remove the compressor's left side cover panel. See Figure12.

Figure 12 Compressor Cover Panel Removed

4. Using two wrenches, disconnect the self-sealing coupling on the inlet side of the adsorber. See Figure 13.

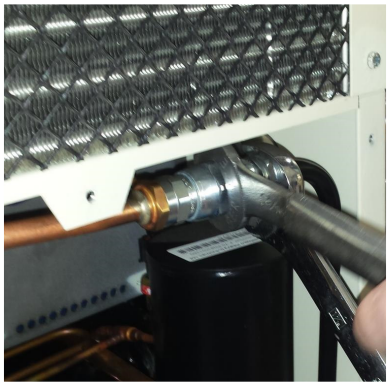

Figure 13 Disconnect Self-Sealing Coupling

5. Use a Phillips screwdriver to remove the two screws holding the adsorber to the base. See Figure 14.

Figure 14 Disconnect Adsorber from Base

6. Remove the locknut on the Aeroquip supply coupling on the front panel. See Figure 15.

Figure 15 Remove Supply Coupling Locknut

7. Pull the adsorber back until the supply coupling clears the front panel. Remove the adsorber. Remove the lock washer from the Aeroquip supply coupling. Retain all hardware to reuse with the new adsorber. See Figure 16.

Figure 16 Remove Adsorber

⚠ WARNING

AVOID INJURY. The adsorber is charged with helium gas. Follow the used adsorber venting procedure for safe disposal of the used adsorber.

Adsorber Installation

1. Remove the dust caps from the gas couplings of the new adsorber. **Do not vent the new adsorber.**

2. Install the lock washer on to the supply coupling of the new adsorber. Insert the supply coupling through the front panel and position the adsorber. See Figure 17.

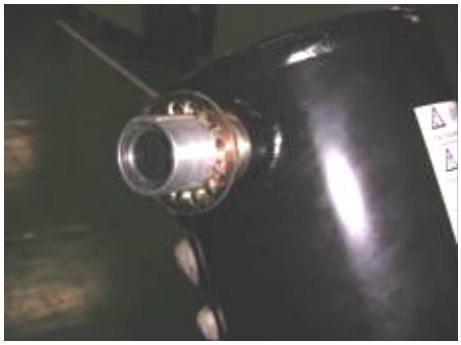

Figure 17 Install Lock Washer on Adsorber

3. Insert and tighten the screws to secure the new adsorber to the base. See Figure 18.

Figure 18 Install Adsorber

4. Install the red nylon washer and the locknut on the supply coupling. Torque the locknut to 54 Nm (40-ft. lbs.). See Figure 19.

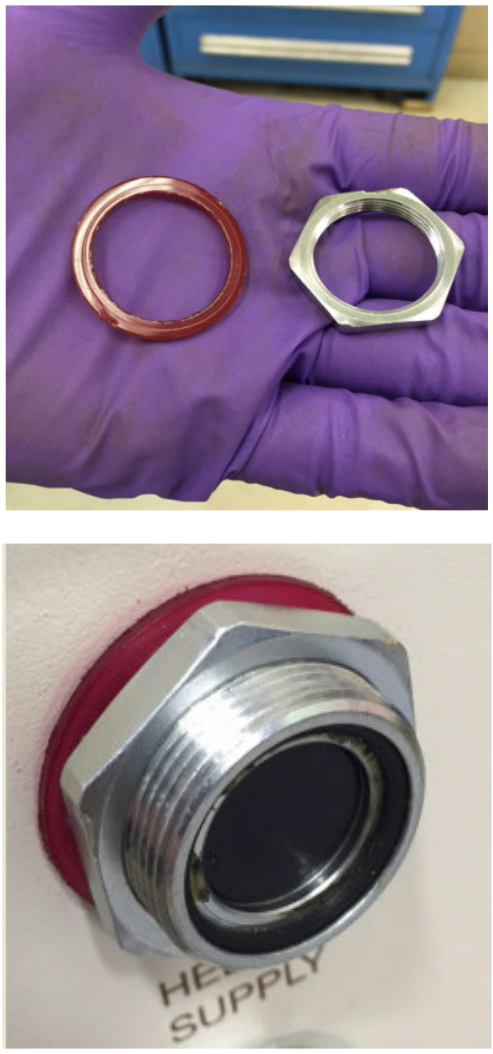

Figure 19 Install Supply Coupling Washer and Locknut

5. Connect the adsorber's self-sealing coupling on its inlet side to the oil separator's outlet coupling. With two wrenches, torque the Aeroquip coupling to 47 ± 7 Nm (35 ± 5 ft. lbs.). See Figure 20.

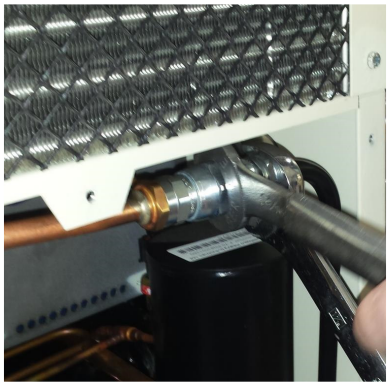

Figure 20 Connect Self-Sealing Coupling

6. Reconnect the supply (red) gas line to the supply coupling on the compressor. Torque the coupling to 47 ± 7 Nm (35 ± 5-ft. lbs.).

7. Using Snoop®, leak check all Aeroquip couplings just completed. Wipe off the Snoop® to prevent rusting. See the Leak Check procedure in Maintenance in this manual. See Figure 21.

Figure 21 Leak Check Aeroquip Couplings

8. Check the equalization pressure. See Specifications in the Operating Manual.

9. Reinstall the compressor's left side cover panel.

This completes the procedure for replacing an adsorber.

Register New Adsorber (30,000 hour life)

When a new adsorber is installed, the adsorber timer must be reset to 30,000 hours so that the correct remaining adsorber life will be displayed on the LCD.

The timer can be reset either through the front panel control buttons or through the RS232 terminal interface.

Through the front panel control buttons:

1. With the Main Power switch turned off, press and hold all four control buttons below the LCD window.
2. Keep these buttons held and turn the Main Power Switch ON to enter "Service Level" mode. Release the buttons.
3. Scroll using the arrow control buttons until display shows "NEW ADS? ON=Yes."
4. Press the ON control button. Display will show "SAVE? Y-ON N-OFF."
5. Press the ON control button again to complete. (Press the OFF control button to back out of the function.) When ON is pressed, display will show: "Saving New ADS". When function is complete, display will again show "NEW ADS? ON=Yes."
6. Turn the main power switch to OFF to leave Service Level.

Through the RS232 Terminal Communication Interface

1. Turn the compressor main power switch ON.
2. Connect the terminal interface computer to the compressor serial port .
3. Send a "g" to the compressor to register a new adsorber (or, alternately, send an "m" to the compressor to return the menu of available functions and then send a "g").
4. Compressor will return "Are you sure? Y/N" Send a "Y" to complete the function. ("N" will back out of the function with compressor returning "Aborted".)
5. When the function is complete, the compressor will return "Adsorber change registered."
6. Turn the compressor main power switch OFF, if desired.

Used Adsorber Venting and Disposal

For safe disposal of the used adsorber:

1. A venting adapter fitting is included with the new adsorber. Attach it to one of the self-sealing couplings on the **used** adsorber. Vent the **used** adsorber to atmospheric pressure.
2. Discard the used adsorber with the venting adapter fitting connected.

Fuse Replacement

Part Required:

HV Fuse Kit P/N 268475A consisting of:

Item	Qty	Description	P/N
1	3	Fuse, Power, 1A, 600V	34162
2	3	Fuse, Control Board, 0.8A, 250V	34172

LV Fuse Kit P/N 268938A consisting of:

Item	Qty	Description	P/N
1	3	Fuse, Power, 2A, 600V	34164
2	3	Fuse, Control Board, 0.8A, 250V	34172

Tool required: #2 Phillips screwdriver
¼" Flat blade screwdriver

Fuses for the FA-40 are located in the electrical chassis of the compressor:

a. Main Power (FU-1, FU-2 and FU-3): (3) 1.0 ampere for HV and 2.0 ampere for LV

b. Cold Head Motor (FU-4, FU-5 and FU-6): (3) 0.8 ampere

1. Disconnect the mains power supply to the compressor (if connected).

⚠ WARNING

AVOID ELECTRIC SHOCK. All electrical supply equipment must meet applicable codes and be installed by qualified personnel.

