



F-70H, F-70L, F-70HP and F-70LP Freedom[®] Series Helium Compressors

Operating Manual

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Table of Contents

	<u>Page</u>
SAFETY	1
SERVICE	5
INTRODUCTION	7
Helium Compressors, Models F-70H, F-70L F-70HP and F-70LP	7
PRINCIPLES of OPERATION	9
DESCRIPTION	11
Components	11
SPECIFICATIONS	13
F-70H Compressor (high voltage model) and F-70HP Compressor (high voltage plus model).....	13
F-70L Compressor (low voltage model) and F-70LP Compressor (low voltage plus model)	13
Electrical Characteristics	13
Compressor Control	14
Front Panel Connections.....	15
Front Panel Mounted Items	15
Environmental Requirements	15
Mounting Position.....	16
Cooling Requirements	16
Water Quality Requirements.....	19
Helium Gas Pressures	19
Refrigerant Quality	19
Color Codes	20
Optional Spacing.....	20
Maintenance Intervals	20
Noise Level	20
Dimensions	20
Weight	20
General Operating Conditions	20
Supplier Name and Address.....	20
Product End of Life Instructions.....	20
Regulatory Compliance	21
INSTALLATION	25
Introduction	25
Receipt Inspection Instructions.....	25
Unpackaging and Product Inspection Instructions	26
Compressor Location	28
Caster Removal.....	28
Transformer Voltage Tap Selection for F-70L and F-70LP.....	28
Transformer Voltage Tap Selection for F-70H and F-70HP	29
Electrical Supply Connection	30
Coolant Connections	33
Compressor Checkout	33
Install the Gas Lines.....	34
Set the System Equalization Pressure.....	36
Install the Cold Head Cable(s).....	37
Compressor Control Preparation	37

Prestart Check.....	39
OPERATION	41
Starting	41
Stopping	41
Cold Head Only Run	42
Restarting After a Power Failure	42
Automatic Restarting After a Helium High Temperature Shutdown Error	42
System Status Display.....	42
MAINTENANCE	45
Adsorber Replacement.....	45
Adsorber Removal.....	45
Adsorber Installation.....	48
Register New Adsorber	51
Used Adsorber Venting and Disposal	51
Fuse Replacement.....	52
TROUBLESHOOTING	55
Error Conditions	55
Clearing Error Conditions	55
Restarting after an Error Condition	56
Troubleshooting Guide	56
Diagnostic Interface Connector Pin Functions	66
RS232 PROTOCOL AND PIN-OUTS	69
General Information.....	69
RS232 Command List	70
Command Structure	70
Command Set	71
CRC Generation.....	75
F-70 Compressors in Parallel Tandem Configuration	77
Tandem System Configuration.....	77
Installation.....	77
Control Configuration.....	78
Operation.....	78
Fault Behavior.....	79
Reset Behavior.....	80

ILLUSTRATIONS LIST

Figure 1	Compressor Flow Diagram	9
Figure 2	Allowable Cooling Water Range for F-70 Compressor and GM Cryocooler	17
Figure 3	Allowable Glycol/Water Range for F-70 Compressor and GM Cryocooler	17
Figure 4	Allowable Cooling Water Range for F-70 Compressor and PT Cryocooler	18
Figure 5	Allowable Glycol/Water Range for F-70 Compressor and PT Cryocooler	18
Figure 6	F-70 Compressors, Front View	23
Figure 7	F-70 Compressors, Dimensions.....	24
Figure 8	Voltage Selection Connectors.....	29
Figure 9	Voltage Tap Configurations.....	30
Figure 10	Connect Mains Power Supply Cable to Mains Power Receptacle...	31
Figure 11	Connect Field Wiring to Mains Terminal Block and Protective Earth Connector.....	32
Figure 12	Connect and Remove the Water Lines.....	33
Figure 13	Attach Identification Label.....	35
Figure 14	Connect Gas Line to Compressor or Cold Head	35
Figure 15	Set the Configuration Mode Selector Switch	38
Figure 16	Compressor Cover Panel Removed.....	45
Figure 17	Disconnect Self-Sealing Coupling.....	46
Figure 18	Disconnect Adsorber from Base.....	46
Figure 19	Remove Supply Coupling Locknut	47
Figure 20	Remove Adsorber.....	47
Figure 21	Install Lock Washer on Adsorber	48
Figure 22	Install Adsorber.....	48
Figure 23	Install Supply Coupling Washer and Lockout	49
Figure 24	Connect Self-Sealing Coupling	50
Figure 25	Leak Check Aeroquip Couplings.....	50
Figure 26	Compressor Cover and Eyebolts.....	53
Figure 27	Electrical Chassis.....	53
Figure 28	Fuse Locations in the Electrical Chassis	54
Figure 29	F-70H and -70HP Compressors Wiring Diagram	60
Figure 30	F-70H and F70HP Compressors Wiring Schematic	61
Figure 31	F-70L Compressor Wiring Diagram.....	62
Figure 32	F-70L Compressor Wiring Schematic.....	63
Figure 33	F-70LP Compressor Wiring Diagram	64
Figure 34	F-70LP Compressor Wiring Schematic.....	65

TABLES

Table 1 Diagnostic Interface Connector Pin Functions, Configuration Mode 1 66

Table 2 Diagnostic Interface Connector Pin Functions, Configuration Mode 2 67

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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.



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.

This equipment must only be connected to a supply mains switch with protective earth. 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.

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.

If this equipment is modified, appropriate inspection and testing must be conducted to ensure safe use of equipment.

CAUTIONS

For an installation using a water chiller or other circulating cooling system:

Use pure ethylene glycol with water for the coolant antifreeze solution. Do not use commercial ethylene glycol sold for automotive cooling systems, which usually contains a fine grit material that can damage the cooling system.

PREVENT EQUIPMENT DAMAGE. Do not use deionized, demineralized or distilled water for cooling water, as it can result in a corrosive environment inside the unit.

Use properly rated commercial equipment for lifting or moving the compressor. Make sure compressor is held in a balanced and stable position. Follow all applicable safety procedures for overhead material transport.

If the compressor is wired for 380/415 ($\pm 10\%$) V3~ electrical service, connecting to a higher voltage may damage the control circuit. Similarly, if it is wired for 480 V3~, 60 Hz, it can be damaged by connecting to 380/415 V3~.

Always thoroughly drain the coolant from the cooling circuit if the compressor is to be shipped or stored.

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

After starting the system for the first time, to be certain that the water lines are properly connected, check that the outlet water temperature is warmer than the inlet water.

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.

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.

CAUTIONS (continued)

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.

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.

ENSURE CORRECT OPERATION. Do not make connections to pins 6, 7, or 8. Signals on these pins may cause the controller to malfunction.

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INTRODUCTION

Helium Compressors, Models F-70H, F-70L F-70HP and F-70LP

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 F-70H (high voltage model), the F-70L (low voltage model), the F-70HP (high voltage plus model) and the F-70LP (low voltage plus model) 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

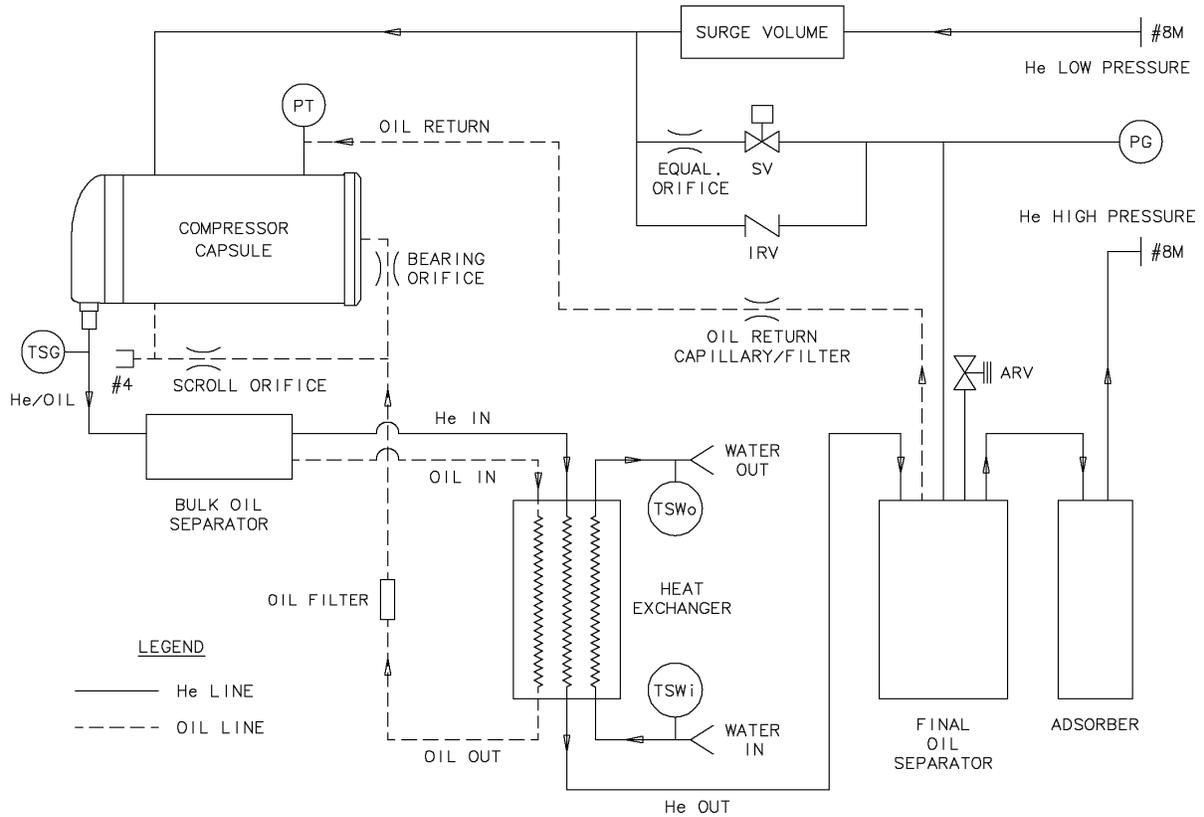


Figure 1 Compressor Flow Diagram

Key	
TSG	Gas temperature thermistor
TSWi	Water-in temperature thermistor
TSWo	Water-out 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.

Principles of Operation

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 three-circuit, water 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.

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 on the printed circuit board inside the electrical chassis box, protect the cold head supply circuit.

Heat Exchanger - Uses water 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 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 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.

Supply Gas High Temperature Thermistor - 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.

Water High Temperature Thermistors - Sense water temperature. One each is located in the "water in" line and in the "water out" line. They provide a warning if the inlet or the outlet water temperature is too high. High outlet water temperature indicates low water flow.

Water In and Out Fittings – two (2) ½" MNPT connections mounted on the front panel.

SPECIFICATIONS

F-70H Compressor (high voltage model) and F-70HP Compressor (high voltage plus model)

Details: Two (2) size 8M gas couplings; water-cooled; 460-480 ($\pm 10\%$) V3~, 60 Hz or 380-415 ($\pm 10\%$) V3~, 50 Hz.

F-70L Compressor (low voltage model) and F-70LP Compressor (low voltage plus model)

Details: Two (2) size 8M gas couplings; water-cooled; 200 ($\pm 10\%$) V3~, 50/60 Hz.

