Brooks Automation
CTI-Cryogenics
8200 Compressor
Installation, Operation, and Service Instructions

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1 Introduction

Overview

This chapter describes this manual and the compressor, including specifications.

Chapter Contents

General

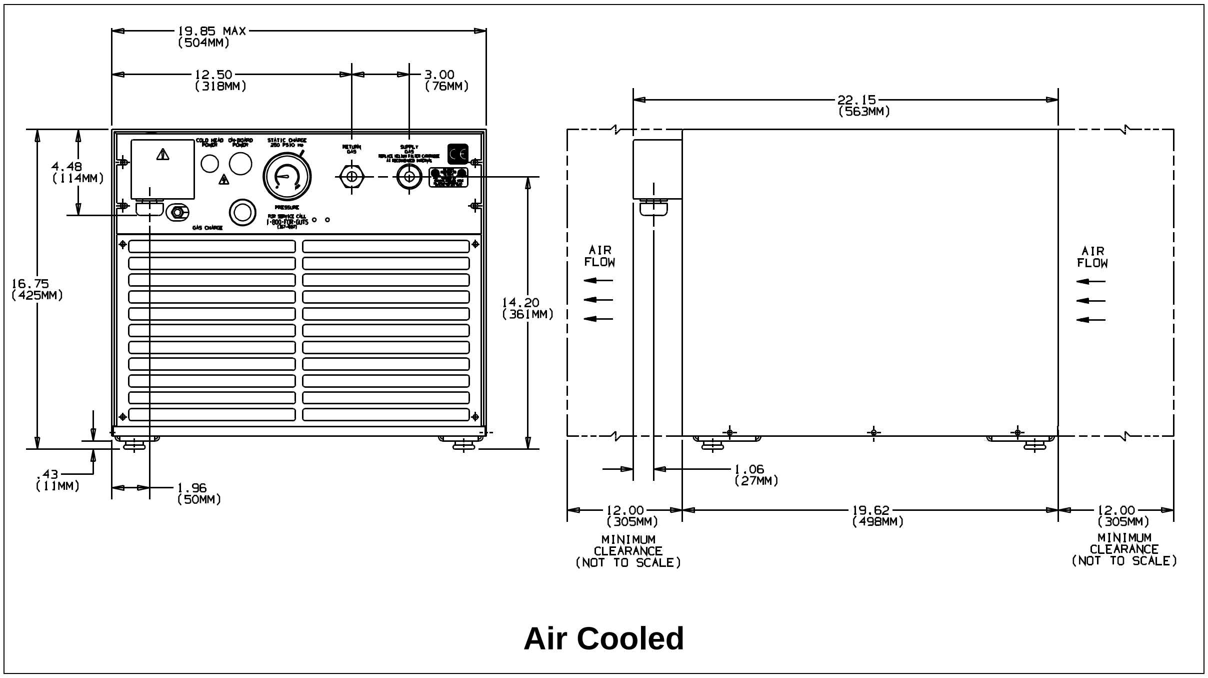
The manual provides instructions for installing, operating and servicing the 8200 Compressor. This compressor is available in two versions: air-cooled, part number 8032549G001/G002 and water cooled, part number 803255G001/G002.

If you are installing or operating a Cryo-Torr or On-Board System you should also have available the appropriate cryopump or refrigerator.

When you purchase a system, you will receive two manuals necessary for system installation.

Installation, Operation and Servicing Instructions

Installation, Operation and Servicing Instructions for your 8200 Compressor provide easily accessible information. All personnel with installation, operation, and servicing responsibilities should become familiar with the contents of these instructions to ensure high quality, safe, reliable performance.



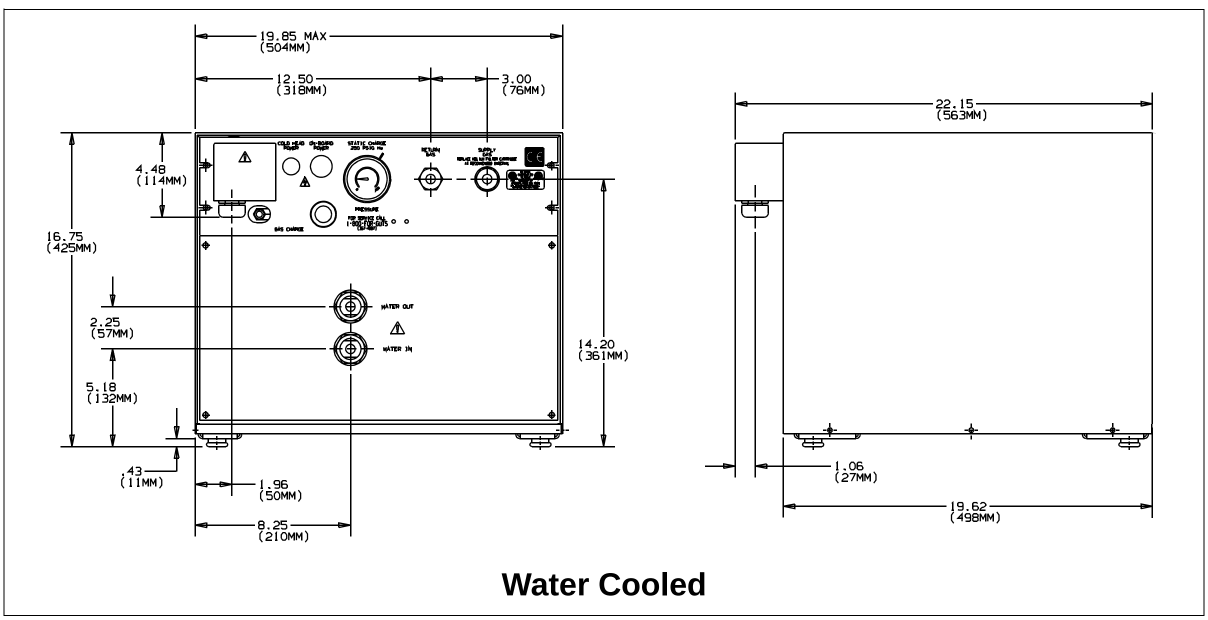
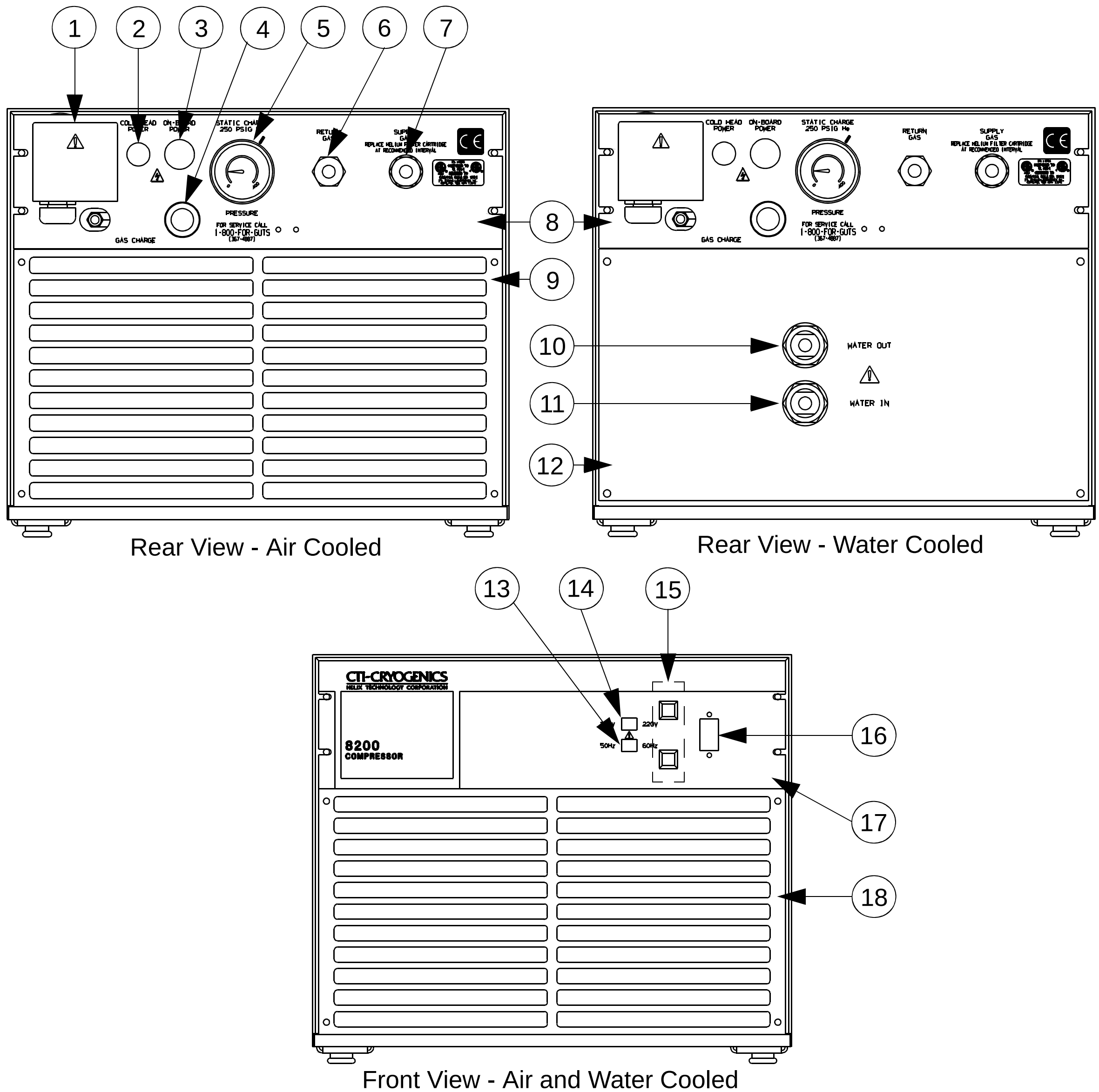