⚠ WARNING

AVOID ELECTRIC SHOCK. Permit only qualified electrical technicians to open electrical enclosures, to perform electrical checks or to perform tests with the power supply connected and wiring exposed. Failure to observe this warning can result in serious injury or death.

CAUTION

PREVENT EQUIPMENT DAMAGE. If the compressor is wired for 380/400/415 V3~ electrical service, connecting to a higher voltage may damage the control circuit. Similarly, if it is wired for 460-480 V3~, it can be damaged by connecting to 380/400/415 V3~.

2. Remove (7) M5 Phillips screws and lock washers using a #2 Phillips screwdriver from the Right side panel and remove the panel. See Figure 22.

Figure 22 Right Side Panel

3. Remove (3) M5 Phillips screws and lock washers using a #2 Phillips screwdriver from the electrical chassis cover and remove the cover from the compressor. See Figure 23.

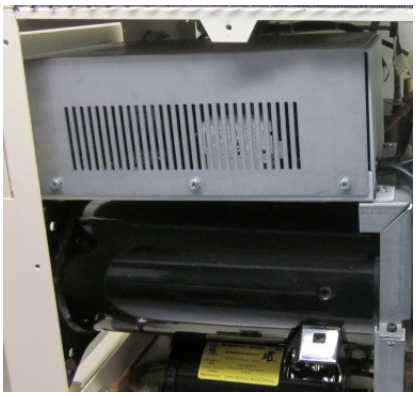

Figure 23 Electrical Chassis Cover

4. Locate the fuse.

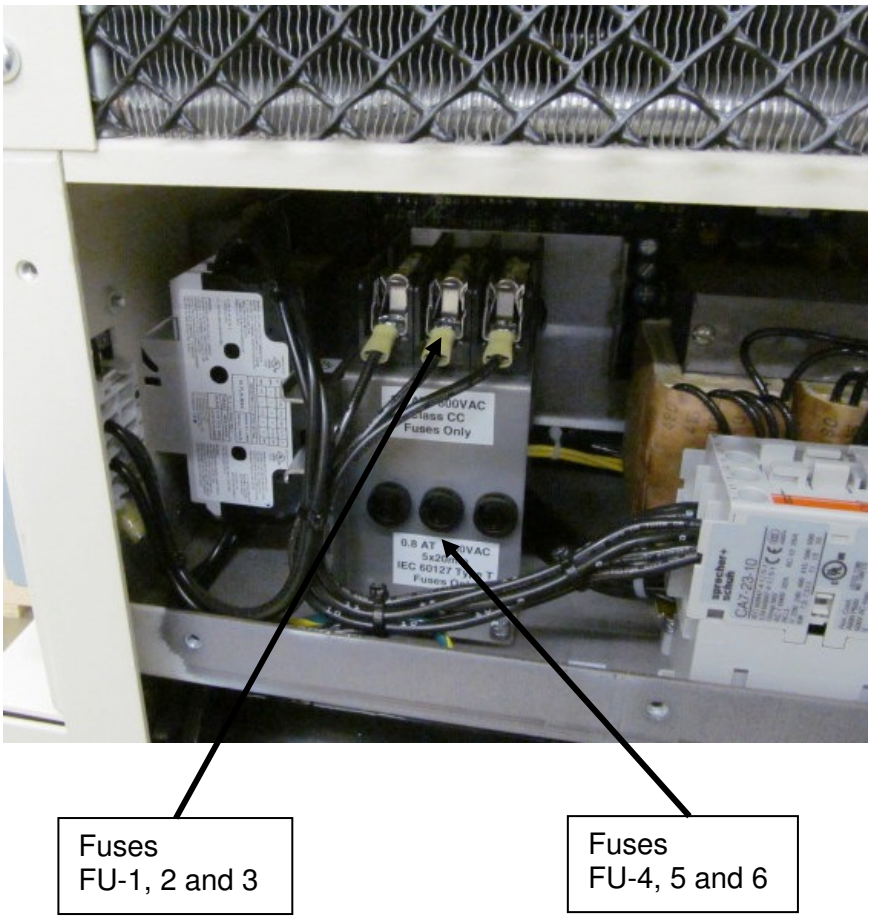

Figure 24 Fuse Locations in the Electrical Chassis

a. For FU-1, FU-2 and FU-3:

1. Remove open fuse from fuse holder and replace with new fuse of same ampere rating.
2. Replace compressor and electrical chassis covers.

b. For FU-4, FU-5 and FU-6:

1. Open fuse holder by inserting screwdriver into cap, push and rotate counter-clockwise.
2 Remove open fuse from cap and replace with new fuse of the same ampere rating.
3 Replace cap and new fuse into holder; with screwdriver, push and rotate clockwise into locked position.
4 Replace compressor and electrical chassis covers.

Charging or Venting

Tools required: Charge and vent tool with valve, #4Fx¼" Swagelok, P/N 267191A.
Bleed adapter, P/N 267192A
Open-end wrenches, 5/8", 3/4"
Helium gas cylinder with pressure regulator and charge line

Charging or venting is required whenever the equalization pressure of the system is outside the range as stated in the Specifications. See Specifications in the F-70 Operating Manual. Venting a component to atmospheric pressure is required if the component needs to be disassembled for repairs or maintenance, including repairs to its self-sealing couplings.

⚠ WARNING

AVOID INJURY. Never use compressed helium gas from a cylinder without a proper regulator. Overpressure can cause serious injury if the system equipment ruptures.

CAUTION

AVOID CONTAMINATION. Follow the charging and venting procedure to prevent reversed flow of system gas. Do not charge through the supply coupling. Do not vent through the return coupling. Reversed flow can contaminate the system with compressor oil.

NOTE

Adapter fittings for charging and venting are available as optional service tools. See the Parts section of this manual.

Charging Procedure

CAUTION

PRESERVE YOUR WARRANTY. Specifications require the use of 99.999% pure helium gas. Using a lesser quality of helium can damage the system and void the warranty.

CAUTION

AVOID A MALFUNCTION. Repeatedly charging the system with helium gas rather than locating and repairing gas leaks can cause a malfunction. Impurities are introduced at an abnormal rate and can freeze in the shield cooler.

To charge helium gas to the system:

1. Stop the compressor.
2. Locate charge and vent tool, P/N 267191A, and bleed adapter, P/N 267192A. Screw bleed adapter into charge and vent tool.
3. Connect the charge line from the pressure regulator of a helium gas cylinder containing 99.999% pure helium with a dew point less than -62° C (-80° F) at 20.7 bar (300 psig) to Swagelok connector on charge and vent tool, P/N 267191A.
4. Slightly open charge and vent tool's valve and thoroughly purge the charge line from the regulator. It is important to remove all air contaminants to prevent them from entering the system.
5. Unscrew the self-sealing coupling on the bleed adapter, P/N 267192A, from the charge and vent tool, P/N 267191A. Close the valve.
6. Use two wrenches to attach the charge and vent tool to the 4M Aeroquip helium charge port on the front of the compressor.
7. Adjust the regulator to the required equalization pressure. See the Specifications section in the F-70 Operating Manual. **Slowly** open the valve on the charge and vent tool. Charge the system with helium gas to the equalization pressure.
8. Close the valves on the charge and vent tool and on the gas cylinder.
9. Disconnect the charge line from the charge and vent tool. Using two wrenches, remove the charge and vent tool. Store the charge line to keep it clean.
10. Leak check the Aeroquip couplings using the Leak Check procedure in this manual

This completes the charging procedure.

Venting Procedure to Adjust the Equalization Pressure

NOTE

This venting procedure is not to be used for gas cleanup of the compressor.

To vent helium gas from the system:

1. Stop the compressor.
2. Be sure the valve on the charge and vent tool, P/N 267191A, is closed. Using two wrenches, install this tool on the 4M Aeroquip helium charge port.
3. **Slowly** open the valve on the charge and vent tool. Vent the system until the required equalization pressure is attained. See Specifications in the F-70 Operating Manual. Close the valve on the tool.
4. Using two wrenches, remove the charge and vent tool from the compressor.

This completes the venting procedure to adjust the equalization pressure.

Gas Cleanup

Tools required: 2 adapter fittings with valve, 8F Aeroquip, 255919B2.
Open-end wrenches, 1", 1 1/8" and 1 3/16".
Helium gas cylinder with pressure regulator and charge line.

If the equalization pressure shown by the compressor's pressure gauge is less than 1.4 bar (20 psig), gas cleanup of the compressor is required. Look for and repair helium leaks. Perform gas cleanup.

If system components are connected and the equalization pressure of the system is less than 1.4 bar (20 psig), check for leaks. Repair leaks. Perform gas cleanup of the system.