Electrical Characteristics

Service required: Four (4) wires (3 phase plus protective ground or earth.)

Power Connection, F-70H, F-70L and F-70HP:

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

F-70H (high voltage model) and F-70HP (high voltage plus 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 Connection, F-70LP:

A field wiring terminal box with an opening for a 1 inch nominal or M32 conduit connector is provided.

Power consumption:	<u>Gifford-McMahon (GM) Operation</u>	<u>Startup</u>
	6.6 – 6.9 kW @ 50 Hz	<8.5 kW @ 50 Hz
	7.5 – 7.8 kW @ 60 Hz	<9.0 kW @ 60 Hz
	<u>Pulse Tube (PT) Operation</u>	<u>Startup</u>
	6.7 – 7.2 kW @ 50 Hz	<8.5 kW @ 50 Hz
	8.0 – 8.5 kW @ 60 Hz	<9.8 kW @ 60 Hz

Rated load current:

For the F-70H and the F-70HP compressors, 13 amperes

For the F-70L compressor, 24 amperes (GM only)

For the F-70LP compressor, 32 amperes

Locked rotor current:

For the F-70H and the F-70HP compressors, 75 amperes at 50/60 Hz

For the F-70L compressor, capsule model ZCH72C3G-TF5, 164 amperes at 50/60 Hz

For the F-70L and the F-70LP compressor, capsule model ZCH72C4G-TF5, 191 amperes at 50/60 Hz

Internal circuit protection

Transformer: (3) 1.0 ampere, time delay, class CC fuses (F-70H and F-70HP)
(FU-1, 2 and 3)

(3) 2.0 amperes, time delay, class CC fuses (F-70L) (FU-1, 2 and 3)

Cold head motor: (3) 0.63 ampere, time delay, 5x20 mm IEC Type T 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 28.

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: IP4X

See the Compressor Wiring Diagrams, Figures 16, 17, 18, 19, 20 and 21.

Compressor Control

Control options

1. Front Panel ON and OFF buttons
2. Control through the Diagnostic Interface
3. Control through the Serial (RS232) Interface (firmware version 1.6 and later)

Control functions

- ON and OFF buttons for local operation of the compressor and cold head.
- 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 gas discharge temperature, when thermistor reads > 93° C (200° F).
(5 automatic restarts at 20 minute intervals before operator correction required.)
 - High compressor motor windings temperature, switch opens at 145° C (293° F),
resets at 61° C (142° F).
 - High compressor motor current draw: F-70H and F-70HP trips at 14 amperes
(capsule model ZCH72C2G), or at 16
amperes (capsule model ZCH72C3G).
F-70L trips at 32 amperes.
F-70LP trips at 40 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 faults:
 - High water temperature, > 35° C (95° F);
 - Low water flow, water out, > 46° C (115° F).

ON/OFF Operation

- Compressor ON/OFF frequency must be less than six (6) times hour, and less than 24 times per day. The restart interval must be more than three (3) minutes. Frequent ON/OFF operation may result in malfunction or damage to the compressor capsule.

Front Panel Connections (See Figure 6.)

- 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.
- Cooling water connections: Swagelok bulkhead fittings, ½” MNPT.
- Cold head cable receptacle: Amphenol 97-3102A-14S-2S
- Mains power connection (F-70H, F-70L and F-70HP): Screw-mounted rectangular industrial connector
- Mains power connection (F-70LP): Terminal block
- Diagnostic interface connector: DB-25, for control and to indicate error condition
 - Proper DB-25 configuration mode must be selected at installation. See Diagnostic Interface Connector in the Compressor Control Preparation section of this manual.
- Serial connector/RS232: DB-9, for control and to indicate error condition (firmware version 1.6 and later)

Front Panel Mounted Items (See Figure 6.)

- 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 (F-70H and F-70HP)
- Configuration mode selector switch

Firmware V1.7 has the following features:

- Hours Run Clock – elapsed time since compressor’s last repair or original manufacture
- Masters Run Clock – total run time on compressor available via RS232 communication and/or service level display
- Adsorber Clock – factory set at 30,000 hours; clock will run down to zero
- Fault Reporting - last 20 faults will be time stamped and available via RS232 communication
- RS232 Interface - hyperterminal used to monitor F-70 compressor via RS232

Environmental Requirements

	<u>Operating</u>	<u>Storage</u>
Ambient Temperature	4° C to 40° C (40° F to 104° F)	-20° C to 65° C (-4° F to 150° F)
Relative Humidity	30% to 70%	10% to 90% (non-condensing)
Magnetic Field Limits	≤ 150 Gauss	
Atmospheric Pressure	70 kPa to 110 kPa	20 kPa to 110 kPa

NOTE

Operating the equipment out of specifications may void the warranty.

Mounting Position

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

Cooling Requirements (See Figures 2, 3, 4 and 5)

<u>Application</u>	<u>Cooling Water Flow Rate</u>
4K GM and 10K GM Cold Head (F-70H/F-70L)	6 to 9 L/min (1.6 to 2.4 gpm)
4K PT Cold Head (F-70H/F-70HP/F-70LP)	6.8 to 9 L/min (1.8 to 2.4 gpm)
Cooling water inlet temperature:	5° C to 25° C (41° F to 77° F)
Cooling water outlet temperature:	45° C (113° F) maximum
Cooling water supply pressure:	8 bar (116 psig) maximum
Pressure drop at 9 L/min:	<1 bar (<14.5 psig)
Alternative coolant	50% pure ethylene glycol + 50% water
Ethylene glycol/water (50/50) flow rate	7.8 to 11.7 L/min (2.1 to 3.1 gpm)

CAUTION

For an installation using a water chiller or other circulating cooling system:
 Use pure ethylene glycol with water for the coolant antifreeze solution. Do not use commercial ethylene glycol sold for automotive cooling systems, which usually contains a fine grit material that can damage the cooling system.