Figure 1-1: Air and Water Cooled 8200 Compressor Dimensions



LEGEND

1. Compressor Input Power Block
2. Cold Head Power Receptacle
3. On-Board Power Receptacle
4. Helium Gas Fitting and Charge Valve
5. Helium Supply Pressure Gauge
6. Helium Gas Return Connector
10. Cooling Water Output
11. Cooling Water Input
12. Rear Plate
13. 50/60 Hz Frequency Selector Switch
14. 208/220 Voltage Range Selector Switch
15. Resettable Circuit Breakers

Figure 1-2: Component Locations

Table 1-1: Power Requirements (Steady-State Conditions)

Part Number	Cooling	Phase	Hz	Operating Voltage Range	Nominal Operating Current	Rated Full Load/Locked Current
8032549G001	Air Air	3 3	50 60	180-220 198-250	10A 10A	12/30A
8032549G002	Air Air	1 1	50 60	180-220 198-250	10A 10A	12/30A
8032550G001	Water Water	3 3	50 60	180-220 198-250	8.5A 8.5A	12/30A
8032550G002	Water Water	1 1	50 60	180-220 198-250	8.5A 8.5A	12/30A
*See the nameplate on the back of the compressor for more details.						

Table 1-2: General Specifications

Specification	Description
Weight	150 lbs (68 kg) max.
Weight (shipping)	155 lbs (70 kg) max.
Power consumption	2.0 kw, nominal operating(water), 2.1 kw nominal operating (air)
Compressor input-power cable (customer-supplied)	Recommended type SO-4 conductor, 600V, neoprene jacket and 14-gauge wire. Install per Appendix C: Electrical Schematics for 8200 Compressor on page 6-7, Electrical Schematic diagram, ensuring compliance with all national, state and local standards.
Helium pressure	Static: 245-255 psig (1688-1757 kPa) at 70 to 80°F (21 to 27°C) Supply: nominal operation: 270-290 psig (1860-2000 kPa) at operating temperature.
Ambient operating temperature range	50 to 100°F (10 to 38°C)

Table 1-2: General Specifications (Continued)

Specification	Description
Interface	Cold head power receptacle: Mates with plug on cold head power cable. On-Board power receptacle: Mates with plug on cold-head power cable. Compressor input-power terminal block enclosure: Mates with input power cable, fabricated by customer or available from CTI-Cryogenics. Gas-supply connector: 1/2-inch self-sealing coupling Gas-return connector: 1/2-inch self-sealing coupling
Adsorber service schedule	Replace every 12 months.
Cooling water requirements (water cooled only)	100°F (38°C) maximum discharge temperature Refer to Table 1-1 on page 1-5, Figure 1-1 on page 1-3, and Figure 1-2 on page 1-4, for parameters.

2 Safety

Overview

This section describes safety conventions for the Brooks Automation Product. All personnel involved in the operation or maintenance of the product must be familiar with the safety precautions outlined in this section.

NOTE: *These safety recommendations are basic guidelines. If the facility where the Product is installed has additional safety guidelines they should be followed as well, along with the applicable national and international safety codes.*

Chapter Contents

Introduction

Follow all safety precautions during installation, normal operation, and when servicing CTI-Cryogenics products.

This chapter explains the safety conventions used throughout this manual. CTI-Cryogenics uses a specific format for cautions and warnings, which includes standard signal words and safety shapes.

See also the *Customer Support* appendix or call your local Customer Support Center for assistance.

Signal Word Descriptions

All cautions and warnings contain signal words, which call attention to safety messages and designate the degree of hazard seriousness. The following table shows the signal words and their meanings that may be used in this document.

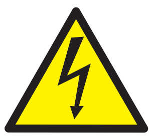
Table 2-1: Safety Signal Words

Term	Example	Definition
CAUTION	**CAUTION**	A signal word that indicates a situation or unsafe practice, which if not avoided may result in **equipment damage**. A CAUTION is highlighted in yellow.
CAUTION	**⚠ CAUTION**	A signal word accompanied by a safety shape that indicates a potentially hazardous situation or unsafe practice. If not avoided, the action may result in **minor or moderate personal injury or equipment damage**. A CAUTION is highlighted in yellow.
WARNING	**⚠ WARNING**	A signal word accompanied by a safety shape that indicates indicates a potentially hazardous situation. If not avoided, the action may result in **serious injury or death**. A WARNING is highlighted in orange.

Safety Shape Descriptions

All cautions and warnings contain safety shapes, which have specific safety meanings. The following table shows some of the safety shapes used in this document and their meanings.

Table 2-2: Safety Shapes

Example	Term	Shape Definition
	General Warning	Indicates a general hazard. Details about this hazard appear in the safety notice explanation.
	High Voltage	Indicates a high voltage hazard.
	Hot Surface	Indicates a surface is hot enough to cause discomfort or a burn.

References

For more information about safety standards, see the following documents:

- ISO 7010: 2003(E), Graphic symbols - Safety colours and safety signs - Safety signs used in workplaces and public areas
- ISO 3864-1: 2002(E), Graphic symbols - Safety colours and safety signs - Part 1: Design principles for safety signs in workplaces and public areas

3 Inspection

Overview

This chapter details unpacking the compressor.

A High-Vacuum Pump or Refrigerator System is packaged in separate cartons for each major component. An Installation, Operation, and Servicing Manual is included in the carton for the component packaged in that carton.