CAUTION

PREVENT EQUIPMENT DAMAGE. Never pull a vacuum on the compressor or on the cold head. The motors will short circuit if started.

⚠ WARNING

AVOID INJURY. Extreme cold can cause frostbite. When handling system components, be careful not to touch any frosted parts.

⚠ WARNING

AVOID INJURY. Do not splash cryogenic liquids on any areas of clothing or exposed skin. Damage to skin tissue will result. Always wear eye protection.

⚠ WARNING

AVOID ASPHYXIATION. Be sure the work area is well ventilated.

⚠ WARNING

AVOID INJURY. Disconnect gas lines only when the compressor is stopped. Disconnecting the cold head while it is cold can create excessively high internal pressure as the gas warms. Material failure and uncontrolled pressure release can cause serious injury.

Gas cleanup is required if the compressor's interior has been opened to the atmosphere or the equalization pressure is 1.4 bar (20 psig) or lower. Gas cleanup is performed with the compressor disconnected from the other system components.

NOTE

If the compressor's interior has been exposed to the atmosphere for an extended period, gas cleanup may not suffice to guarantee system gas purity. Contact a Service Center.

1. Disconnect the gas lines from the compressor. Plug the disconnected gas line couplings.
2. Locate two adapter fittings P/N 255919B2. Be sure their valves are closed. Attach them to the supply and return Aeroquip couplings on the compressor.

3. Connect a charge line to the pressure regulator of a helium gas cylinder containing 99.999% pure helium gas with a dew point less than -62° C (-80° F) at 20.7 bar (300 psig). Adjust the gas cylinder pressure regulator to 0.35 bar (5 psig).
4. While connecting the charge line to the adapter fitting on the compressor's return coupling, thoroughly purge the charge line from the regulator. It is important to remove all air contaminants to prevent them from entering the system.
5. Adjust the pressure regulator to 15.2 bar (220 psig). Open the valve on the adapter fitting and charge the compressor to 15.2 bar (220 psig).
6. Close the valve on the adapter fitting used for charging.
7. Run the compressor for at least 30 minutes to heat the oil to operating temperature. Stop the compressor.
8. Open the vent valve on the supply coupling of the compressor. Watch the compressor's pressure gauge. When the pressure falls to 0.35 to 0.7 bar (5 to 10 psig), close the vent valve. Open the charge valve to increase the pressure to 15.2 bar (220 psig). Close the charge valve.
9. Start the compressor
10. After running 30 to 45 seconds, stop the compressor. Open the vent valve and vent the compressor to 0.35 to 0.70 bar (5 to 10 psig). Close the vent valve.
11. Repeat steps 8, 9 and 10 ten (10) times, and then go to Step 12.
12. Open the charge valve on the adapter fitting. Charge the compressor to the equalization pressure. Close the charge valve.
13. Allow the compressor to cool. Read the pressure gauge with the compressor at 20° C (68° F). Adjust the equalization pressure by charging or venting to conform to the Specifications.
14. Close the gas cylinder valve and adjust the pressure regulator to zero psig.
15. Disconnect the charge line from the adapter fitting. Store the charge line to keep it clean.
16. Remove both adapter fittings.
17. If other components need cleaning, perform the appropriate procedures in their manuals. Otherwise, reconnect the supply and return gas lines. Torque the gas line couplings to 47 ± 7 Nm (35 ± 5 ft. lbs.).
18. Leak check the Aeroquip couplings. See the Leak Check section.

This completes the gas cleanup procedure for the compressor.

Heat Exchanger Cleaning

Heat exchanger cleaning to remove collected dust and debris is required regularly to maintain proper compressor operation. Cleaning is recommended twice a year, but it may be necessary more often, depending on the operating environment.

In order to clean the heat exchanger:

1. Stop the compressor and confirm the fan has stopped.

2. Using a portable vacuum cleaner, remove dust and debris for the outside (suction side) of the heat exchanger. See Figure 25. Cleaning the inside surface is not necessary. Do not remove the fan guard to clean the inside surface.

A soft brush or soft brush attachment may be used to help remove dust.

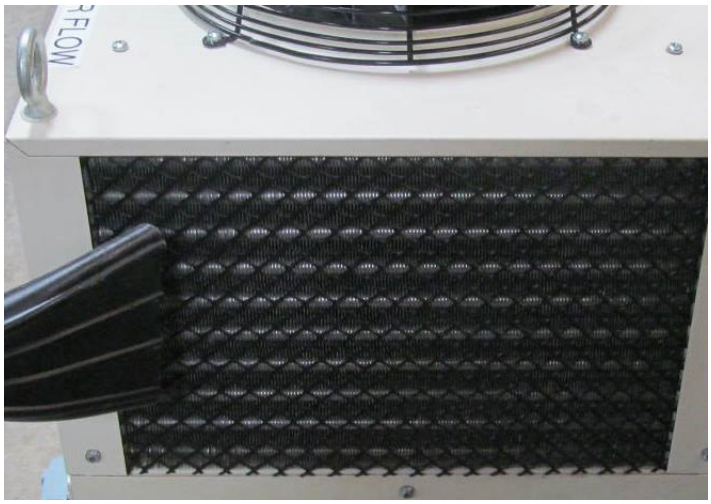

Figure 25 Clean Heat Exchanger

⚠ WARNING

AVOID INJURY. Do not touch heat exchanger fins. Fins are sharp and may cause injury.

CAUTION

PREVENT EQUIPMENT DAMAGE. Do not insert object or admit fluids through fan guard under any circumstances. Injury or malfunction may occur.

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TROUBLESHOOTING

Error Conditions

An error condition will cause either a system alarm or a shutdown. The following table lists the alarm and the shutdown errors that are monitored. Overload trip of the Mains Power switch (described below) is not monitored or reported.

LCD Display First Line	Type	Error	Indication
Helium Temp-ERR	Shutdown	High helium discharge temperature	(TSG) Temperature > 93°C (200°F)
Helium Temp-ERR	Shutdown	Helium out heat exchanger temperature	(TSGo) Temperature > 60°C (140°F)
Helium Out Temp-ERR	Alarm	High helium out heat exchanger temperature	(TSGo) Temperature > 50°C (122°F).
Motor Temp-ERR	Shutdown	High compressor motor winding temp (internal protector open)	Return Pressure > 140 psig while compressor is commanded on.
Phase/Fuse-ERR	Shutdown	Phase sequence or open fuse	Monitored by microprocessor
Return Pressure-ERR	Shutdown	Loss of gas charge	Return pressure < 15 psig.
DB-25 Config1-ERR (or Config2)	Shutdown	Remote cable does not match switch setting	Monitored by microprocessor

If the compressor has been shut down by one of these interlocks, do not restart until the problem has been found and corrected. Refer to the Troubleshooting Guide to identify the problem.

In the event of a shutdown error, the compressor motor and cold head valve motor are turned off. The microprocessor will annunciate the error condition via signals at the Diagnostic Interface Connector, via RS232 and via the LCD Display. See Figure 2 and Tables 1, 2 and 3.

The Mains Power switch trips when steady-state current exceeds 1.2 x the front panel set point. When tripped, the switch knob locates halfway between the on and off positions.

Clearing Error Conditions

NOTE

Errors can be cleared locally and via RS232 only when configuration mode is set for Mode 1. When configuration mode is set for Mode 2, errors must be cleared using the Diagnostic Interface.

When an error is corrected, the message(s) can be cleared from the display and the system diagnostics connector by any of the following procedures:

- Apply a momentary signal to the diagnostic interface connector, or
- Press the DISPLAY UP and DISPLAY DOWN (arrow) buttons simultaneously, or
- Turn the Main Power switch to off, pause briefly, then turn back on, or
- Send the RS232 reset command.

Restarting after an Error Condition

When the shutdown is caused by helium discharge high-temperature, the compressor will be able to restart only after it has cooled enough for the thermistor to read a temperature below the cut-off point. After waiting for the compressor to cool, clear the error message then push the ON button to restart. Should the compressor fail to start, allow more cooling time. Repeat the restart procedure.

If the shutdown is due to a motor high temperature, the motor winding high temperature switch will automatically reset in approximately 45 minutes. To restart the compressor, clear the error message then push the ON button. If the compressor fails to start, allow more cooling time. Repeat the restart procedure.

If the motor circuit protector opens, the knob moves part way toward OFF. Reset it by turning the knob completely to OFF, then clockwise to ON. The compressor and the cold head should start automatically.