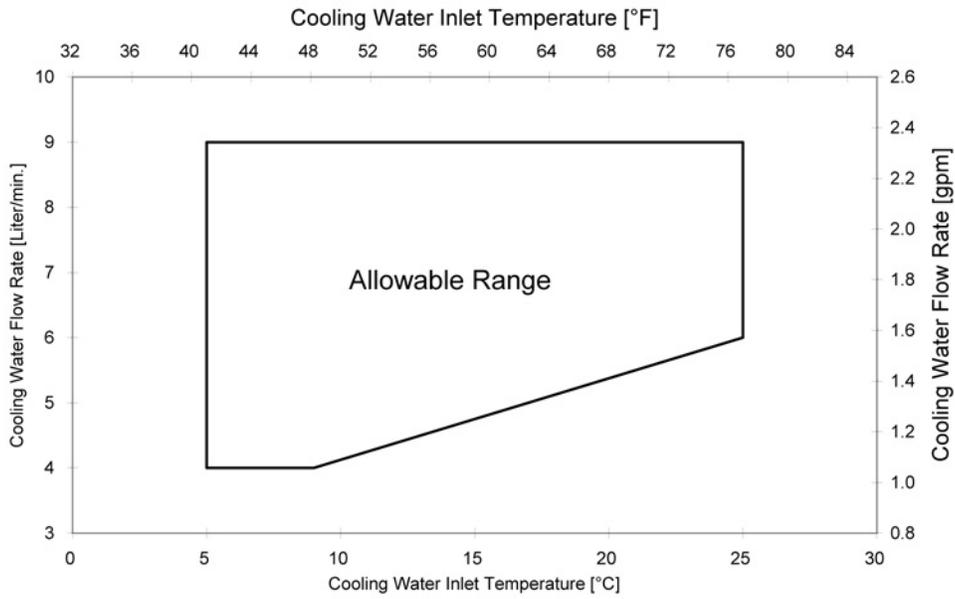


Figure 2 Allowable Cooling Water Range for F-70 Compressor and GM Cryocooler

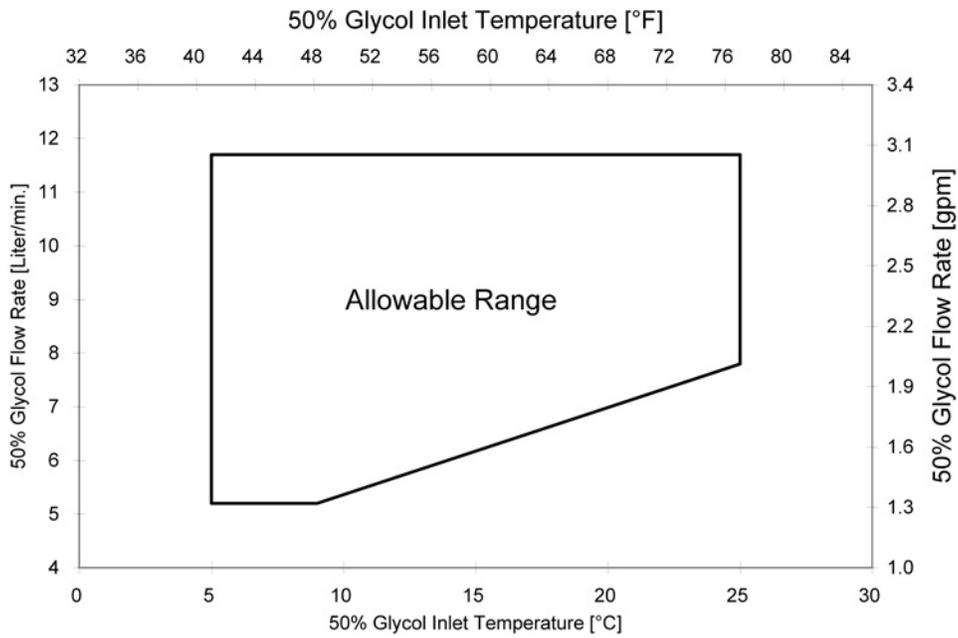


Figure 3 Allowable Glycol/Water Range for F-70 Compressor and GM Cryocooler

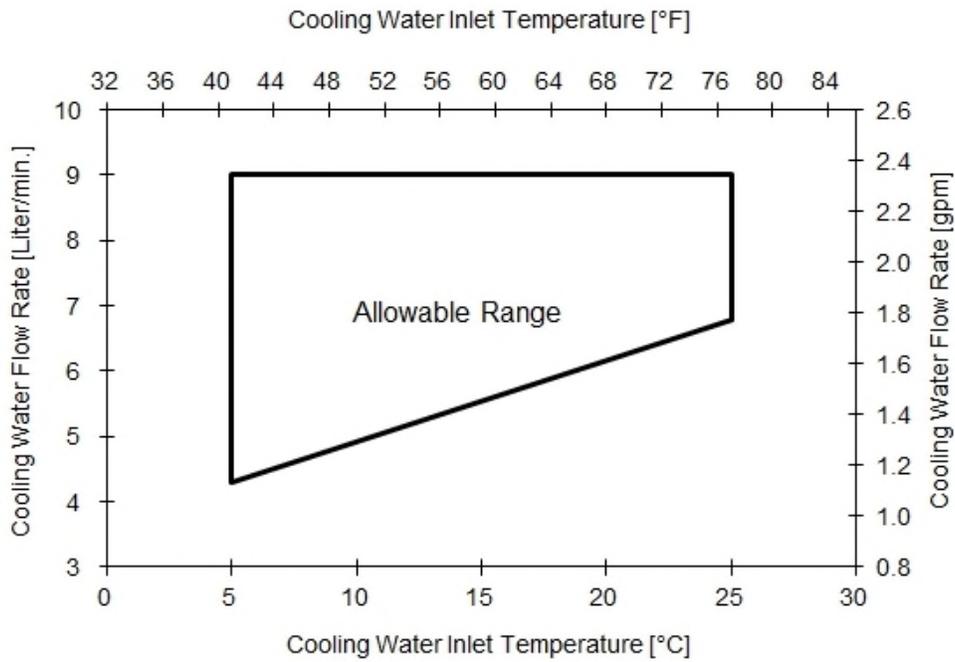


Figure 4 Allowable Cooling Water Range for F-70 Compressor and PT Cryocooler

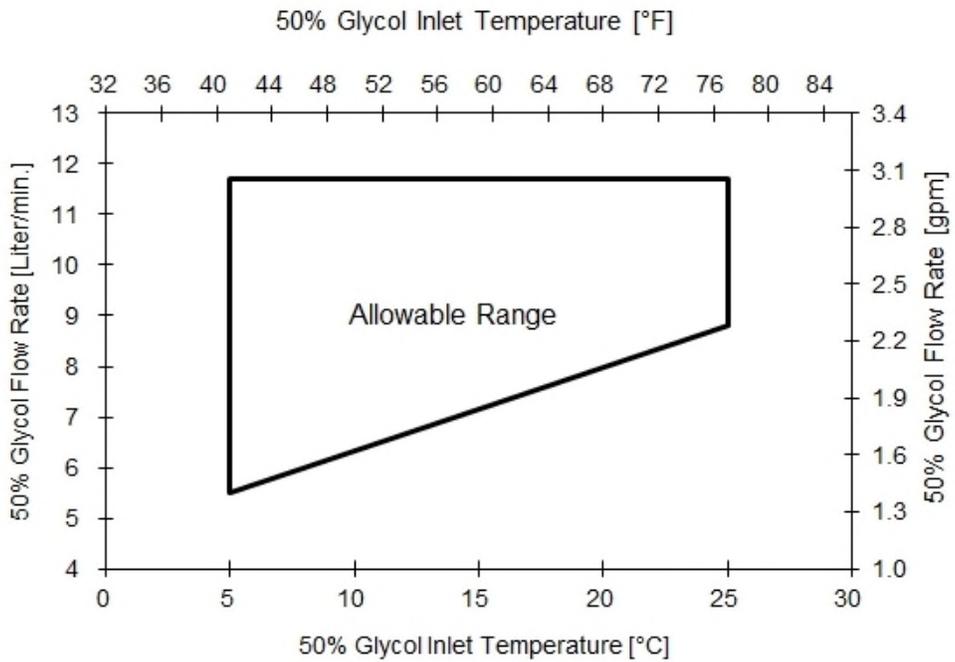


Figure 5 Allowable Glycol/Water Range for F-70 Compressor and PT Cryocooler

Water Quality Requirements

Water supplied for cooling the compressor should be filtered through a 300-micron screen and meet the following quality limits:

<u>Item</u>	<u>Initial Values for non-Replenished (closed) System</u>	<u>Values for Continuously Replenished (open) System</u>
Suspended solids, µg/L	<250	<250
Particle size, µm	<300	<300
pH (25° C)	6.5 to 8.0	6.0 to 8.0
Alkalinity (ppm)	100 max.	50 max.
Hardness (ppm)	200 max.	50 max.
Chloride (ppm)	200 max.	50 max.
Sulfate (ppm)	200 max.	50 max.
Iron (ppm)	1.0 max.	0.30 max.
Sulfur ion (ppm)	None detected	None detected
Ammonium ion (ppm)	1.0 max.	0.20 max.
Silica (ppm)	50 max.	30 max.
Calcium (ppm)	100 max.	50 max.
Magnesium (ppm)	100 max.	50 max.

CAUTION

PREVENT EQUIPMENT DAMAGE. Do not use deionized, demineralized or distilled water for cooling water, as it can cause a corrosive environment inside unit.

Helium Gas Pressures

<u>Application</u>	<u>Equalization Pressure at 20° C (68° F) for 12 to 20 m long gas lines</u>	<u>Operating (Supply) Pressure *</u>
4KGM Cold Head, 50/60 Hz	1.35-1.40 MPa {1.36 MPa (198 psig) nominal}	1.80 - 2.30 MPa (261 - 334 psig)
10KGM Cold Head, 60 Hz	1.35-1.40 MPa {1.36 MPa (198 psig) nominal}	1.80 - 2.30 MPa (261 - 334 psig)
10KGM Cold Head, 50 Hz	1.40-1.45 MPa {1.43 MPa (207 psig) nominal}	1.83 - 2.32 MPa (265 - 337 psig)
4K Pulse Tube Cold Head, 50/60 Hz	1.65-1.70 MPa {1.66 MPa (240 psig) nominal}	2.0 – 2.5 MPa (290 - 363 psig)
CH-110 / CH-110LT, 50/60 Hz	1.45-1.48 MPa { 1.46 MPa (212 psig) nominal}	2.14 – 2.34 MPa (310 - 340 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 -50° C (-58° 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

Compressor helium connections are color-coded to match color labels provided with 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.

Optional Spacing

Allow 600 mm (24") space in front of the compressor for access to electrical, water 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

< 65 dB(A) at 1m

Dimensions

See Figure 7.
Three removable eyebolts are furnished for lifting.

Weight (approximate)

Compressor: 100 kg (220 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 GmbH
Authorized Representative's Address	Daimlerweg 5a D-64293 Darmstadt Germany
Authorized Representative's Contact Information	Tel: +49 (0) 6151-860-610 Fax: +49 (0) 6151-800-252 E-mail: contact@sumitomocryo.de
Type of Equipment	Cryogenic Refrigeration Systems

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

F-70H, F-70L, F-70HP and F-70LP Series Compressors

are in conformity with the relevant Union harmonization legislation



Application of Council Directives:

- **Machinery Directive 2006/42/EC**
- **EMC Directive 2014/30/EU**
- **RoHS Directive 2011/65/EU and as amended 2015/863/EU**
 - **Exemptions 6a, 6c, 7a, and 7c-1**



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: 
 Mark O. Derakhshan
 Chief Executive Officer, SCAI
 September 2022



UKCA 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 Hampshire RG21 6YT United Kingdom
Authorized Representative's Contact Information	Tel: +44 (0) 1256 853333 Fax: +44 (0) 1256 471507 E-mail: uksales@shicryogenics.com ukservice@shicryogenics.com
Type of Equipment	Cryogenic Refrigeration Systems

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

F-70H, F-70L, F-70HP and F-70LP Series Compressors

are fully compliant with the essential requirements and relevant requirements of the following UK regulations:

- **Supply of Machinery (Safety) Regulations 2008**
- **Electromagnetic Compatibility Regulations 2016**
- **The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 (as amended January 2021)**
 - Exemptions used 6a, 6c, 7a, 7c-1