Chapter Contents

The Compressor

On receipt, remove the 8200 Compressor from its shipping carton and inspect the compressor for evidence of damage as described in this Section.

1. Unpack and remove the compressor from its shipping carton.

2. Check the carton contents. It should contain:

   a. 8200 Compressor (air cooled or water cooled).

   b. Compressor Manual part number 8040353.

3. After unpacking, inspect the compressor for evidence of damage as follows:

   c. Inspect the compressor overall exterior for damage.

   d. Report damage to the shipper at once.

   e. Retain shipping cartons for storage or return shipment.

   When installing your system, CTI recommends that as you unpack a component, you perform an inspection and the necessary tasks for system installation for the component according to the manual included with the component. Final system installation and operation will be performed following procedures in the high-vacuum pump or refrigerator manual.

4. Check the helium pressure gauge. The gauge should indicate 250 psig (1725 kPa) minimum at 70°F. If additional gas pressure is required, follow the instructions in Helium Circuit Decontamination on page 5-9.

4 Installation

Overview

This chapter provides complete installation procedures for the Brooks Automation Product.

Chapter Contents

Compressor Installation

Installation of your compressor requires no special tools other than those supplied in the Installation and Scheduled Maintenance Tool Kit.

Preparing the Compressor Input-Power Cable

To supply input power to the 8200 compressor requires the fabrication of a 600-volt power cable that has an SO-4 conductor, 600-volt rating neoprene jacket and 14-gauge or 2.3 mm^2 wire.

Unit must be wired by an authorized electrician in accordance with the national Electrical Code, ANSI/NFPA 70-1987, as well as the local codes. This shall include installation of a readily accessible disconnect device into the fixed wiring supplying power.

An insulated earthing conductor that is identical in size, insulation material and thickness to the earth and unearth branch circuit supply conductors, except that it is green with or without one or more yellow stripes is to be installed as part of the branch circuit which supplies the unit or system. The earthing conductor described is to be connected to the earth at the service equipment, or supplied by a separately derived system at the supply transformer or generator.

Proceed as follows:

⚠WARNING

High Voltage

High voltage electric shock could cause severe injury or loss of life.

Do not connect the compressor to the power source at this time. Complete the preparation and panel reinstallation before electrically connecting the compressor.

1. Prepare the input power cable by terminating each of the four conductors with a #10 ring terminal. Follow the terminal manufacturer's instructions to insure proper crimping.

2. Disassemble the electrical terminal enclosure cover, mounted on the compressor rear panel, as shown in Figure 4-1 on page 4-4. Remove the two screws securing the cover and lift it off.

3. If necessary, back off strain relief screws.

4. Thread input power cable end up through the strain relief into the enclosure.

5. Attach the power conductors onto the appropriate terminals of the terminal block.

    a. For three-phase hookups, attach the three power leads to terminals X, Y and Z.

    b. For single-phase hookups, attach the two power leads to terminals X and Y. DO NOT USE TERMINAL Z.

6. Tighten all terminals to 18-22 in.-lbs. torque.

7. Tighten down screws on strain relief.

CAUTION

Equipment Damage

To avoid damaging the power cable, ensure that strain relief is tightened down on the outer insulation of the input power cable, and that the cable does not slide.

8. Remount the terminal enclosure cover and secure with two screws.

9. Refer to Final Preparation of Compressor on page 4-8 for correct phasing checkout procedure.

WARNING

High Voltage

High voltage electric shock could cause severe injury or loss of life.

Ensure that the ground wire is grounded and uninterrupted.

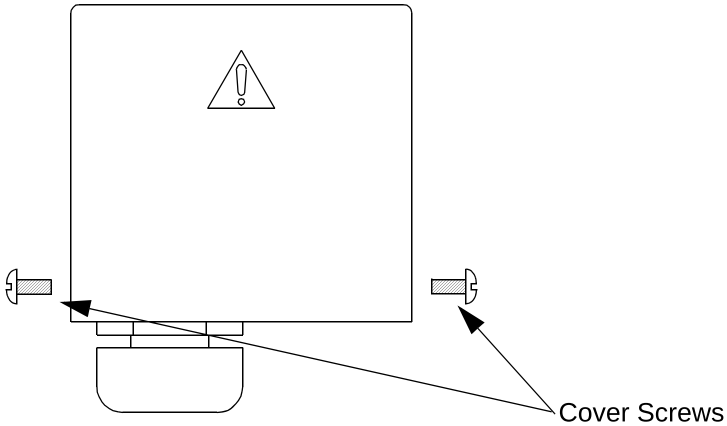


Figure 4-1: Electrical Terminal Enclosure with Cover in Place

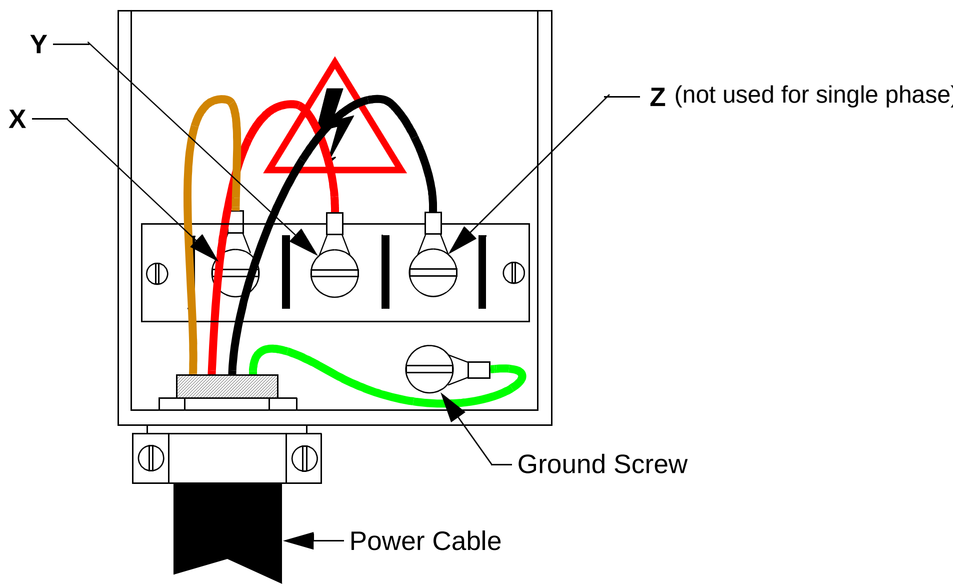


Figure 4-2: Assembly of Conductors to Terminal Block

Cooling Water Requirements (Water-Cooled Compressors Only)

If flexible water hose connections are used, install the barbed fittings supplied with the compressor on the input and output connections:

1. Apply a light coating of standard plumbing thread sealant on the barbed fitting threads.

2. Tighten fittings on 1/2-inch FPT input and 1/2-inch FPT output connections. DO NOT OVERTIGHTEN.

3. Connect flexible hoses to the fittings and secure with hose clamps.

   If hard piping is desired, install the water lines directly onto the compressor 1/2-inch FPT input and output connections. DO NOT OVERTIGHTEN.

CAUTION

Equipment Damage

To avoid damaging adjacent equipment, check water connections for leaks.

Cooling Water: General Considerations

- Cooling water must meet flow and pressure requirements. See Cooling Water: Flow and Pressure Requirements on page 4-6.
- To conserve water, the shut off the cooling water when the compressor is not running.

NOTE: *If cooling water below 45°F (7°C) runs through the compressor while the compressor is not operating, the compressor oil will change viscosity and thicken, causing the compressorto overheat and shut off at startup. In this event, repeatedly restart the compressor, allowing it to run until it has shut off several times. The oil temperature will rise and then the compressor will run continuously.*

- Drain and purge water from the compressor before shipping it back to the factory or subjecting it to freezing conditions. Purge water from the compressor by blowing compressed air, regulated between 30 to 40 psig (200 to 275 kPa) into the compressor output connection, and allow water to exit from the water input connection.