Troubleshooting Guide

The Troubleshooting Guide that follows lists problems that can occur in the system and suggests causes and corrective actions.

Problem	Possible Cause	Corrective Action
System shutdown LCD reads Helium Temp-ERR	Low oil level or blocked oil circulation.	Try five times to restart the compressor. If it does not start, consult a SCAI Service Center.
	Ambient air temperature is too high.	Operate compressor when air temperature is between 4 and 38℃.
	Cooling air flow is blocked or restricted.	Clean heat exchanger or remove restriction.
	Cooling fan does not operate when compressor is on.	Check fuses. If fuses are good, contact a Service Center.
	Faulty gas thermistor or PCB.	Contact a Service Center.
System shutdown LCD reads Motor Temp-ERR	Compressor motor windings high temperature switch opens. Compressor motor windings have overheated.	Check to make sure heat exchanger is clean and air is flowing normally. Consult a Service Center if the problem persists. Allow about 45 minutes for the windings to cool enough for the switch to reset.

Problem	Possible Cause	Corrective Action
System shutdown LCD reads Motor Temp-ERR (continued)	Reversed phase or loss of phase.	Check mains power.
	Fuse(s) opened or poor power quality.	If power checks indicate utilities are within specifications, check fuses.
	Cooling air flow is blocked or restricted.	Clean heat exchanger or remove restriction.
	Cooling fan does not operate when compressor is on.	Check fuses. If fuses are good, contact a Service Center.
System shutdown LCD reads Phase Seq-ERR or Phase/Fuse-ERR	Fuse(s) opened or poor power quality.	If power checks indicate utilities are within specifications, check fuses.
System shutdown LCD Return Press-ERR.	Compressor has lost helium charge.	Refer to Charging or Venting, Gas Clean-up and Leak Check in the Service Manual.
System shutdown LCD reads FAIL instead of ERR.	Sensor is disconnected.	Contact a Service Center.
Compressor and cold head motor do not start when the start switch on the compressor is pushed.	No electrical power.	Check that the power source is on and connected.
	Wrong voltage.	Compare customer's electric service with system specifications.
	Main power phase sequence is wrong.	Interchange any two- (2) incoming power leads (except ground.
	Defective component in the power circuit.	Refer to Compressor Motor troubleshooting in this section.
	Tripped motor circuit protector on the front panel.	Reset the protector by turning the knob to OFF, then turn the knob clockwise to ON. Compare electric service with the system specifications. Consult a Service Center if the problem persists.

Problem	Possible Cause	Corrective Action
Compressor starts but shuts down later.	Cooling air flow is blocked or restricted.	Clean heat exchanger or remove restriction.
	Cooling fan does not operate when compressor is on.	Check fuses. If fuses are good, contact a Service Center.
System starts but gas pressure is abnormally high or low.	Wrong equalization pressure.	Refer to Specifications and the section on Charging or Venting.
	Gas line couplings are not fully engaged.	Be sure that all gas couplings are fully engaged and torqued.
	Gas lines are connected wrong.	Reconnect. See the Installation section.
Cold head motor does not start when the compressor starts.	Cold head cable is not connected.	Stop the compressor. Connect the cable. Check connections at the cold head and at the compressor.
	Open circuit in the cold head cable.	Disconnect the cable. Check each conductor for continuity. Replace the cable if necessary.
	FU-4, FU-5 or FU-6 fuse is blown.	See Fuse Replacement in the Maintenance section of this manual.
Cold head motor hums but does not start.	Open circuit in the cold head cable.	Disconnect the cable. Check each conductor for continuity. Replace the cable if necessary
	Valve disc stalled on the valve stem.	Check the system equalization pressure. Consult a Service Center.
	FU-4, FU-5 or FU-6 fuse is blown.	See Fuse Replacement in the Maintenance section of this manual.

Problem	Possible Cause	Corrective Action
Cold head motor runs, but there is no cooldown.	Gas line couplings are not fully engaged.	Be sure that all gas couplings are fully engaged and torqued.
	Gas lines are connected wrong.	Reconnect. See the Installation section.
Intermittent operation.	Compressor is cycling on and off.	Check input power. Compare with Specifications. Check for blocked or dirty heat exchanger. Check for proper fan operation.
	Cooling air flow is blocked or restricted.	Clean heat exchanger or remove restriction.
	Cooling fan does not operate when compressor is on.	Check fuses. If fuses are good, contact a Service Center.
Loss of refrigeration capacity.	Compressor malfunction.	Check input power and equalization pressure. Compare with Specifications. Check for blocked or dirty heat exchanger. Check for proper fan operation.
Compressor shuts down, LCD display is blank	FU-1, FU-2, or FU-3 fuse is blown.	See Fuse Replacement in the Maintenance section of this manual.
	Malfunctioning control boards.	Contact a Service Center.
Compressor is unresponsive to remote Diagnostic Interface control	Configuration selector switch is in the wrong position.	Turn off power and move the switch to the correct position. See Diagnostic Interface Connection in the Installation section of this manual.
Remote status signals Diagnostic Interface do not match actual status	Configuration selector switch is in the wrong position or was in the wrong position when power was supplied to the controller.	Turn off power and move the switch to the correct position. See Diagnostic Interface Connection in the Installation section of this manual.
LCD display shows configuration error	Configuration selector switch is in the wrong position or was in the wrong position when power was supplied to the controller.	Turn off power and move the switch to the correct position. See Diagnostic Interface Connection in the Installation section of this manual.