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

By: 
 Mark O. Derakhshan
 Chief Executive Officer, SCAI
 September 2022

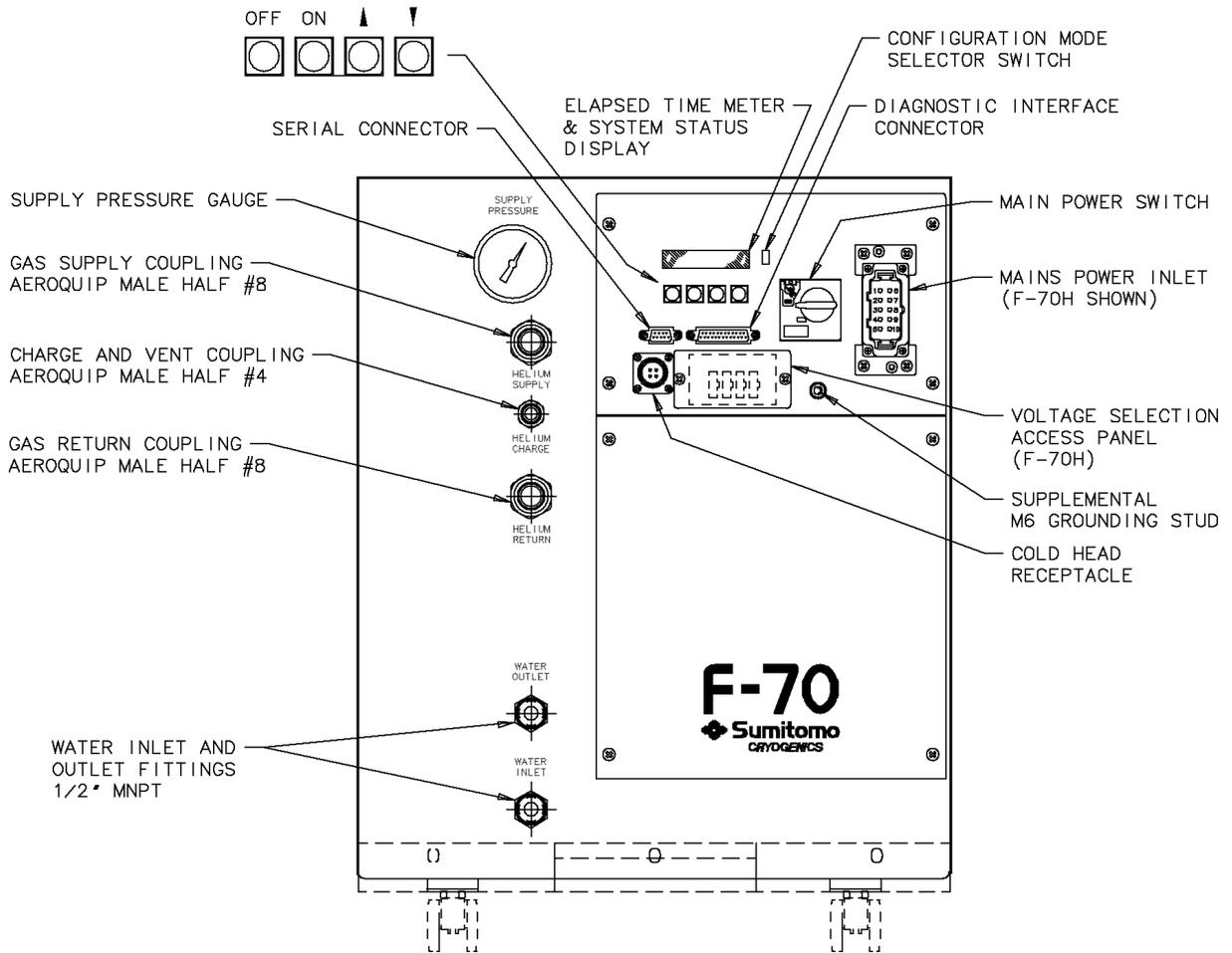


Figure 6 F-70 Compressors, Front View

Specifications

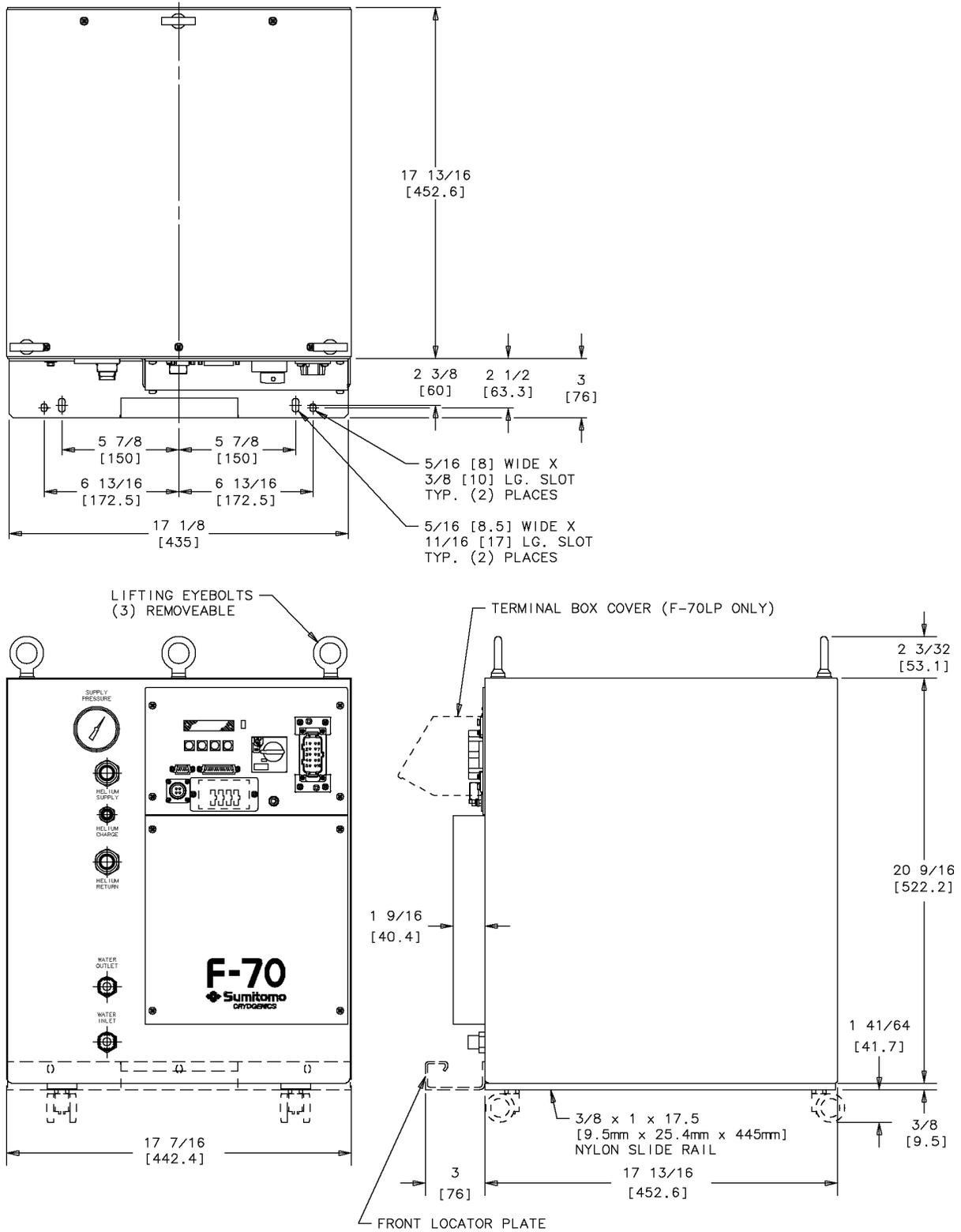


Figure 7 F-70 Compressors, Dimensions

Dimensions are in inches and [mm].

INSTALLATION

Introduction

Install the F-70 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.

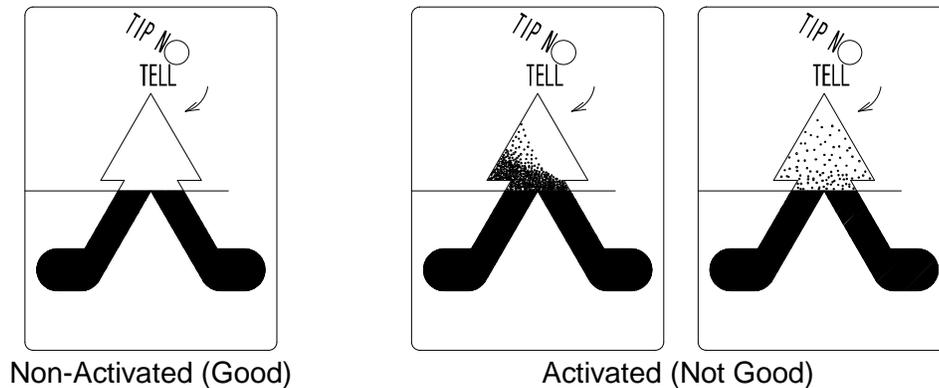
2.2 Look through the “peep hole” on the container. View the pressure gauge on the Compressor Unit front panel. The pressure gauge should indicate 207 – 212 PSIG at 68°F (1430 – 1460 kPa at 20°C).

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.



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 7.

CAUTION
PREVENT EQUIPMENT DAMAGE. Use properly rated commercial equipment for lifting or moving the compressor. Make sure compressor is held in a balanced and stable position. Follow all applicable safety procedures for overhead material transport.

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 F-70H or F-70HP compressor is wired for 400 V3~, 50Hz (400 ±10% V3~) electrical service, connecting to a higher voltage may damage the control circuit. Similarly, if it is wired for 480 V3~, 60 Hz, it can be damaged by connecting to 400 V3~.

Connect power and water to the compressor. See the next sections Compressor Location, Electrical Supply Connection, Coolant Connections 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

Compressor can be moved to site location using pre-assembled casters.

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 40° C (40° F to 104° F).

The compressor must be installed base down, within 5 degrees of horizontal, and preferably at a height convenient for making connections and reading the pressure gauge.

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

Caster Removal

Use the following procedure for applications not requiring casters.

1. Elevate and support the compressor base about 3 ½" to 4" (90 to 100 mm) above the work surface. Do not tip the compressor more than 10 degrees.
2. Using a 7 mm open-end wrench on the flat of the caster's stem, turn the stem to remove it from the nut inside the compressor's base. Continue to remove the other casters.
3. Lower the compressor to rest on its Nylon slide rails.

Transformer Voltage Tap Selection for F-70L and F-70LP

The F-70L and F-70LP Compressors are permanently configured for 200 (±10%) V3~, 50 Hz. No changes are required for this model.

Transformer Voltage Tap Selection for F-70H and F-70HP

There are four (4) possible voltage taps: 380V, 400V, 415V and 480V. The compressor is factory set for 400V3~.

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 F-70H or F-70HP Compressor is wired for 400 V3~, 50 Hz (380/415 \pm 10% V3~) electrical service, connecting it to a higher voltage may damage the control circuit. Similarly, if it is wired for 480 V3~, 60 Hz, it can be damaged by connecting to 400 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 8.
3. Move the exposed connector half from the incorrect voltage tap connector to the voltage tap connector labeled for the correct supply voltage. Make sure the connector latches in place. See Figure 9.
4. Replace the clear plastic window.
5. Reconnect the compressor's main power.



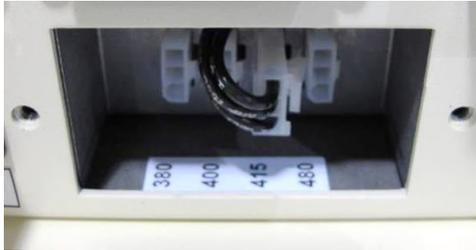
Figure 8 Voltage Selection Connectors



380V Connection



400V Connection



415V Connection



480V Connection

Figure 9 Voltage Tap Configurations

Electrical Supply Connection

- Tools required:
- #3 Phillips screwdriver
 - #2 Phillips screwdriver (F-70LP)
 - ¼" Flat-bladed screwdriver (F-70LP)
 - 5 mm hex driver

The F-70 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. This equipment must only be connected to a supply mains switch with protective earth. All electrical supply equipment must meet applicable codes and be installed by qualified personnel.

⚠ 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.

F-70H, F-70L and F-70HP:

Connect mains power supply cable into the mains power receptacle on the front panel and fasten cover with attached screws. See Figure 10.



Figure 10 Connect Mains Power Supply Cable to Mains Power Receptacle

F-70LP:

Remove terminal box cover. Install conduit or cable gland of wiring method approved by local codes. Connect field wiring to the mains terminal block and the protective earth connector. See Figure 11.

Recommended Tightening Torque: L1, L2, L3 Terminal Block – 4.0 N·m (35 in·lbs)
Protective Earth – 2.3 N·m (20 in·lbs)



Figure 11 Connect Field Wiring to Mains Terminal Block and Protective Earth Connector

Coolant Connections

Tools required: Open-end wrench, 15/16”
 Open-end wrench to suit customer’s water lines fittings

Using two wrenches, connect coolant supply and return lines to the water in and water out fittings on the front of the compressor. See Figure 12. Ensure that the Water In connection is connected to the supply line from the user’s cooling water or coolant supply. Turn on the coolant and check the water lines for leaks. Tighten the fittings if necessary. See Specifications for cooling requirements.



Figure 12 Connect and Remove the Water Lines

CAUTION

PREVENT EQUIPMENT DAMAGE. Always thoroughly drain the coolant from the cooling circuit if the compressor is to be shipped or stored.

Compressor Checkout

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

1. For the F-70H (high voltage model) and F-70HP (high voltage plus 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.
3. While the compressor is running, lightly touch the water supply and return lines. The return (water out) line should be warmer. If the return water line is cooler than the supply (water in) line, stop the compressor and reverse the water connections.

NOTE

The compressor has reversed-phase protection to prevent it from running in reverse. If it does not start and the LCD displays “Phase Seq – 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 13.

NOTE

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

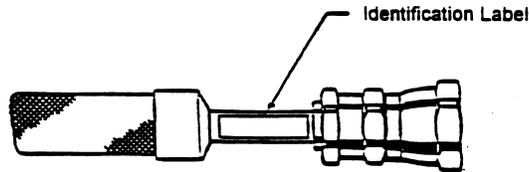


Figure 13 Attach Identification Label

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 14. 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.

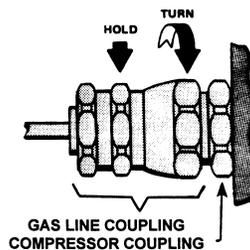


Figure 14 Connect Gas Line to Compressor or Cold Head

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.

Set the System Equalization Pressure

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.