Table 4-1: Cooling Water Specifications

Parameter	Value
Maximum Inlet Temperature	90°F (32°C)
Minimum Inlet Temperature	50°F (10°C)
Flow Rate	1.0±0.5 gpm (3.8±1.9 lpm)
Pressure Drop (inlet-to-outlet)	approximately 3.5 psig differential
Min. / max. Inlet Presure	5 to 100 psi (6.9 bars)
Alkalinity	7.0 - 8.7 pH
Calcium Carbonate	<75 ppm
Resistivity	<100k Ohm - cm
NOTE: *Water conditioning may be required for applications not meeting these requirements. Additional parameters appear in Appendix F: Additional Cooling Water Quality Parameters on page 6-15.*	

Cooling Water: Flow and Pressure Requirements

Use Figure 4-1 on page 4-4 and Figure 4-4 on page 4-7 to determine the minimum acceptable cooling water supply pressure at different flow rates and temperatures

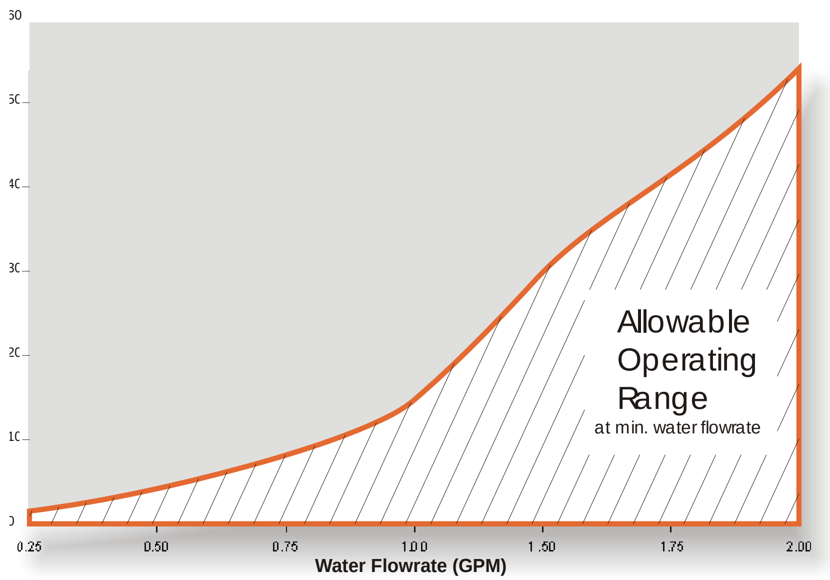


Figure 4-3: 8200 Compressor Cooling Water Flow and Pressure Requirements

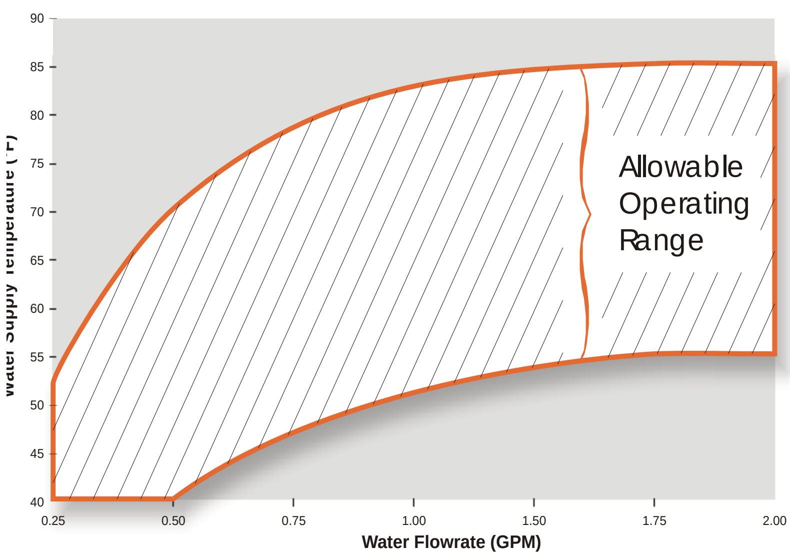


Figure 4-4: 8200 Compressor Water Cooling Requirements

Cooling Water: Heat Load and Temperature Rise

Heat load to facility water is approximately 5000 Btu/hr, or 1500 Watts. With a 1.0 GPM water flow this translates to an approximate water temperature rise of 10ºF (5.6ºC)

Final Preparation of Compressor

1. Using a voltmeter, measure the phase-to-phase voltage from the power source. Compare this voltage to Table 4-1 and position the voltage range selector switch to the “208V” or “220V” position as required. Also, set the frequency selector switch to the 50 Hz or 60 Hz position, as appropriate. See Figure 1-2 on page 1-4 for location of selector switches.

Table 4-1: Voltage Specifications

Operating Voltage Range 60 Hz	50 Hz	Voltage Adjustment Switch S1 Position
198-212	180-212	208V
213-250	213-220	220V

2. Ensure that water is turned on for the water-cooled compressor.

3. Set the compressor ON/OFF switch (3) to OFF. Connect the input-power cable to the power source Refer to Table 1-1 on page 1-5, for electrical power requirements.

4. Turn the compressor switch to the ON position and allow the compressor to run for 15 minutes to stabilize the oil circuit. Make sure that the compressor fan operates freely in the air-cooled compressor.

5. Switch off the compressor and disconnect the input-power cable.

6. Install the compressor in its permanent location on a level surface. Air cooled units must have a minimum clearance of 12 inches at the front and back for adequate airflow.

Connecting the Compressor to the Cold Head

Make the connections between the cryopump and compressor. See Figure 4-5 on page 4-10.

1. Remove dust plugs and caps from the supply fittings and return lines, compressor, and cold head. Check all fittings.

2. Connect the helium-gas return line from the gas-return connector on the rear of the compressor to the gas-return connector on the cold head.

3. Connect the helium-gas supply line from the gas-supply connector on the rear of the compressor to the gas-supply connector on the cold head.

4. Attach the supply and return line identification decals (CTI-Cryogenics supplied) to their respective connecting piping ends.

5. Verify proper helium supply static pressure by confirming that the helium pressure gauge reads 245-250 psig (1690-1725 kPa), in an ambient temperature range of 60 to 100°F (16 to 38°C).

NOTE: *To ensure the compressor continues to perform optimally, do not run it unless it is connected to a cryopump or waterpump.*

If the indicated pressure is higher than 250 psig (1725 kPa), reduce the pressure as follows:

a. Remove the flare cap from the gas charge fitting located on the rear of the compressor.

b. Open the gas charge valve very slowly. Allow a slight amount of helium gas to escape until the helium pressure gauge reads 250 psig (1725 kPa).

c. Close the gas charge valve and reinstall the flare cap.

If the indicated pressure is lower than 245 psig (1690 kPa), add helium gas as described in Helium Circuit Decontamination on page 5-9.

	WARNING **High Voltage** High voltage electric shock could cause severe injury or loss of life. Before you make any electrical connections, turn off the compressor with the ON/OFF power switch on the front of the compressor.

6. Make the following electrical connections.

   a. Connect the cold head power cable to the rear panel of the compressor and the other end to the electrical power connector on the high-vacuum pump cold head.

   b. Connect the compressor input power cable to the power source.

   c. Turn on compressor.

   d. Your system is now ready for operation.