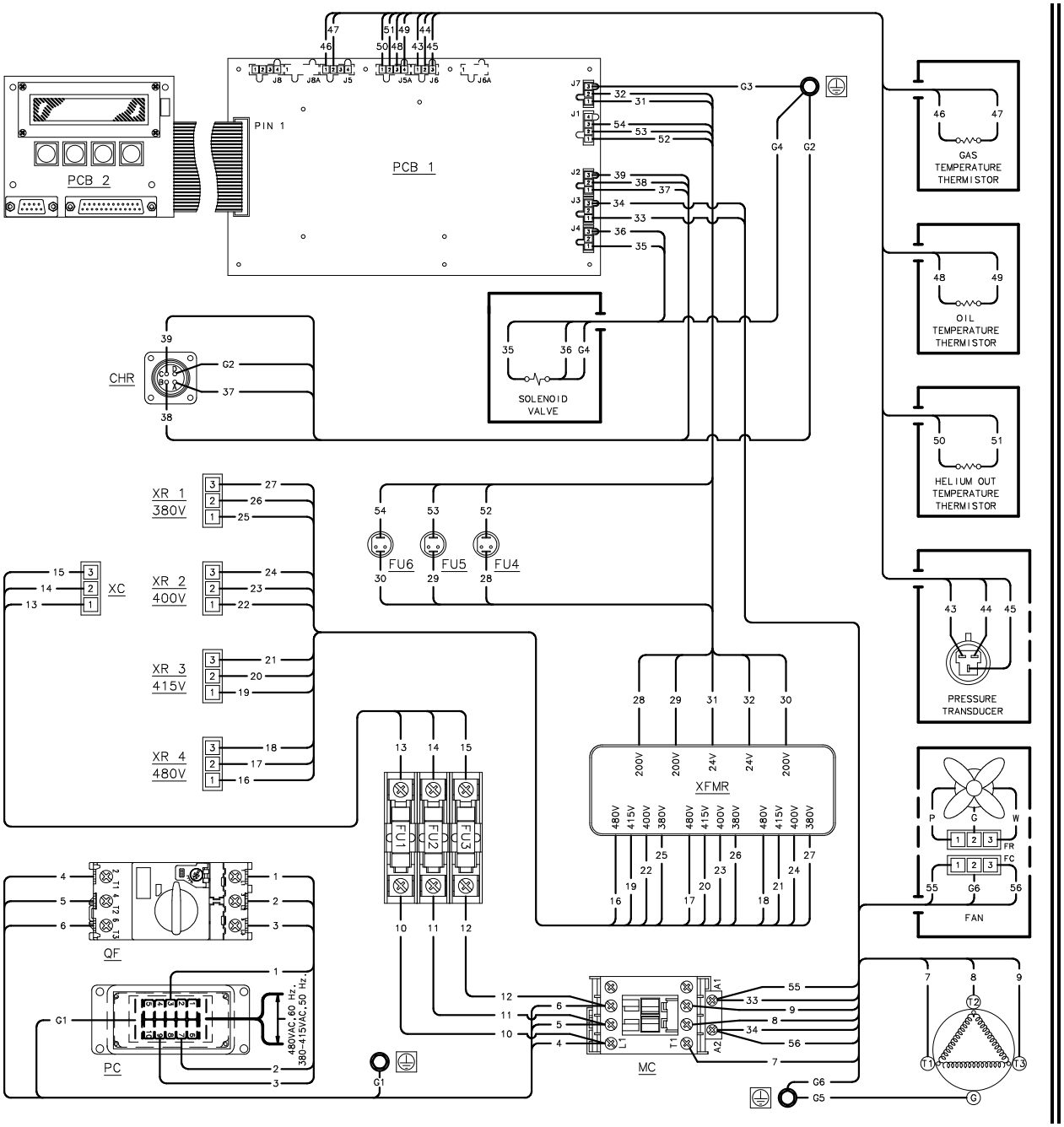


Figure 26 FA-40H Compressor Wiring Diagram

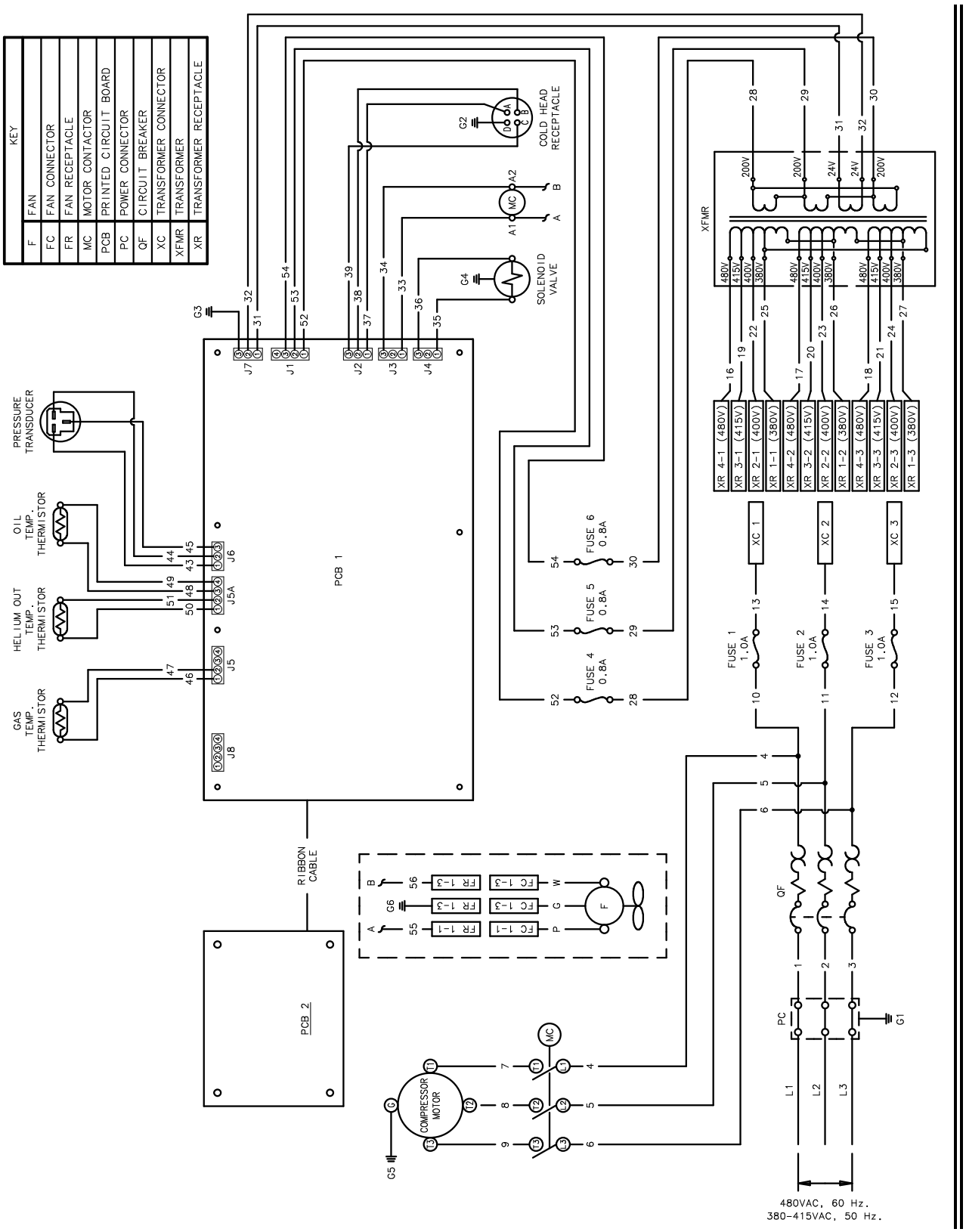


Figure 27 FA-40H Compressor Wiring Schematic

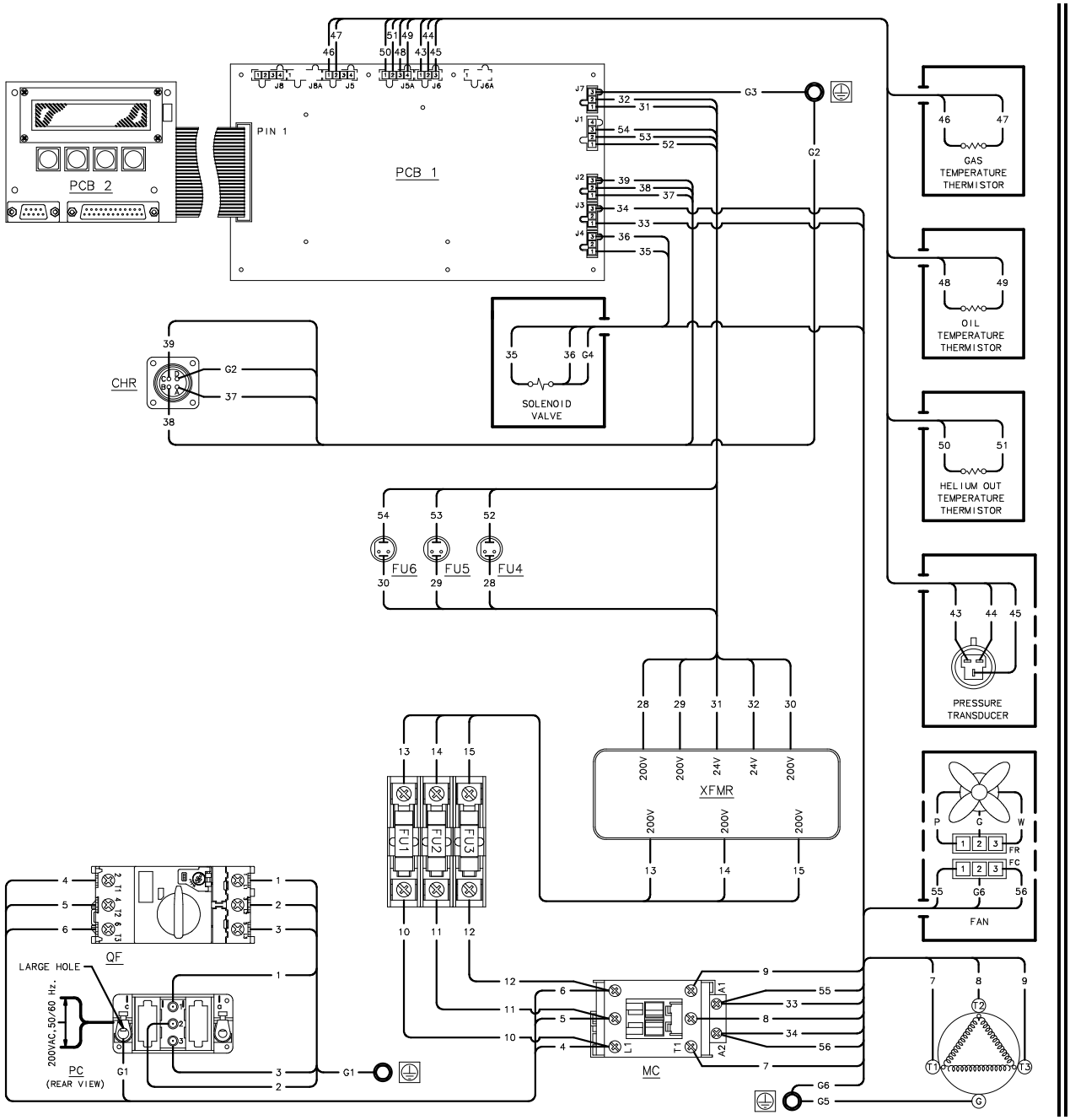


Figure 28 FA-40L Compressor Wiring Diagram

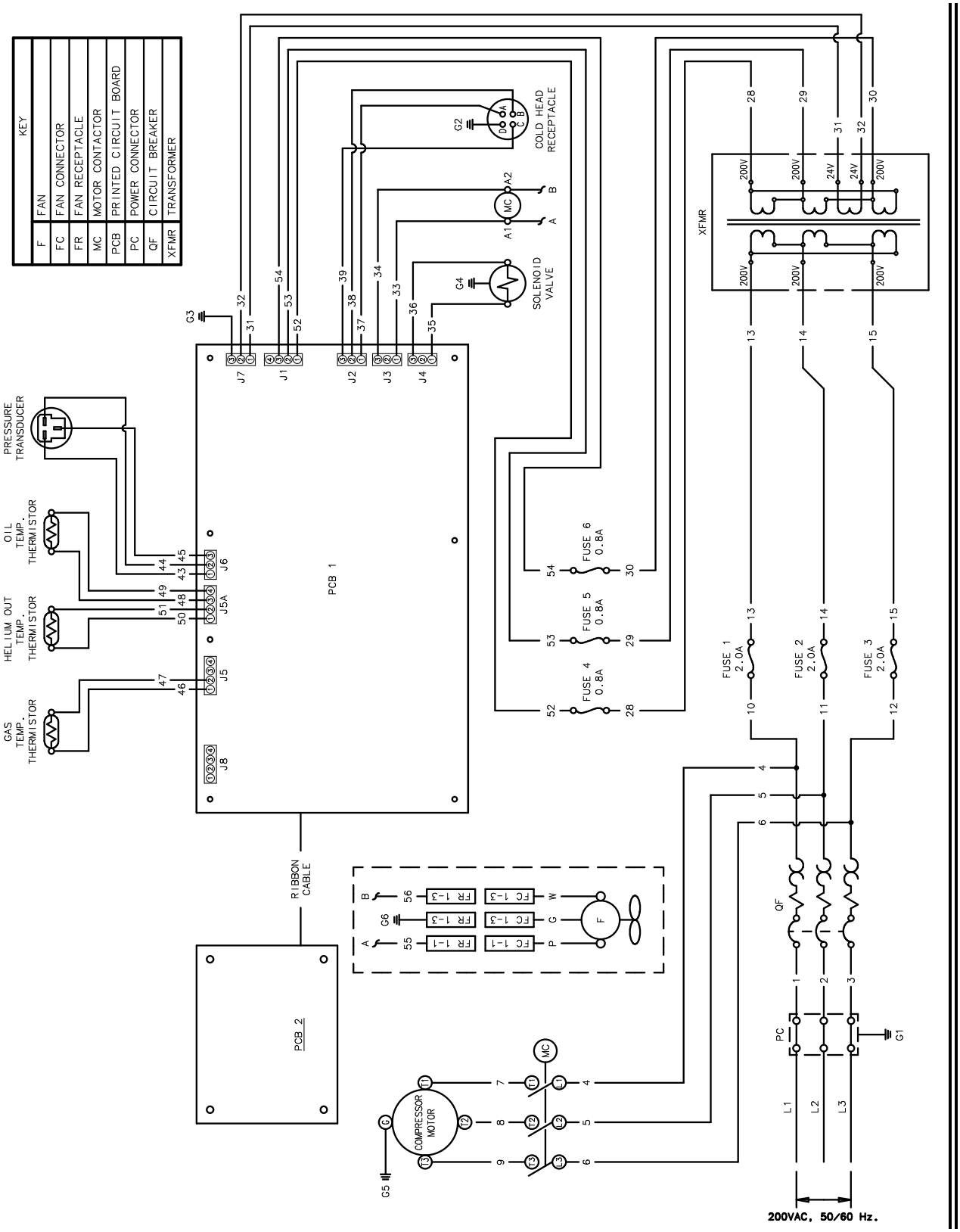


Figure 29 FA-40L Compressor Wiring Schematic

DB-25 Diagnostic Interface Connector Pin Functions

Pin #	Function
3	Reset. System error conditions are cleared by momentary application of a +24VDC, 2 mA signal to this pin.
4	Cold head pause. The cold head only will turn off while a +24VDC, 2 mA signal is applied to this pin if the system was turned on remotely (pin 6). The cold head will restart when the signal is removed.
6	System ON/OFF. The compressor and cold head will turn on when +24VDC, 2 mA signal is applied to this pin. They will turn off when the signal is removed.
7	Remote control ON/OFF high. When electrical continuity (< 20 ohms) is applied between pins 7 and 8, system will turn off in fault condition. (Continuity can be used to require Mode 2 operation.)
8	Remote control ON/OFF low. See Pin 7 description.
10	Compressor return pressure analog value, 0.5-4.5 VDC linear relative to pin 24: PSI Absolute = 125 x (volts) – 47.8
11	Not active. 0 VDC, 20 mA max. signal.
12	Protective earth ground
13	Protective earth ground
14	High Hx helium out temp. If the temperature of the helium gas exiting the heat exchanger is > 50 ℃, this pin will carry a +24VDC, 20 mA max. signal.
15	High Hx oil out temp. If the temperature of the oil leaving the heat exchanger is too high, this pin will carry a +24VDC, 20 mA max. signal.
16	Low pressure shutdown. On a compressor return low pressure error (<15 psig) this pin will carry a +24 VDC, 20 mA max. signal.
17	Power error. On a phase or fuse error, this pin will carry a +24VDC, 20 mA max. signal.
18	Gas temp error. On a high helium gas discharge temperature error, or high Hx helium out temperature error, this pin will carry a +24VDC, 20 mA max. signal.
19	Run status. When the compressor and cold head are running or the compressor is running with the cold head paused, this pin will carry a +24VDC, 20 mA max. signal.
20	Motor winding temperature error. On a high compressor motor winding temperature error, this pin will carry a +24VDC, 20 mA max. signal.
24	0 VDC, 100 mA signal power source.