1. Check that all gas lines are properly connected to cryopump(s) and compressor as shown in system schematic.
2. Supply power to the compressor, set the compressor's main power switch to ON. Do not start the compressor.
3. Press \uparrow push button three (3) times. Read return pressure (psig) on front panel display.
4. Refer to system operating manual and check that helium gas pressure shown in the display is within specified range with compressor and entire system at 20°C (68°F).
5. If pressure is too high, these tools are required:
 - Adapter fitting with valve
4F Aeroquip, P/N 253757B
Open end wrenches, sizes $\frac{5}{8}$ " and $\frac{3}{4}$ "
 - 5.1 Check that compressor is stopped and at 20°C (68°F).
 - 5.2 Be sure the valve on the adapter fitting P/N 253757B is closed. Using two wrenches, install this adapter fitting on the 4M Aeroquip helium fill port.
 - 5.3 **Slowly** open the valve on the adapter fitting. Vent the system until the required equalization pressure is attained. See Specifications. Close the valve on the adapter fitting.
 - 5.4 Remove the adapter fitting from the compressor. Use two wrenches.
6. If pressure is too low, these tools are required:
 - Adapter fitting with valve
4F Aeroquip, P/N 253757B
Open end wrenches, sizes $\frac{5}{8}$ " and $\frac{3}{4}$ "
Helium Supply
Regulator
Charge line

- 6.1 Stop the compressor.
- 6.2 Locate an adapter fitting, P/N 253757B. Slightly open the adapter fitting's valve. Use two wrenches to attach it to the 4M Aeroquip helium fill port on the front of the compressor. Close the valve.
- 6.3 Connect a charge line to the pressure regulator of a helium gas cylinder containing 99.995% pure helium with a dew point less than -50° C (-58° F) at 20.7 bar (300 psig).
- 6.4 When connecting the charge line to the adapter fitting, thoroughly purge the charge line from the regulator. Slightly open the valve on the adapter fitting and release a small volume of gas from the compressor. While both the charge line and the adapter fitting are purging, connect them together. It is important to remove all air contaminants to prevent them from entering the system.
- 6.5 Adjust the regulator to the required equalization pressure. See the Specifications section in this manual. **Slowly** open the valve on the adapter fitting. Charge the system with helium gas to the equalization pressure.
- 6.6 Close the valves on the adapter fitting and on the gas cylinder.
- 6.7 Disconnect the charge line from the adapter fitting. Remove the adapter fitting. Store the charge line to keep it clean.

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 F-70 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 and 2 in the Troubleshooting section of this manual.

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

Mode 1 allows an F-70 Diagnostic Interface to replace an HC-10 compressor remote control interface. Mode 2 allows an F-70 Diagnostic Interface to replace a CSW-71TW External Connector (JR) interface.

2. Securely connect a control cable providing the necessary operating signals to the front panel Diagnostic Interface DB25 connector.

Serial Interface (RS232) Control Preparation (Firmware version 1.6 and later):

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 4. 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 15.



Figure 15 Set the Configuration Mode Selector Switch

Prestart Check

1. Check that the cooling water lines are connected and that the supply is connected to the water in connection. Turn on the coolant and check the lines for leaks. Tighten the fittings if necessary. See Cooling Requirements in Specifications.
2. Check that all electric connections are made:
 - a. Power to the compressor
 - b. Cold head cable
 - c. Diagnostic interface cable
3. Check that the diagnostic interface selector switch is properly set (if used).
4. Check that the electrical power supply is switched on.
5. 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

WARNING

AVOID INJURY. If this equipment is modified, appropriate inspection and testing must be conducted to ensure continued safe use of equipment.

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 or 2 in the Troubleshooting section of this manual. The compressor and cold head will start.

For Serial Interface (RS232) Control (firmware version 1.6 and later): 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).

CAUTION

PREVENT EQUIPMENT DAMAGE. After starting the system for the first time, to be certain that the water lines are properly connected, check that the outlet water temperature is warmer than the inlet water.

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 or 2 in the Troubleshooting section of this manual. The compressor and cold head will stop.

For Serial Interface (RS232) Control (firmware version 1.6 and later): 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

If a power outage occurs while using the RS-232 interface to control the compressor, when the power comes back 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. The compressor controls are shifted back to “programming mode” and the first eight (8) LCD blocks will appear blacked out.

To restore control over the compressor through the RS-232 interface:

1. Turn OFF the compressor.
2. Toggle OFF the main circuit breaker.
3. Disconnect the RS-232 cable from the compressor.
4. Toggle ON the main circuit breaker.
5. Reinstall the RS-232 cable.

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

Automatic Restarting After a Helium High Temperature Shutdown Error

If a helium discharge high temperature shutdown error causes a shutdown of the system, the compressor will attempt to restart itself 5 times at 20 minute intervals before a reset signal must be provided to the compressor. A reset signal or power outage will clear the shutdown error and reset the automatic restart counter.

If the system is set for DB25 Configuration Mode 2 and a helium high temperature shutdown error occurs, the system will ignore remote (Diagnostic Interface) resets during the first 19 minutes of the 20 minute interval to prevent rapid on-off cycling of the compressor.

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
Water Temp-OK
Water Flow-OK
Motor Temp-OK
Phase Seq (sequence)-OK or Phase/Fuse-OK (v1.6 and later)
Return Press-OK
Ads Life XXXXX
DB-25 Config (switch configuration)-OK
Rtn Press (current return pressure)
Software Version
Cold Head Run (When in OFF state only)

NOTE

If software version shows “F-70 v2.4”, refer to Operating Manual P/N 267473A instead of this manual.

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 scrolled to 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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MAINTENANCE

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.

WARNING

AVOID 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.

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 cover panel. See Figure16.



Figure 16 Compressor Cover Panel Removed

4. Using two wrenches, disconnect the self-sealing coupling on the inlet side of the adsorber. See Figure 17.



Figure 17 Disconnect Self-Sealing Coupling

5. Use a Phillips screwdriver to remove the two screws holding the adsorber to the base. See Figure 18.



Figure 18 Disconnect Adsorber from Base

6. Remove the locknut on the Aeroquip supply coupling on the front panel. See Figure 19.



Figure 19 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 20.



Figure 20 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 21.



Figure 21 Install Lock Washer on Adsorber

3. Insert and tighten the screws to secure the new adsorber to the base. See Figure 22.



Figure 22 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 23.



Figure 23 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 24.



Figure 24 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 25.



Figure 25 Leak Check Aeroquip Couplings

8. Check the equalization pressure. See Specifications in the Operating Manual.
9. Reinstall the compressor's 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

Parts required: Internal fuse kit, F-70H, P/N 267127A, including
(3) Power fuses, 1.0 ampere, 600 V, class CC, P/N 34162 (FU-1, 2 and 3)
(3) Control board fuses, 0.63 ampere, 250 V, IEC Type T, P/N 34687 (FU-4, 5 and 6)

Parts required: Internal fuse kit, F-70L, P/N 267128A, including
(3) Power fuses, 2.0 ampere, 600 V, class CC, P/N 34164 (FU-1, 2 and 3)
(3) Control board fuses, 0.63 ampere, 250 V, IEC Type T, P/N 34687 (FU-4, 5 and 6)

Tool required: #2 Philips screwdriver
flathead screwdriver

 **WARNING**
AVOID ELECTRIC SHOCK. Disconnect the power to the compressor before troubleshooting the electrical components.

Three (3) Class CC time delay fuses (1.0 ampere for F-70H) FU-1, FU-2, and FU-3 are located in the electrical chassis box. See Figure 28.

Three (3) Class CC time delay fuses (2.0 ampere for F-70L) FU-1, FU-2, and FU-3 are located in the electrical chassis box. See Figure 28.

Three (3) 0.63 AT fuses, FU-4, FU-5 and FU6 are located on the printed circuit board (PCB 1) in the electrical chassis box. See Figure 28.

If the LCD display reads Phase Seq-ERR, check all fuses FU-1 through FU-6. If no phase sequence error is indicated but the diagnostic interface connection signals are behaving erratically or the compressor will not run or build pressure, check fuses FU1-FU3.

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 F-70H 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~.

2. Using a #

Figure 26 Compressor Cover and Eyebolts

3. Using a #2 Philips screwdriver, remove (6) M5 Philips pan head screws and lock washers from top and side of electrical chassis cover. Remove cover to expose electrical chassis. See Figure 27.



4. **Figure 2** Philips screwdriver, remove (15) M5 Phillips flat head screws and lock washers, along with (3) eyebolts and plain washers, from top and sides of compressor. Remove cover to expose internal components of compressor. See Figure 26.



27 Electrical Chassis

4. Locate the fuses. See Figure 28.



Fuses, FU-1, FU-2,
FU-3

PCB 1 with
Fuses, FU-4,
FU-5, FU-6

Figure 28 Fuse Locations in the Electrical Chassis

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.

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

1. Taking care not to damage fuse or printed circuit board, use flathead screwdriver to gently remove open fuse from fuse holder contact clamps.
2. Using thumb and forefinger, press new replacement fuse of same ampere rating into fuse holder.
3. Replace compressor and electrical chassis covers.

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	Temperature > 93°C (200°F)
Water Temp-ERR	Alarm	High water supply temperature.	Temperature > 35°C (95°F).
Water Flow-ERR	Alarm	Low water flow	Temperature > 46°C (115°F)
Motor Temp-ERR	Shutdown	High compressor motor winding temp (internal protector open)	Return Pressure > 140 psig while compressor is commanded on.
Phase Seq-ERR v1.6 and later: 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 System Diagnostics Connector and via the LCD Display. Signals are available on the 25-pin connector for output to an external device. See Figure 6 and Tables 1 and 2.

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 only when configuration mode is set for Mode 1. When configuration mode is set for Mode 2, errors must be cleared using the DB25 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

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. Check cooling water temperature and flow. Compare with Specifications.

If the shutdown is due to a motor high temperature, the motor winding high temperature relay will automatically reset in approximately 30 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.

<u>Problem</u>	<u>Possible Cause</u>	<u>Corrective Action</u>
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.
	Supply water temperature is too high.	Scroll LCD display. If Water Temp-ERR is indicated, supply water temperature is too high. Provide 5° C to 25° C cooling water.
	Water flow rate is inadequate.	Scroll LCD display. If Water Flow-ERR is indicated, the water flow rate is too low. Set water flow rate at 6 to 9 L/min.
	Water flow is reversed.	Refer to Compressor Checkout for correct installation of the water lines.
	Faulty gas thermistor or PCB.	Contact a Service Center.

Troubleshooting

<u>Problem</u>	<u>Possible Cause</u>	<u>Corrective Action</u>
System shutdown LCD reads Motor Temp-ERR	Compressor motor windings high temperature switch opens. Compressor motor windings have overheated.	Scroll LCD display. If Water Temp-ERR or Water Flow-ERR is indicated, cooling water is inadequate. Refer to Specifications. Consult a Service Center if the problem persists. Allow about 30 minutes for the windings to cool enough for the switch to reset.
	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.
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.

Troubleshooting

<u>Problem</u>	<u>Possible Cause</u>	<u>Corrective Action</u>
Compressor starts but shuts down later.	Insufficient coolant for the compressor.	Check the coolant flow and temperature. Refer to Specifications.
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.	Contact a Service Center to have a qualified electrical technician replace the fuse inside the electrical enclosure.
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.	Contact a Service Center to have a qualified electrical technician replace the fuse inside the electrical enclosure

Troubleshooting

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, coolant flow and temperature. Compare with Specifications.
Loss of refrigeration capacity.	Compressor malfunction.	Check input power, coolant flow and temperature, and equalization pressure. Compare with Specifications.
Compressor shuts down, LCD display is blank	FU-1, FU-2, or FU-3 fuse is blown.	Contact a Service Center to have a qualified electrical technician replace the fuse inside the electrical enclosure.
	Malfunctioning control boards.	Contact a Service Center.
Compressor is unresponsive to remote (DB-25 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 (DB-25 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.