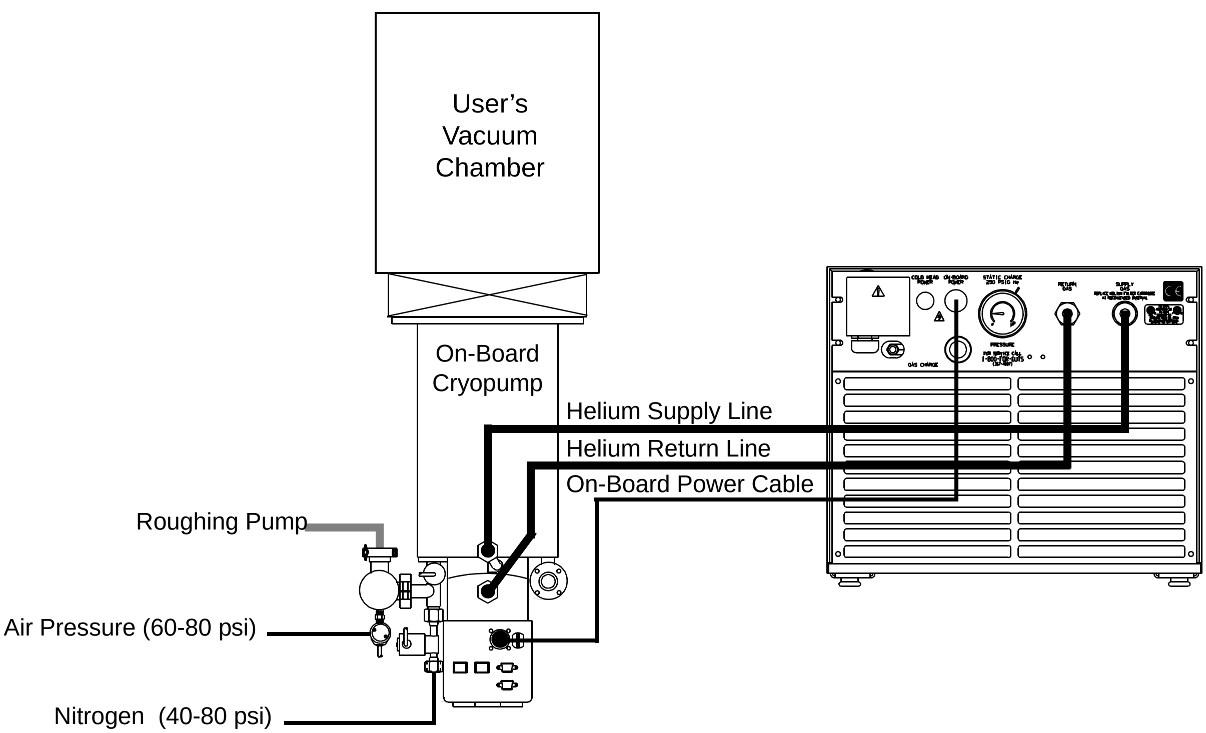


Figure 4-5: Typical 8200 Compressor Installation

5 Maintenance Procedures

Overview

This chapter provides complete maintenance procedures for the Brooks Automation Product.

Chapter Contents

Scheduled Maintenance

The only scheduled maintenance required on the 8200 Compressor is replacement of the compressor adsorber (part number 8080255K001) every 12 months.

WARNING

High Voltage

High voltage electric shock could cause severe injury or loss of life.

Always disconnect the compressor from all sources of electrical power before performing any maintenance procedures.

Removing the Compressor Adsorber

1. Shut down the compressor.
2. Disconnect the compressor input power cable from its electrical power source.
3. Disconnect the flex lines from the gas-return and gas-supply connectors at the rear of the compressor.
4. Remove the screws holding the compressor rear grille, rear panel, front panel and cover (Figure 1-2 on page 1-4). Front and rear panels remain in place.
5. Use the two wrenches (supplied) to avoid loosening the body of the coupling from its adapter.
6. Unscrew the two self-sealing coupling halves quickly to minimize gas leakage as shown in Figure 5-2 on page 5-3.
7. Disconnect the adsorber-inlet self-sealing coupling as shown in Figure 5-2 on page 5-3.
8. Remove the bolts, nuts, and washers that secure the adsorber to the base of the compressor. Save all nuts, bolts, and washers for installing the replacement adsorber.
9. Carefully lift the adsorber inward until the outlet self-sealing coupling clears the rear panel and remove the adsorber as shown in Figure 5-3 on page 5-4.
10. Remove the adsorber from the compressor as shown in Figure 5-2 on page 5-3.

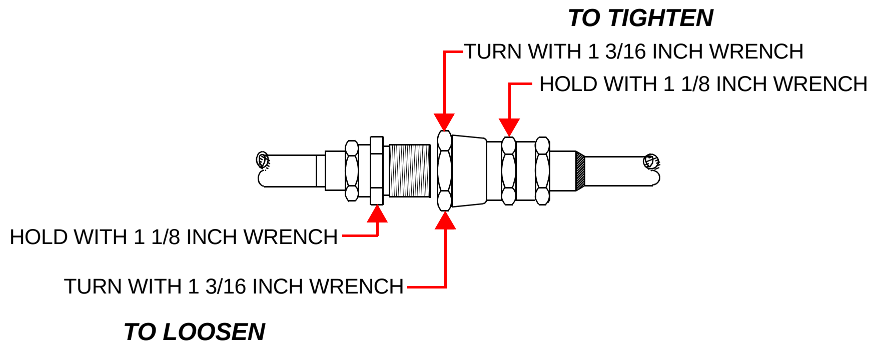


Figure 5-1: Adjusting the Self-Sealing Connectors

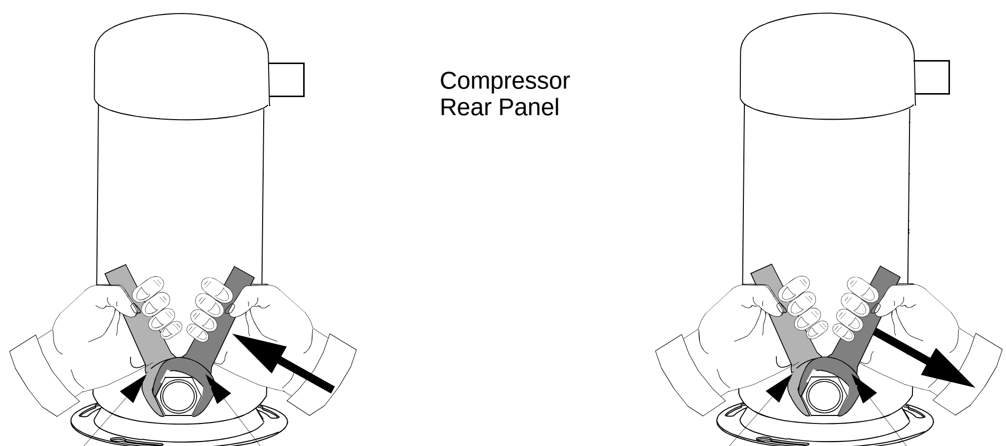


Figure 5-2: Disconnecting/Connecting the Adsorber Self-Sealing Coupling

CAUTION

Explosive Pressure

High pressure explosions could cause severe injury and equipment damage. Appropriately depressurize the adsorber before disposing of it.

To depressurize the adsorber, attach the depressurization fitting (included in the *Installation and Scheduled Maintenance Tool Kit*) to the coupling half at either end of the adsorber and tighten it slowly.