25	+24VDC, 100mA signal power source.

Table 1 DB-25 Diagnostic Interface Connector Pin Functions, Configuration Mode 1

Pin #	Function
4	Cold head pause. The cold head only will turn off while a 0 VDC, 2 mA signal is applied to this pin if Remote Control is ON (pins 7 and 8 continuity) and System is ON (pin 6). The cold head will restart when the signal is removed.
5	Reset. System error conditions are cleared by momentary application of a 0 VDC, 2 mA signal to this pin.
6	System ON/OFF. The compressor and cold head will turn on when 0 VDC, 2 mA signal is applied to this pin. They will turn off when the signal is removed. Input is opto-isolated.
7	Remote control ON/OFF high. System control is responsive only to DB-25 control inputs (and not responsive to front panel ON/OFF buttons) when electrical continuity (<20 ohms) is applied between pins 7 and 8. When continuity is absent, system shutdown occurs.
8	Remote control ON/OFF low. See Pin 7 description.
10	Compressor return pressure analog value, 0.5-4.5 VDC linear relative to pin 24: PSI Absolute = 125 x (volts) – 47.8
11	Not active. 0 VDC, 20 mA max. signal.
12	Protective earth ground
13	Protective earth ground
14	Run status. When the compressor and cold head are running or the compressor is running with the cold head paused, this pin will carry a 0 VDC, 20 mA max. signal.
15	Motor winding temperature error. On a high compressor motor winding temperature error, this pin will carry a 0 VDC, 20 mA max. signal.
16	Solenoid open. When the internal bypass solenoid valve is open, this pin will carry a 0 VDC, 20 mA max. signal.
17	Power error. On a phase or fuse error, this pin will carry a 0 VDC, 20 mA max. signal.
18	High Hx helium out temp. If the temperature of the helium gas exiting the heat exchanger is > 50 °C, this pin will carry a +24VDC, 20 mA max. signal.
19	High Hx oil out temp. If the temperature of the oil leaving the heat exchanger is too high, this pin will carry a +24VDC, 20 mA max. signal.
21	Gas temp error. On a high helium gas discharge temperature error, or high Hx helium out temperature error, this pin will carry a +24VDC, 20 mA max. signal.
23	Low pressure shutdown. On a compressor return low pressure error (<15 psig) this pin will carry a 0 VDC, 20 mA max. signal
24	0 VDC signal power source.
25	+24VDC, 100mA signal power source.