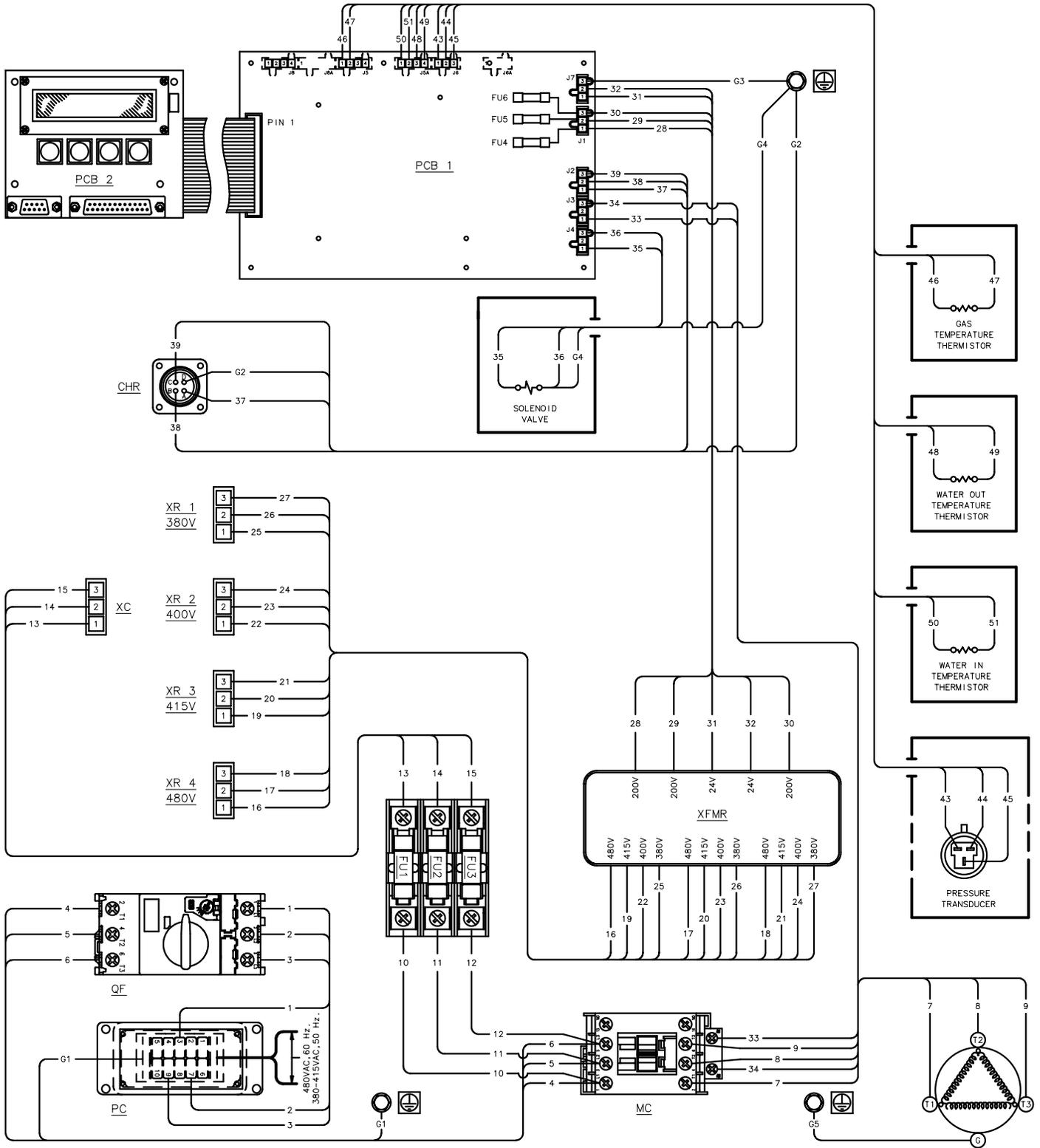


Figure 29 F-70H and F-70HP Compressors Wiring Diagram

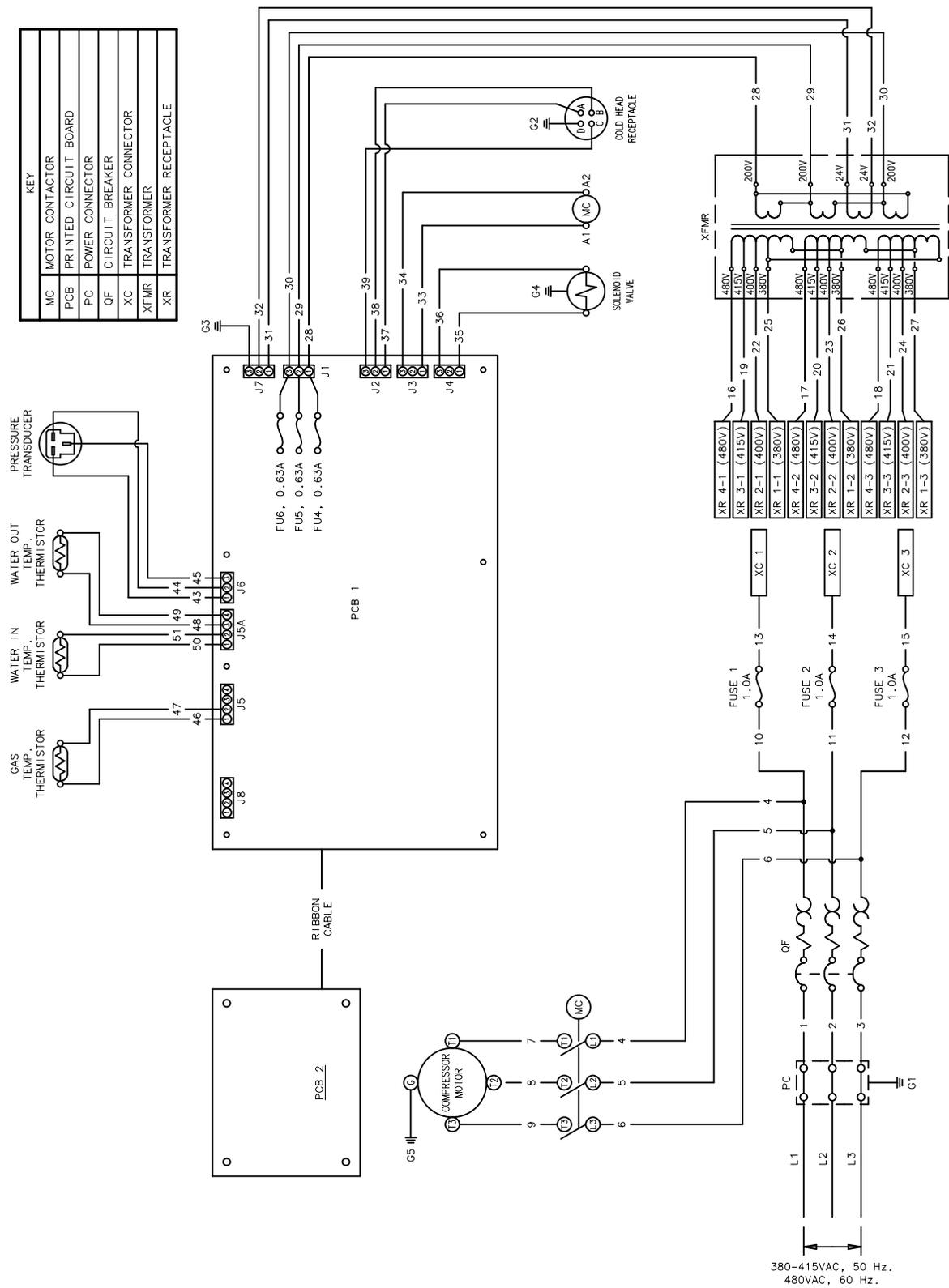


Figure 30 F-70H and F-70HP Compressors Wiring Schematic

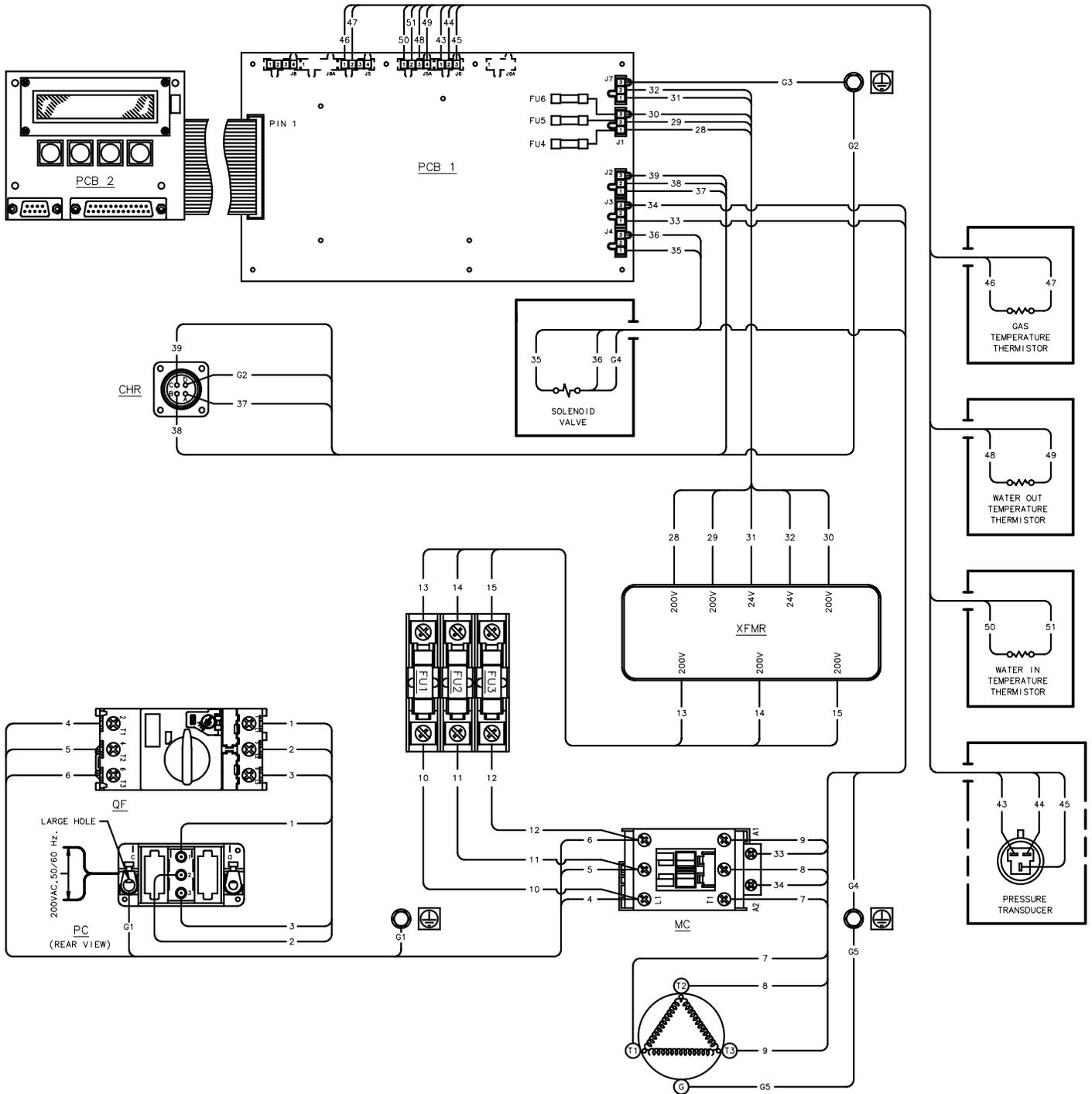


Figure 31 F-70L Compressor Wiring Diagram

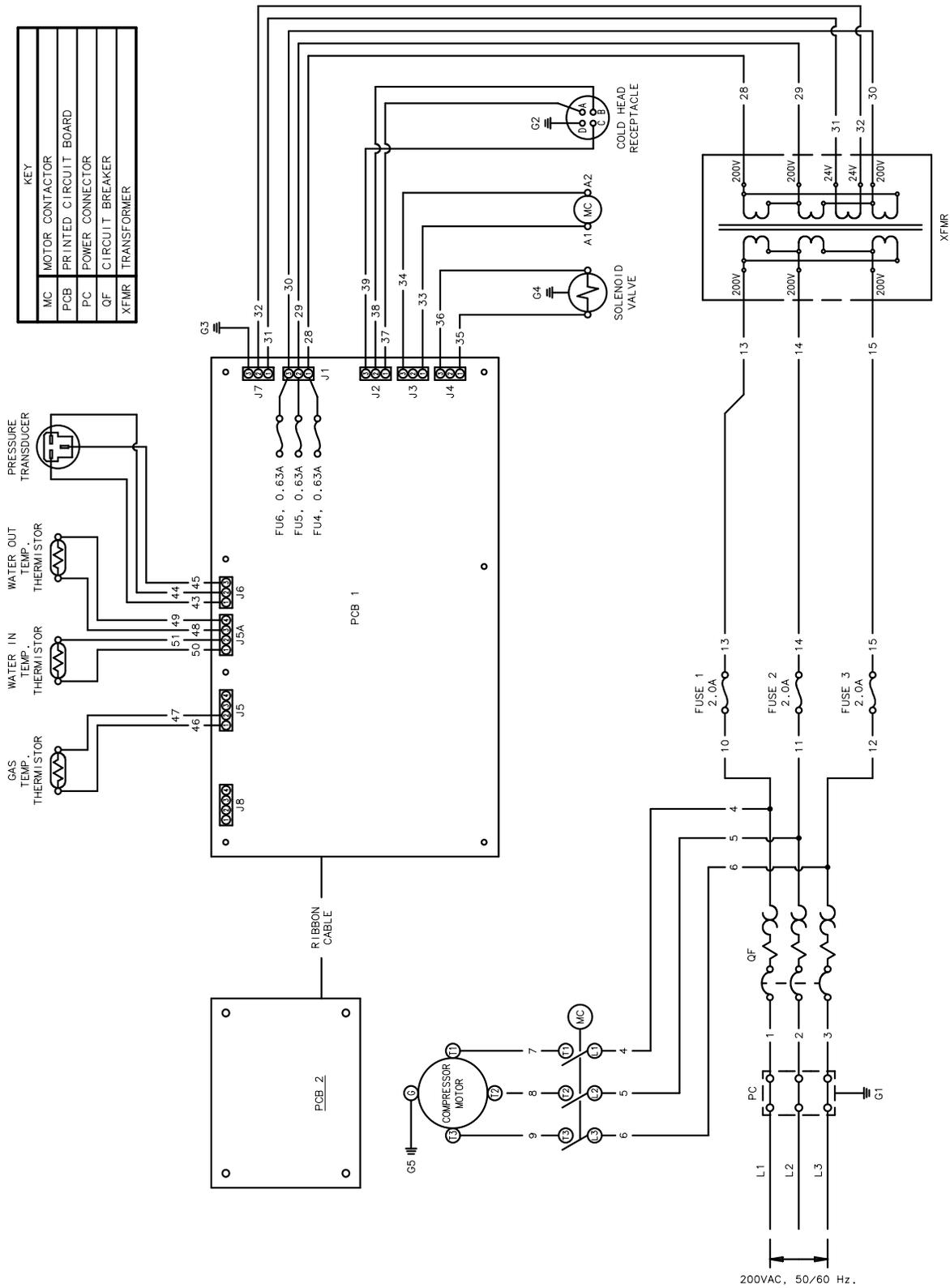


Figure 32 F-70L Compressor Wiring Schematic

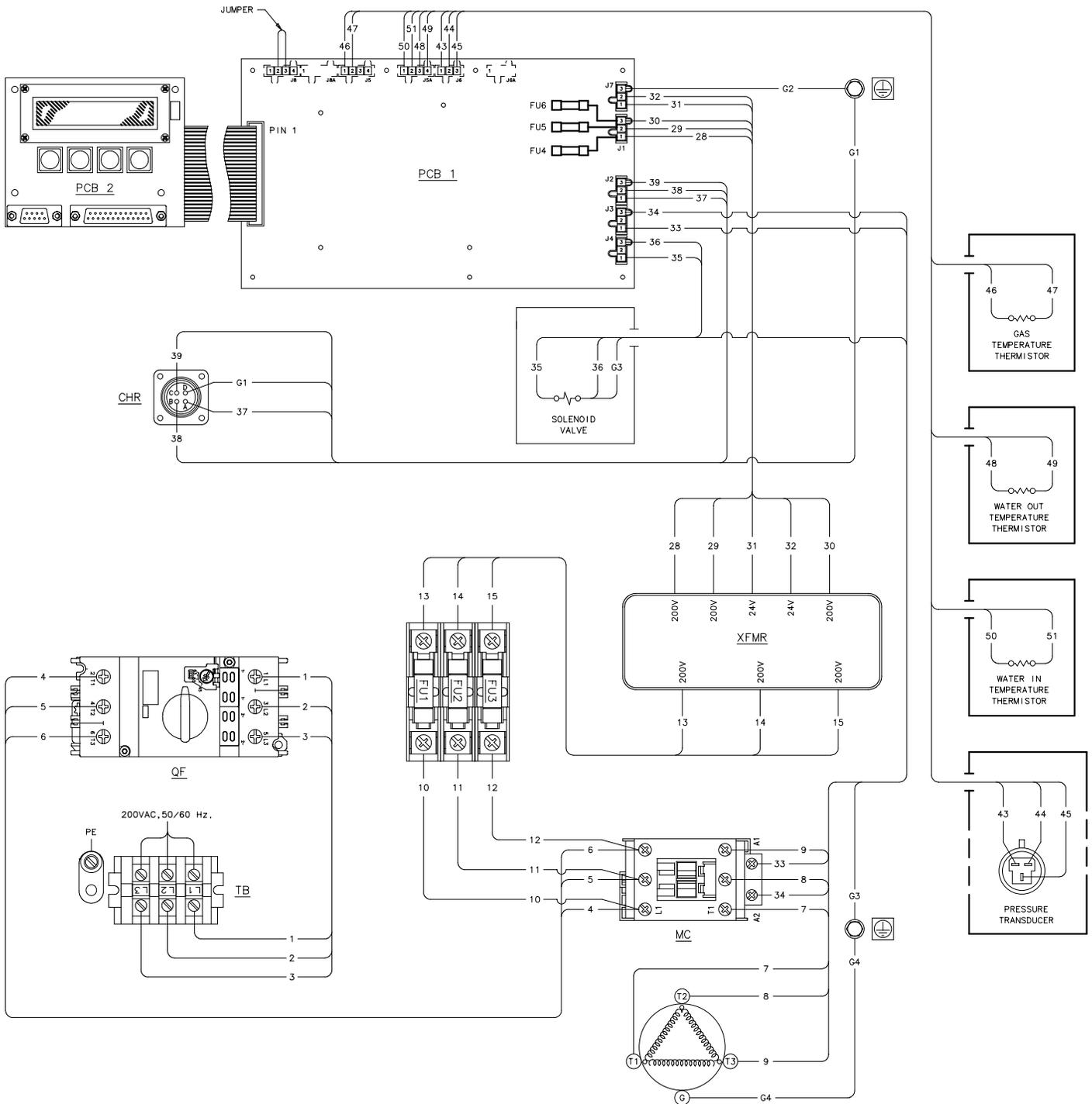


Figure 33 F-70LP Compressor Wiring Diagram

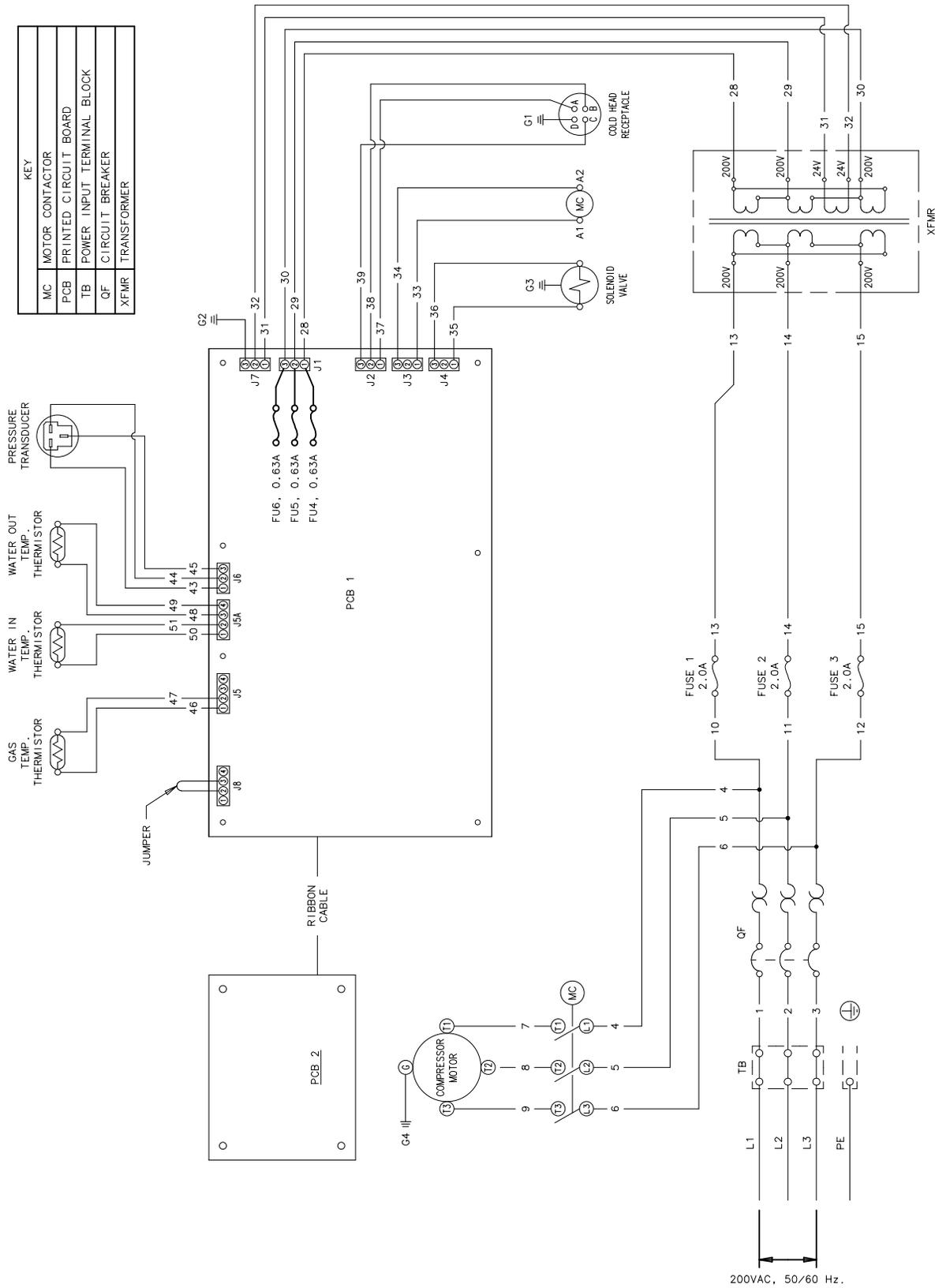


Figure 34 F-70LP Compressor Wiring Schematic

Diagnostic Interface Connector Pin Functions

<u>Pin #</u>	<u>Function</u>
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 water temp. If the temperature of the water supply to the heat exchanger is too high, this pin will carry a +24VDC, 20 mA max. signal.
15	Low water flow. If the temperature of the water 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, 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 Diagnostic Interface Connector Pin Functions, Configuration Mode 1

<u>Pin #</u>	<u>Function</u>
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 water temp. If the temperature of the water supply to the heat exchanger is too high, this pin will carry a 0 VDC, 20 mA max. signal.
19	Low water flow. If the temperature of the water leaving the heat exchanger is too high, this pin will carry a 0 VDC, 20 mA max. signal.
21	Gas temp error. On a high helium gas discharge temperature error, this pin will carry a 0 VDC, 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 Diagnostic Interface Connector Pin Functions, Configuration Mode 2

(This page is intentionally blank.)