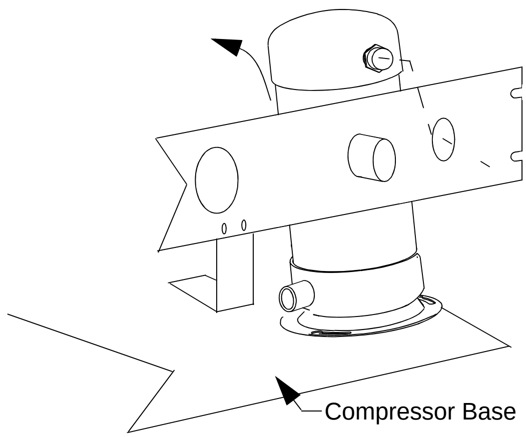


Figure 5-3: Removing the Adsorber from the Compressor

Installing the Compressor Adsorber

1. Install the replacement adsorber as follows:

    a. Remove the dust caps from the self-sealing coupling halves at each end of the replacement adsorber.

    b. Write installation date on the adsorber decal.

    c. Install the replacement adsorber following the steps for compressor adsorber removal in reverse order. Use the hardware saved in Step 5 on Page 5-2.

2. Connect the adsorber to the compressor internal piping. Refer to Figure 5-2 on page 5-3.

a. Check the self-sealing connector flat rubber gasket to make sure that it is clean and properly positioned.

CAUTION

Equipment Damage

To avoid damaging equipment, ensure you hold the left coupling nut while tightening the right coupling nut, as shown in Figure 5-2 on page 5-3 and Figure 5-1 on page 5-3.

b. Make the first turns by hand and then firmly seal the connection using the two wrenches until the fittings "bottom." Refer to Figure 5-2 on page 5-3 and Figure 5-1 on page 5-3, for proper coupling of the self-sealing connection

3. Replace the cover and the front and rear grilles and secure them

4. Ensure that the pressure gauge reads 245-250 psig (1690-1725 kPa). If additional gas pressure is required, follow the instructions in Adding Helium Gas on page 5-6.

5. Reconnect the return and supply flex lines to the compressor.

6. Connect the compressor input power cable to the electrical power source.

Unscheduled Maintenance

Suggested Unscheduled Maintenance Equipment

It is advisable to keep on hand the unscheduled maintenance equipment and disposable supplies listed below.

1. Helium, 99.999% pure.
2. Pressure regulator (0-3000/0-400 psig).
3. Maintenance manifold, part number 8080250K003*.
4. Helium charging line terminating in a 1/4-inch female flare fitting, part number 7021002P001.
5. Installation and Scheduled Maintenance Tool Kit, part number 8032040G004.

*Available from stock; consult the factory or your sales representative.

Adding Helium Gas

Use only 99.999% pure helium gas.

CAUTION

Equipment Damage

To avoid damaging the cold head and other parts through contamination, maintain pressure in the cold head.

If the compressor helium pressure gauge reads 0, decontamination is required. Refer to the Helium Circuit Decontamination on page 5-9, or contact the Product Service Department.

1. A user-supplied helium charging line terminating in a 1/4-inch female flare fitting, and a two-stage pressure regulator rated at 0-3000/0-400 psig is required for this operation.
2. If you need to add helium more than once every several months, check for leaks caused by improperly connected self-sealing connections or any mechanical joint within the compressor.

There are two conditions that require the addition of helium gas:

1. Compressor not operating; helium pressure gauge reads 245 psig or below.

2. Compressor operating; helium pressure reads 270 psig, or below.

To add helium gas:

1. Attach a pressure regulator (0-3000/0-400 psig) and charging line to a helium gas (99.999% pure) bottle. DO NOT OPEN THE BOTTLE AT THIS TIME. Purge the regulator and charging lines as instructed in steps a through e below. Do not use helium gas that is less than 99.999% pure.

   a. Open the regulator a small amount by turning the adjusting knob clockwise until it contacts the diaphragm, then turn approximately 1/8 to 1/4 turn more, so that the regulator is barely open.

   b. Slowly open the bottle valve, and purge the regulator for 10 to 15 seconds. Turn the regulator knob counterclockwise until the helium stops flowing.

   c. Connect the charge line to the helium pressure regulator.

   d. Remove the flare cap of the gas charge fitting on the rear of the compressor. Loosely connect the charge line to the charge fitting.

   e. Set the helium pressure regulator to 10 to 25 psig (70-125 kPa). Allow helium gas to flow through the charging line and around the loosened flare fitting for 30 seconds to purge the charging line of air. Then tighten the flare nut at the end of the charge line.

   (This procedure is required to ensure that both the regulator and the charging line will be purged of air and that the air trapped in the regulator will not diffuse back into the helium bottle. For best results, CTI suggests a dedicated helium bottle, regulator, and line, which are never separated, for adding helium.)

2. Set the helium pressure regulator to 300 psig (2070 kPa). Depending on the compressor operating state, add helium gas:

   a. If the compressor is running (approximately 2 hours operating time) under normal operating conditions, slowly open the helium charge valve on the rear of the compressor. When the helium pressure gauge rises to 270 - 290 psig (1860 - 2000 kPa) tightly close the charge valve.

b. If the compressor is not running, slowly open the helium charge valve. When the helium pressure gauge rises to 245 - 255 psig (1688 - 1757 kPa), tightly close the charge valve.

CAUTION

Equipment Damage

To avoid discharging the relief valve, add helium gas slowly, less than 50 psi per second.

3. Ensure that the helium charge valve on the compressor is tightly closed. Shut off the helium pressure regulator on the helium bottle and remove the charging line from the male flare fitting. Shut off the helium gas bottle valve. Reinstall the flare cap.

Helium Circuit Decontamination

Refer to **Section 4 - Maintenance** of the appropriate On-Board Cryopump Installation Operation, and Maintenance manual for information on helium circuit decontamination.

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6 Appendices

Overview

The following appendices are included to provide the user with a single location for specific information related to the Brooks Automation Product.

Contents

Appendix A: Customer Support Information

Customer Support Center Locations

To locate a Customer Support Center near you, please visit our website ***www.brooks.com*** on the world wide web and select *CONTACT* on the home page.

Guaranteed Up-Time Support (GUTS®)

For 24-hour, 7-day per week Guaranteed Up-Time Support (GUTS) dial:

1 800-367-4887 - Inside the United States of America

+1 *508-337-5599* - Outside the United States of America

Product Information

Please have the following information available when calling so that we may assist you:

- Product Part Number
- Product Serial Number
- Product Application
- Specific Problem Area
- Hours of Operation
- Equipment Type
- Vacuum System Brand/Model/Date of Manufacture

E-mail

For your convenience, you may also e-mail us at:

techsupport@brooks.com

Appendix B: Troubleshooting Procedures

Read these safety notices before you perform any troubleshooting procedures:

WARNING

High Voltage

High voltage electric shock could cause severe injury or loss of life.

Always disconnect the compressor from all sources of electrical power before performing any maintenance or troubleshooting procedures.

CAUTION

Burn Hazard

To avoid being burned, wait for the pump to cool down so that it is cool to the touch after operating, before working on the inside of the compressor.

Table 6-1: Compressor Troubleshooting Procedures

Problem	Possible Cause	Corrective Action
1) System power ON/OFF switch (CB1) and compressor switch (S1) remains in the ON position when switched on but the compressor will not run. Refer to Figure 6-1 on page 6-8 for identification of all electrical components.	**1a)** The thermal protective switch (TS1) is closed, activating the relay-trip coil in the ON/OFF switch (SW1).	**1a)** Test switch (TS1) on air-cooled compressor; test (TS1) and (TS2) on water-cooled compressor. If continuity is found in any switch, contact the Product Service Department.
	1b) Incorrect phasing at input power.	**1b)** Correct phase sequence at input power cable.
	1c) Excessive current drain has activated the series trip in the compressor ON/OFF switch.	**1c)** Measure and record the current and contact the Product Service Department.