Table 2 DB-25 Diagnostic Interface Connector Pin Functions, Configuration Mode 2

Pin #	Function
1	Low pressure error. Opto-isolated, solid state. Low pressure error is absent when continuity (<50 ohms) is present between pins 1 and 2. Low pressure error is indicated when open circuit (>10E6 ohms) exists between pins 1 and 2. 24VDC maximum allowed voltage
2	
3	Temperature Error. Opto-isolated, solid state. High operating temperature error is absent when continuity (<50 ohms) is present between pins 3 and 4. High operating temperature error is indicated when open circuit (>10E6 ohms) exists between pins 3 and 4. 24VDC maximum allowed voltage
4	
6	Run Status. Non-isolated. When the compressor and cold head are running or the compressor is running with the cold head paused, +24VDC will be present between pins 6 (+) and pin 7 (-). 20 mA maximum allowed current. Pin 7 is at earth potential (Do not use as PE connection)
7	
13	Control Voltage. Non-isolated. When power is applied to the compressor, +24VDC will be present between pins 13 (+) and pin 7 (-). 20 mA maximum allowed current. Pin 7 is at earth potential
12	Reset. Opto-isolated. System error conditions are cleared by momentary application of a 24 VDC, 20 mA signal to pins 12 (+) and 14 (-).
14	
8	System ON/OFF. Non-isolated. The compressor and cold head will turn on when continuity (<100 ohms) is applied between pins 8 and 15. They will turn off when the signal continuity is removed (>10E8 ohms).
15	

Table 3 Diagnostic Interface Connector Pin Functions, Configuration Mode 1 with DA15-to-DB-25 Adapter, SCAI P/N 268121A

RS-232 PROTOCOL AND PIN-OUTS

General Information

This section describes the FA-40 compressor RS232 interface only. It does not describe overall operation or safety of the FA-40 compressor. Please refer to the FA-40 operating manual for operating instructions and warnings. The information in this section should be used only after safe operation of the FA-40 compressor is understood.

1. FA-40 Front Panel Connection: Male DB-9 connector
   Pin 2 = Receive
   Pin 3 = Transmit
   Pin 5 = Earth Ground (connected to compressor chassis ground)

2. RS232 parameters.
   a. Baud - 9600
   b. No parity
   c. 8 bit data
   d. 1 bit stop

The FA-40 sends no unsolicited messages. It only responds to commands from a host computer.

NOTE

RS232 commands that change operation of the FA-40 compressor (on, off, reset, cold head run, cold head pause and pause off) have equal value as front panel key press control. The FA-40 will respond equally to either source of control input in the order in which it is received.

NOTE

There are no error routines or checks to prevent possible conflicts if a compressor is both connected to a Diagnostic Interface control element and an RS232 control element except:

1. RS232 commands that change operation of the FA-40 compressor are active only when the compressor is set for Diagnostic Interface Configuration Mode 1 (reference operating manual). RS232 commands that transmit data are active for both Diagnostic Interface Configuration Mode 1 and Mode 2.

2. In Configuration Mode 1, active DB-25/DA-15 operating signals will take priority over front panel key press and RS232 control. Diagnostic Interface Configuration Mode 2 does not permit either RS232 or front panel key press control.

RS232 Command List (See the Command Set section below for command descriptions and examples)

1. Information Commands

$TEA: Read all temperatures	$TEn: Read temperature n (n = 1, 2 ,3, or 4)
$PRA: Read all pressures	$PRn: Read pressure n (n = 1 or 2)
$STA: Read status bits	$ID1: Read firmware version and elapsed operating hours

2. Operating Commands

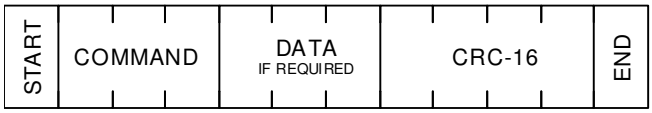
$ON1: On	$OFF: Off
$RS1: Reset	$CHR: Cold head run
$CHP: Cold head pause	$POF: Cold head pause off

3. Responses: $???: Invalid command received

Command Structure

The individual bytes of any communication packet (frame) are restricted to the ASCII domain of 0x20 (20H, space) through 0x7E (7EH, tilde), plus 0x0D (carriage return).

The basic communication frame from the host computer to the FA-40 compressor is comprised of a start character, a command mnemonic, data (if required), checksum, and a message end character.



Start Character: This is always 0x24 (24H, dollar sign).

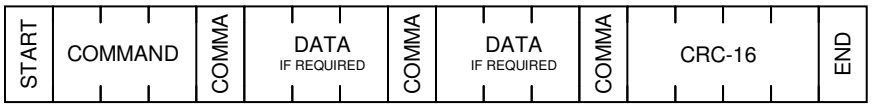
Command: This is a 3 character mnemonic. It defines the action which will be taken by the controller.

Data: Data will be transmitted as ASCII text equivalents. Example: the number 123 will be text "123". In the event that a floating point number is to be conveyed, then it will also be in plain text. Example: 123.9 will be text "123.9". The data field length is fixed depending on the command that is issued. This will be defined at the command level.

Checksum (CRC-16): The checksum is a 16 bit CRC (CRC-16). It is transmitted as four-digit ASCII hex. Example: a 16 bit binary checksum “001001110101011” in four-digit ASCII equals "23AB". The check sum calculation includes the “$” start character, command field, and data field (if present). See section E below for description of CRC-16 generation.

End of message: This is always 0x0D (0DH carriage return). This assures that the end of message character falls outside the standard text domain and will not be incorporated in commands, data, or checksums.

The response frame from the FA-40 compressor is similar to the command frame, but includes delimiters between the various fields.



Start Character: This is always 0x24 (24H, dollar sign).

Command: This is a 3 character mnemonic. It is the same as (echoes) the command sent from the host controller.

Delimiter: This is always 0x2C (2CH, comma).

Data: Data will be transmitted as ASCII text equivalents. Example: the number 123 will be text "123". In the event that a floating point number is to be conveyed, then it will also be in plain text. Example: 123.9 will be text "123.9". The data field length is fixed depending on the command that is issued. This will be defined at the command level.

Checksum(CRC-16): The checksum is a 16 bit CRC. It is transmitted as four-digit ASCII hex. Example: a 16 bit binary checksum "001001110101011" in four-digit ASCII equals "23AB". The check sum calculation includes the "$" start character, command field, data fields (if present), and all commas including the comma preceding the checksum. See section E below for description of CRC-16 generation.

End of message: This is always 0x0D (0DH carriage return). This assures that the end of message character falls outside the standard text domain and will not be incorporated in commands, data, or checksums.

Command Set

$TEA: Read all temperatures
Command with checksum and carriage return = $TEAA4B9<cr>
Response: $TEA,T1,T2,T3,T4,<crc-16><cr>

T1 through T4 are compressor internal temperatures in degrees C.
T1 = Compressor capsule helium discharge temperature
T2 = Oil out of heat exchanger temperature
T3 = Gas out of heat exchanger temperature
T4 is inactive (returns "000") for most FA-40 variants.

The temperature fields are always 3 characters long and are rounded to the nearest degree. Temperatures less than 100 ℃ have leading zeroes.

Example: $TEA,086,040,031,000,3798<cr> corresponding to T1 = 86℃, T2 = 40℃, T3 = 31℃ and where 3798 is the checksum and <cr> is the carriage return.

$Ten: Read selected temperature (n = 1, 2, 3, or 4)
Command with checksum and carriage return = $TE140B8<cr>, $TE241F8<cr>, $TE38139<cr>, or $TE44378<cr>
Response: $TEn,Tn,<crc-16><cr>

Example: host sends $TE140B8cr. The response from the compressor is $TE1,086,ADBC<cr> corresponding to temperature T1 = 86℃ and where ADBC is the checksum and <cr> is the carriage return.

$PRA: Read all pressures
Command with checksum and carriage return = $PRA95F7<cr>
Response: $PRA,P1,P2,<crc-16><cr>

P1 is the compressor return pressure in PSIG. P2 is inactive (returns “000”) for most FA-40 variants.

The pressure fields are always 3 characters long and are rounded to the nearest whole number. Pressures less than 100 psig have leading zeroes.

Example: $PRA,079,000,0CEC<cr> corresponding to P1 = 79 psig and where 0CEC is the checksum and <cr> is the carriage return.

$PRn: Read selected pressure (n = 1 or 2)
Command with checksum and carriage return = $PR171F6<cr> or $PR270B6<cr>
Response: $PRn,Pn,<crc-16><cr>

Example: host sends $PR171F6<cr>. The response from the compressor is $PR1,079,2EBD<cr> corresponding to pressure P1 = 79 psig and where 2EBD is the checksum and <cr> is the carriage return.