RS232 PROTOCOL AND PINOUTS

General Information

This section describes the F-70 compressor RS232 interface only. It does not describe overall operation or safety of the F-70 compressor. Please refer to the F-70 operating manual for operating instructions and warnings. The information in this section should be used only after safe operation of the F-70 compressor is understood.

1. F-70 Front Panel Connection: Male DB-9 connector
 - Pin 2 = Receive
 - Pin 3 = Transmit
 - Pin 5 = Earth Ground (connected to compressor chassis ground)

CAUTION

ENSURE CORRECT OPERATION. Do not make connections to pins 6, 7, or 8. Signals on these pins may cause the controller to malfunction.

2. RS232 parameters.
 - a. Baud - 9600
 - b. No parity
 - c. 8 bit data
 - d. 1 bit stop
 - e. Recommended timeout: ≥ 600 msec

The F-70 sends no unsolicited messages. It only responds to commands from a host computer.

NOTE

RS232 commands that change operation of the F-70 compressor (on, off, reset, cold head run, cold head pause and pause off) have equal value as front panel key press control. The F-70 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 (DB25) control element and an RS232 control element except:

1. RS232 commands that change operation of the F-70 compressor are active only when the compressor is set for DB25 Configuration Mode 1 (reference operating manual). RS232 commands that transmit data are active for both DB25 Configuration Mode 1 and Mode 2.
2. In Configuration Mode 1, active DB25 operating signals will take priority over front panel key press and RS232 control. DB25 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 \$TE_n: Read temperature n (n = 1, 2, 3, or 4)
 - \$PRA: Read all pressures \$PR_n: Read pressure n (n = 1 or 2)
 - \$STA: Read status bits \$ID1: Read firmware version and elapsed operating hours

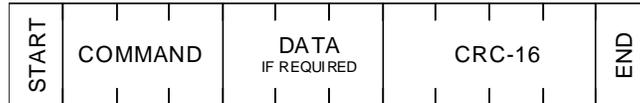
2. Operating Commands
 - \$ON1: On \$OFF: Off
 - \$RS1: Reset \$CHR: Cold head run
 - \$CHP: Cold head pause \$POF: Cold head pause off

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 F-70 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 F-70 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 = Water outlet temperature
 T3 = Water inlet temperature
 T4 is inactive (returns "000") for most F-70 variants.

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

Example: \$TEA,086,040,031,000,3798<cr> corresponding to T1 = 86°C, T2 = 40°C, T3 = 31°C 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°C 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 F-70 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 DB25 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 = Water Flow alarm. 0 = no alarm.

Bit 4 - 1 = Water Temperature 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") for most F-series compressors, 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, DB25 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);
}

```

F-70 Compressors in Parallel Tandem Configuration



Note: Compressors connected together in parallel by gas manifold must be turned on and off approximately together to prevent unwanted oil migration or gas line and cold head oil contamination.

Caution: Prevent Equipment Damage. Only use tandem part number compressors in a tandem system. Tandem compressors have special firmware and must be connected through a tandem interlock cable. Unless tandem compressors are interlocked, oil contamination and equipment damage will occur.

Caution: Preserve your warranty. Only use tandem part number compressors in a tandem system.

Tandem System Configuration:

Certain Sumitomo cold heads specify the use of parallel tandem F-70 compressors. A tandem system consists of two specially programmed compressors, an interlock control cable, and gas lines and manifolds connecting the helium flow in parallel arrangement. Please refer to the appropriate cold head manual for the installation configuration. Please contact [Sumitomo Sales] for component part number information.

Receipt Inspection: Follow the receipt inspection instructions found in previous sections of this manual

Installation:

Electrical power: Each F-70 compressor in a tandem system shall be connected to an electrical power supply circuit as an individual compressor as specified and instructed in previous sections of this manual and according to each compressor's power requirement label. For F-70H and F-70HP models, ensure the transformer tap connections are properly selected as previously described.

Coolant: Supply cooling water or coolant to each compressor as specified in previous sections of this manual.

Note: Parallel coolant connections are recommended as serial connection may result in out-of-specification coolant supply.

Interlock cable: Refer to the appropriate cold head manual for tandem interlock cable installed configuration. Securely connect the tandem interlock cable to the DB25 Diagnostic Interface connection of each compressor.

Checkout: Once the compressors are supplied with electrical power and coolant and connected by the interlock cable, they may be operated as described in the Compressor Checkout section of this manual. There is no need to connect gas lines at this time. As part of checkout, confirm tandem interlock by using one compressor to turn on both compressors and using one compressor to turn off both compressors.

Note: A compressor programmed for tandem operation will not operate individually. The interlock cable must be installed and both compressors operated together.

Gas lines and manifolds: After checkout has been successfully completed, gas lines and manifolds may be installed. Refer to the appropriate cold head manual for manifold and gas line installed configuration. Make gas line and manifold coupling connections as described in previous sections of this manual.

Cold head cable: Refer to the appropriate cold head manual for cold head cable installed configuration. Make cable connections as described in previous sections of this manual.

Diagnostic Interface Connection: If using Diagnostic Interface Control, this control is available for the tandem system when using an interlock cable having a diagnostic interface tap connection. Securely connect a control cable providing the necessary operating signals to the Dsub25 tap connection.

Serial (RS232) Connection: If using serial control, securely connect a cable providing the signals described in the RS232 section of this manual to each compressor individually. See below for further information. Observe the caution in the RS232 section to make no connections to pins 6, 7, or 8.

Control configuration: (Mode 1): Tandem compressor systems are only available with mode 1 diagnostic interface configuration. See the Compressor Control Preparation section of this manual for more information on mode 1 configuration.

Operation: Operation is as described in the Operation section of this manual for Configuration Mode 1 with the following additional clarifications:

- The front panel buttons of either compressor are able to turn the tandem system on or off. Each compressor's LCD display information applies only to that individual compressor. For Cold Head Only run, control the compressor connected to the cold head.
- Diagnostic Interface control and information has the following characteristics:
 - Each compressor's front panel Diagnostic Interface connection has pins 5 and 11 active in mode 1 for interlock control. These pins communicate the on/off status to the other compressor and are not connected to the interlock cable tap connector.
 - The interlock cable diagnostic interface tap connection is part of the interlock cable and has the following characteristics:
 - 24V DC power (pin 25) comes only from the compressor near the tap connection (that compressor connected to that end of the tandem interlock cable also having the tap connector).
 - 0VDC (pin 24) is connected in common to both compressors
 - Remote control On/Off (for mode 2 operation), pins 7 and 8, are not connected

- Reset and Cold Head Pause signals are common to both compressors. Combined current draw is approximately 3 mA. Signals affect both compressors simultaneously.
 - The System ON/OFF signal (pin 6) controls the tandem system by controlling the compressor near the tap connection, which in turn controls the other compressor. The pin 6 connection is not common to both compressor. The compressor under pin 6 control (the near compressor) is in remote mode and unresponsive to the front panel off button. The other compressor is in local mode and is responsive to the front panel off button (see Fault Behavior below.)
 - The Run status signal (pin 19) reports the run status of the tandem system by reporting the status of the compressor near the tap connection. The pin 19 connection is not common to both compressors
 - The compressor return pressure analog signal reports the pressure of the compressor near the tap connector. The analog pressure connection is not common to both compressors.
 - The warning and error signals (pins 14, 15, 16, 17, 18, and 20) show a warning or error from either compressor. These pins are connected in common to both compressors
- RS232 control may be used for the tandem system by commanding each compressor individually.
 - On/Off control for the tandem system can be accomplished by sending the on or off command to either compressor. There is no need to send to both.
 - Reset command will only control the individual compressor receiving the command.
 - RS232 Cold Head Pause On/Off and Cold Head Run commands will only control the individual compressor receiving the commands. Ensure the RS232 connection and commands control the compressor connected to the cold head.
 - Status, ID, read temperature, and read pressure commands only control the individual compressor receiving the commands.

Note: When the tandem system is turned on from one compressor, there is an approximate 2-second delay before the other compressor turns on. This delay purposefully staggers the in-rush current for each compressor. When first starting the tandem system from one compressor, if the second compressor fails to start or starts and immediately stops, there is an approximate 5-second delay before the first compressor shuts down.

Fault Behavior

- Automatic restart 20 minutes after a helium discharge high temperature fault is disabled.
- When a water temperature or flow warning occurs in either compressor, the appropriate diagnostic interface signal at the tap connection will become active. The display for the affected compressor(s) will show the error condition.
- When on front panel button or RS232 control, a fault causing a shutdown will cause the tandem system to turn off. The compressor(s) experiencing the fault will be in fault mode, will display and log the error information, and will require a reset. If the other

compressor did not experience the fault, no reset is required for this compressor. After correcting the problem, provide a reset to the affected compressor(s).

- When on Diagnostic Interface control (pin 6 run signal) a fault causing a shutdown will cause the tandem system to turn off in fault mode. The affected compressor will display and log the error information. If the affected compressor is other than the compressor receiving the pin 6 signal, the compressor receiving the pin 6 signal will only log Tandem error and display no error. After correcting the problem, a reset is required before the system will properly respond to a pin 6 run signal. Similarly, shutting off the compressor not receiving the pin 6 signal will cause a Tandem error and shutdown in the compressor receiving the pin 6 signal. A reset is required before the system will properly respond to a pin 6 run signal.

Reset Behavior (see Clearing Error Conditions section of this manual)

- Front panel display button combination or power cycle: Each compressor must be reset individually
- RS232 reset command: Each compressor must be reset individually
- Diagnostic Interface (Pin 3 at tandem interlock cable tap connection): momentary reset signal resets both compressors simultaneously.