Table 6-1: Compressor Troubleshooting Procedures

Problem	Possible Cause	Corrective Action
2) System power ON/OFF switch (CB1) remains in the ON position, but the compressor will not run.	**2a)** No power coming from the power source.	2a) Check service fuses, circuit breakers, and wiring associated with power source, and repair as needed.
	2b) Incorrect or disconnected wiring within the compressor.	**2b)** Check the compressor against its electrical schematic, Figure 6-1 on page 6-8.

Table 6-1: Compressor Troubleshooting Procedures

Problem	Possible Cause	Corrective Action
3) Compressor stops after several minutes of operation and remains off.	**3a)** High temperature of the compressor is caused by insufficient cooling water, resulting in the opening of thermal protective switch (water-cooled compressor only).	**3a)** Confirm that cooling water to the compressor is flowing. Confirm that proper cooling water flow rate and pressure exist by referring to Figure 4-3 on page 4-7.
	3b) After turn-off, very cold cooling water was left running through the compressor. The resulting low oil temperature has caused a restriction of oil flow through the metering orifice during startup.	**3b)** Turn on the compressor and allow it to run until it has stopped several times, allowing the oil temperature to rise and the compressor to operate continuously for one hour minimum.
	3c) Very cold cooling water is circulating through the compressor. The resulting low oil temperature causes a restriction of oil flow through the metering orifice during startup.	**3c)** Recheck for proper cooling water temperature per, Cooling Water Requirements (Water-Cooled Compressors Only).
	3d) Ambient temperature is unusually high resulting in the opening of the thermal protective switch (air-cooled compressor only).	**3d)** Provide a free flow of air to the compressor. Confirm a 12-inch (30 cm) clearance at the front and back of the compressor. Confirm unobstructed and clean heat exchanger surfaces.
	3e) Insufficient helium supply pressure is indicated by the supply pressure gauge.	**3e)** Add helium per, Unscheduled Maintenance on page 5-6.
	3f) High temperature of the compressed helium in the discharge line from the compressor pump has tripped the thermal protective switch.	**3f)** Confirm that oil is visible in the compressor sight glass (air-compressor only).
	3g) Mechanical seizure.	**3g)** Contact the Product Service Department.

Table 6-1: Compressor Troubleshooting Procedures

Problem	Possible Cause	Corrective Action
4) Compressor pump stops after several minutes of operating and then switches ON and OFF at short intervals.	**4a)** Intermittent power source voltage.	**4a)** Confirm power source voltage between 198-250V, 60 Hz or 180-220V, 50 Hz and restore if necessary.
5) Compressor operates but cold head motor does not run.	**5a)** Loose or defective cable.	**5a)** Check cold head cable.
6) Cooling water leaving the compressor exceeds 100°F.	**6a)** The water coming into the compressor is too warm.	**6a)** Ensure the water coming into the compressor is between 50°F (32°C) and 90°F (10°C).
	6b) The water is becoming too warm within the compressor due to a problem with the compressor.	**6b)** Contact the Product Service Department.

Appendix C: Electrical Schematics for 8200 Compressor

The following electrical schematics for the 8200 Compressor are in this appendix:

- 8200 Compressor Electrical Schematic part number 8032563P001
- 8200 Compressor Electrical Schematic part number 8032564P001

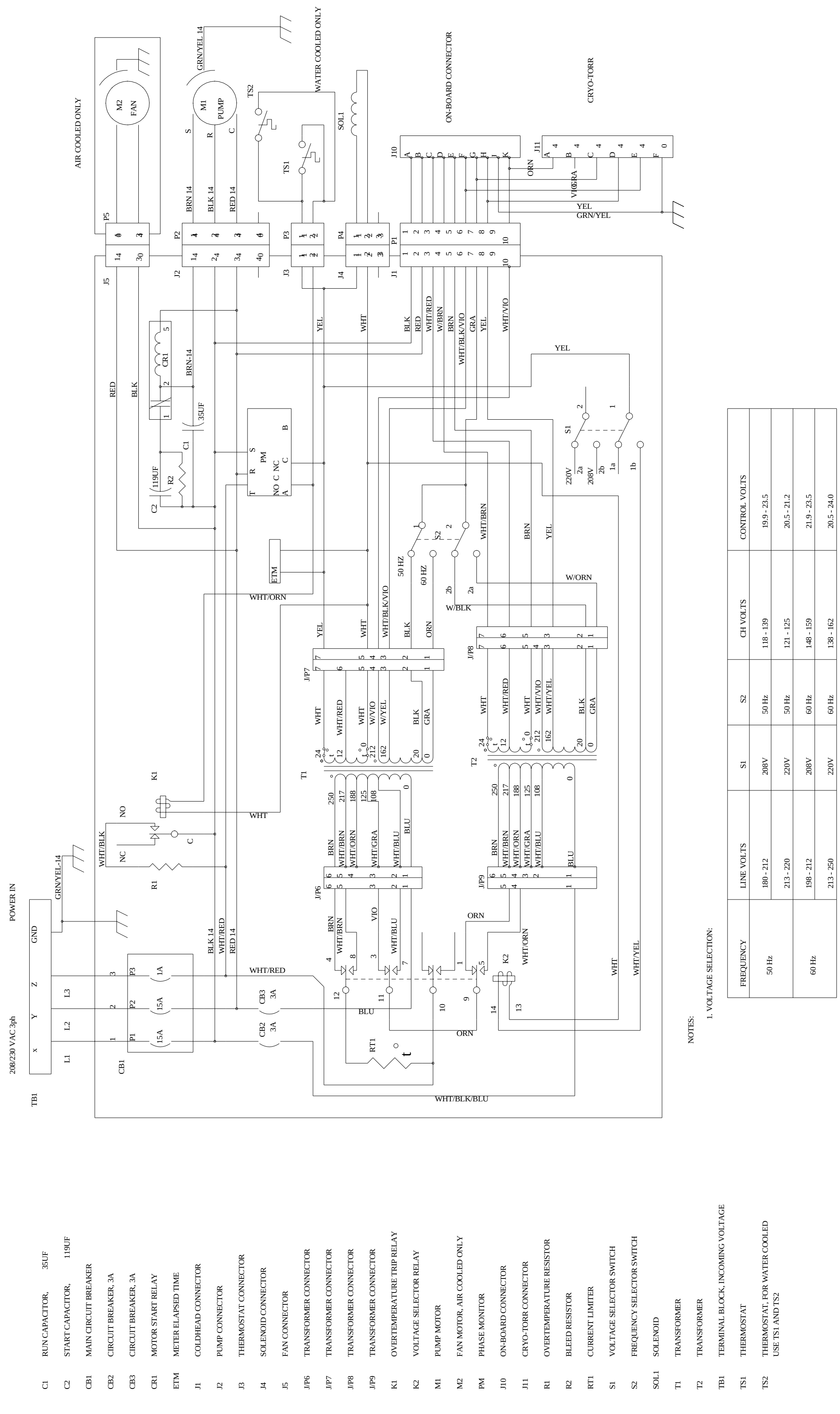
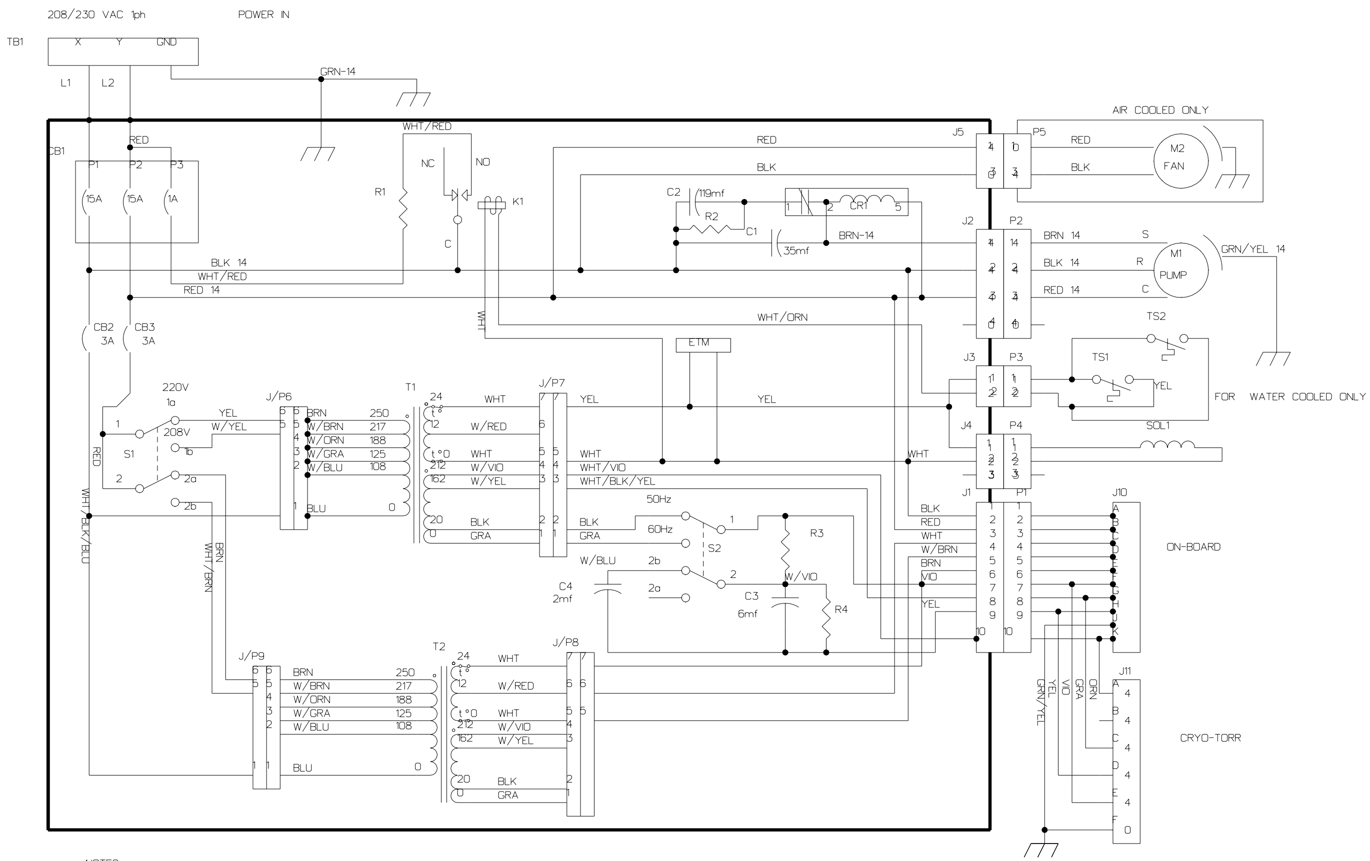