$STA: Read Status bits
Command with checksum and carriage return = $STA3504<cr>
Response: $STA,status bits,<crc-16><cr>

The status bits are contained in a four character field that is the ASCII hex equivalent of a 16 bit word. For example, a status bit field of "0301" is equivalent to a binary '0000001100000001". The left most character is the MSbit. Bits are defined as follows:

Bit 15 - 0 = Configuration 1. 1 = Configuration 2. Note that in Configuration 2 only the "read" RS232 commands are functional. Note: Refer to compressor operating manual for explanation and setting of configuration 1 or 2.

Bit 14 - spare.

Bit 13 - spare.

Bit 12 - spare.

Bit 11 - MSbit of state number.

Bit 10 - Middlebit of state number.

Bit 9 - LSbit of state number. The state number reflects the state of operation:

7 - Oil Fault Off
6 - Fault Off
5 - Cold Head Pause
4 - Cold Head Run
3 - Remote On
2 - Remote Off (temporary state not normally returned)
1 - Local On
0 - Local Off

NOTE

Remote ON and OFF are states accessed exclusively with the DB-25/DA-15 Diagnostic Interface connector. RS232 on, off, and reset commands operate as Local states.

Bit 8 - 1 = Solenoid on. 0 = Solenoid off.

Bit 7 - 1 = Pressure alarm. 0 = no alarm.

Bit 6 - 1 = Oil Level alarm. 0 = no alarm.

Bit 5 - 1 = Oil out from heat exchanger alarm. 0 = no alarm.

Bit 4 - 1 = Gas out from heat exchanger alarm. 0 = no alarm.

Bit 3 - 1 = Helium Temperature alarm. 0 = no alarm.

Bit 2 - 1 = Phase Sequence/Fuse alarm. 0 = no alarm.

Bit 1 - 1 = Motor Temperature alarm. 0 = no alarm.

Bit 0 - 1 = System ON. 0 = System OFF.

Example response $STA,0301,2ED1<cr> corresponds to binary 0000001100000001 or : Local ON, solenoid ON, System ON, and no alarms.

$ID1: Read firmware version and elapsed operating hours
Command with checksum and carriage return = $ID1D629<cr>
Response: $ID1,version number,elapsed hours,reserved number,<crc-16><cr>

The version number is a three character text field corresponding to the firmware version. The elapsed hours are an eight character text field corresponding to elapsed operating hours (including tenths) with preceding 0's.

Example: $ID1,1.6,005842.1,000,1E26<cr> = corresponding to firmware version 1.6, elapsed operating hours = 5,842.1 hours, the reserved number field is three (3) characters long and is inactive (returns "000") and where 1E26 is the checksum and <cr> is the carriage return.

$ON1: On
Command with checksum and carriage return = $ON177CF<cr>
Response: $ON1,<crc-16><cr>

When the compressor is off and without active fault, this will turn the compressor and cold head on. If the command is sent while the compressor is in other states, the RS232 response will be returned, but no action will occur.

$OFF: Off
Command with checksum and carriage return = $OFF9188<cr>
Response: $OFF,<crc-16><cr>

When the compressor and/or cold head is on, this will turn either or both off. If the command is sent while the compressor and cold head are off, the RS232 response will be returned, but no action will occur.

$RS1: Reset
Command with checksum and carriage return = $RS12156<cr>
Response: $RS1,<crc-16><cr>

Clears fault indications from the RS232 status response, Diagnostic Interface, and LCD display, and, if the compressor is in Fault Off state (off because of fault), compressor will go to OFF state. If the command is sent while no faults are indicated or not in Fault Off state, the RS232 response will be returned, but no action will occur.

$CHR: Cold Head Run
Command with checksum and carriage return = $CHRFD4C<cr>
Response: $CHR,<crc-16><cr>

When the compressor is off, this will turn on the cold head only. If no subsequent off command is received, the cold head will turn off automatically after 30 minutes. If the command is sent while the compressor is not in an Off state, the RS232 response will be returned, but no action will occur.

$CHP: Cold Head Pause
Command with checksum and carriage return = $CHP3CCD<cr>
Response: $CHP,<crc-16><cr>

When the compressor and cold head are on, this will turn off the cold head only. If the command is sent while the compressor is not in an On state, the RS232 response will be returned, but no action will occur.

$POF: Cold Head Pause Off
Command with checksum and carriage return = $POF07BF<cr>
Response: $POF,<crc-16><cr>

When the compressor is on with the cold head off (Cold Head Pause state), this will turn the cold head back on (return to normal ON state). If the command is sent while the compressor is not in Cold Head Pause state, the RS232 response will be returned, but no action will occur.

INVALID: Malformed or invalid message from host computer.
Response: $???,<crc-16><cr> (crc-16 = 3278)

Every time the controller receives an end of message character (carriage return), it checks the preceding message for errors. These include: lack of a message start character, unrecognized mnemonic, incorrect message length, invalid checksum. If any of these fail the check, then the controller responds with the above "error" message.

CRC Generation

1. CRC-16 ANSI (also MODBUS) is used. The CRC-16 is first started by pre-loading a 16 bit register with all 1's. The process begins by applying successive 8-bit bytes of the message to the current contents of the register. Only the eight bits of the data in each character are used for generating the CRC. Start, stop, and parity bits do not apply to the CRC.

During generation of the CRC, each 8-bit character is Exclusive-ORed (XORed) with the register contents. Then the result is shifted in the direction of the least significant bit (LSB), with a zero filling the most significant bit (MSB). The LSB is then examined. If the LSB is a 1, the register is XORed with a preset fixed value (A001h). If the LSB is a 0, then no XOR takes place.

This process is repeated until eight shifts have been performed. After the last shift, then the next 8-bit message byte is XORed with the 16-bit register. The eight-shift processes above are repeated.

After all of the message bytes have been XORed and shifted, the result is the CRC.

2. A pre-formatted indexed table of read-only values can be XORed with the 16 bit register as a substitute for the iterative shift-and-XOR-with-A001h process described above. Example C code for this method is given here:

```
const unsigned int crcTable[] = {
      0,49345,49537,320,49921,960,640,49729,
      50689,1728,1920,51009,1280,50625,50305,1088,
      52225,3264,3456,52545,3840,53185,52865,3648,
      2560,51905,52097,2880,51457,2496,2176,51265,
      55297,6336,6528,55617,6912,56257,55937,6720,
      7680,57025,57217,8000,56577,7616,7296,56385,
      5120,54465,54657,5440,55041,6080,5760,54849,
      53761,4800,4992,54081,4352,53697,53377,4160,
      61441,12480,12672,61761,13056,62401,62081,12864,
      13824,63169,63361,14144,62721,13760,13440,62529,
      15360,64705,64897,15680,65281,16320,16000,65089,
      64001,15040,15232,64321,14592,63937,63617,14400,
      10240,59585,59777,10560,60161,11200,10880,59969,
       60929,11968,12160,61249,11520,60865,60545,11328,
       58369,9408,9600,58689,9984,59329,59009,9792,
       8704,58049,58241,9024,57601,8640,8320,57409,
       40961,24768,24960,41281,25344,41921,41601,25152,
       26112,42689,42881,26432,42241,26048,25728,42049,
       27648,44225,44417,27968,44801,28608,28288,44609,
       43521,27328,27520,43841,26880,43457,43137,26688,
       30720,47297,47489,31040,47873,31680,31360,47681,
       48641,32448,32640,48961,32000,48577,48257,31808,
       46081,29888,30080,46401,30464,47041,46721,30272,
       29184,45761,45953,29504,45313,29120,28800,45121,
       20480,37057,37249,20800,37633,21440,21120,37441,
       38401,22208,22400,38721,21760,38337,38017,21568,
       39937,23744,23936,40257,24320,40897,40577,24128,
       23040,39617,39809,23360,39169,22976,22656,38977,
       34817,18624,18816,35137,19200,35777,35457,19008,
       19968,36545,36737,20288,36097,19904,19584,35905,
       17408,33985,34177,17728,34561,18368,18048,34369,
       33281,17088,17280,33601,16640,33217,32897,16448,
};

unsigned __int16  CreateChecksum(unsigned char* source)
      {
      unsigned __int16 crc16 = 0xffff;
      unsigned __int16 crcdata;
      unsigned int messageptr = 0;
      do
        {
         crcdata = source[messageptr] ^ crc16;
         crc16 = (crc16 >> 8) ^ (crcTable[crcdata & 0x00ff]);
         messageptr++;
         }
       while(source[messageptr] != 0x00);
       return(crc16);
       }
```