Figure 6-1: 8200 Compressor Electrical Schematic part number 8032563P001

C1 RUN CAPACITOR, 35UF
C2 START CAPACITOR, 119UF
C3 RUN CAPACITOR, 6UF
C4 RUN CAPACITOR, 2UF
CB1 MAIN CIRCUIT BREAKER
CB2 CIRCUIT BREAKER, 3A
CB3 CIRCUIT BREAKER, 3A
CR1 MOTOR START RELAY
ETM METER ELAPSED TIME
J/P1 COLDHEAD CONNECTOR
J/P2 PUMP CONNECTOR
J/P3 THERMOSTAT CONNECTOR
J/P4 SOLENOID CONNECTOR
J/P5 FAN CONNECTOR
J/P6 TRANSFORMER CONNECTOR
J/P7 TRANSFORMER CONNECTOR, 8 PIN
J/P8 TRANSFORMER CONNECTOR
J/P9 TRANSFORMER CONNECTOR
K1 RELAY, TRIP RELAY
M1 PUMP MOTOR
M2 FAN MOTOR, AIR COOLED ONLY
J10 ON-BOARD CONNECTOR
J11 CRYO-TORR CONNECTOR
R1 OVERTEMPERATURE RESISTOR 100 OHM
R2 BLEED RESISTOR, 15K
R3 COLDHEAD PHASE-SHIFTING RESISTOR 150 OHM
R4 BLEED RESISTOR, 100K, 2W
S1 VOLTAGE SELECTOR SWITCH
S2 FREQUENCY SELECTOR SWITCH
SOL1 SOLENOID
T1 TRANSFORMER
T2 TRANSFORMER
TB1 TERMINAL BLOCK, INCOMING VOLTAGE
TS1 THERMOSTAT
TS2 THERMOSTAT, FOR WATER COOLED
USE TS1 AND TS2



NOTES:

1 VOLTAGE SELECTION

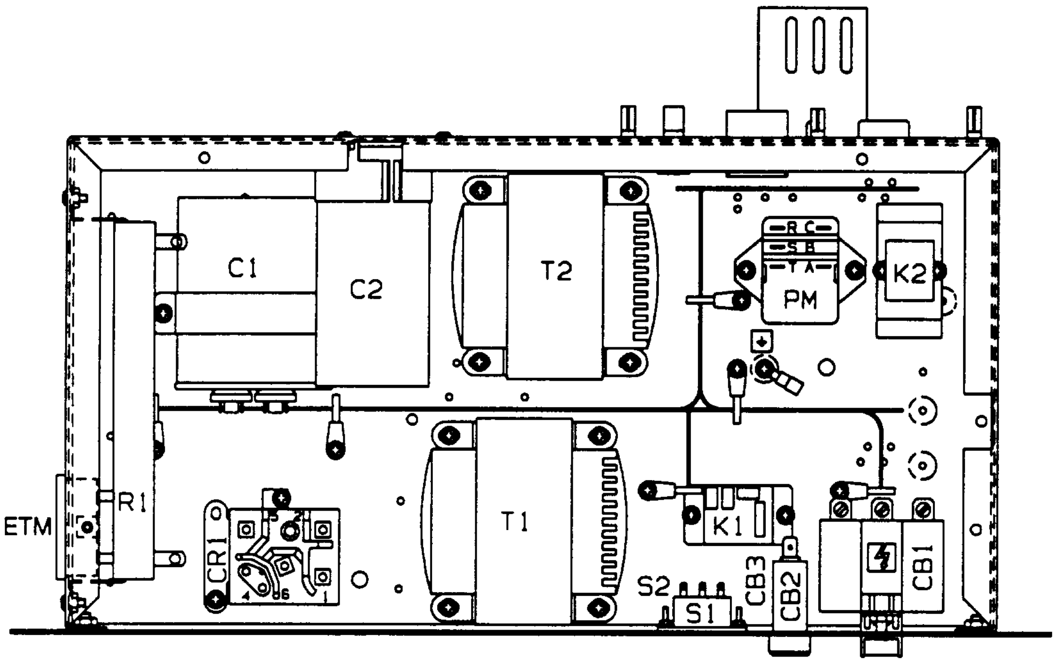
FREQUENCY	LINE VOLTS	S1	S2	CH VOLTS	CONTROL VOLTS
50 Hz	180 - 212	208V	50 Hz	118 - 139	199 - 235
	213 - 220	220V	50 Hz	121 - 125	205 - 212
60 Hz	198 - 212	208V	60 Hz	148 - 159	219 - 235
	213 - 250	220V	60 Hz	138 - 162	205 - 240

Figure 6-2: 8200 Compressor Electrical Schematic part number 8032564P001

Appendix D: Components in the Electrical Control Module of the 8200 Compressor

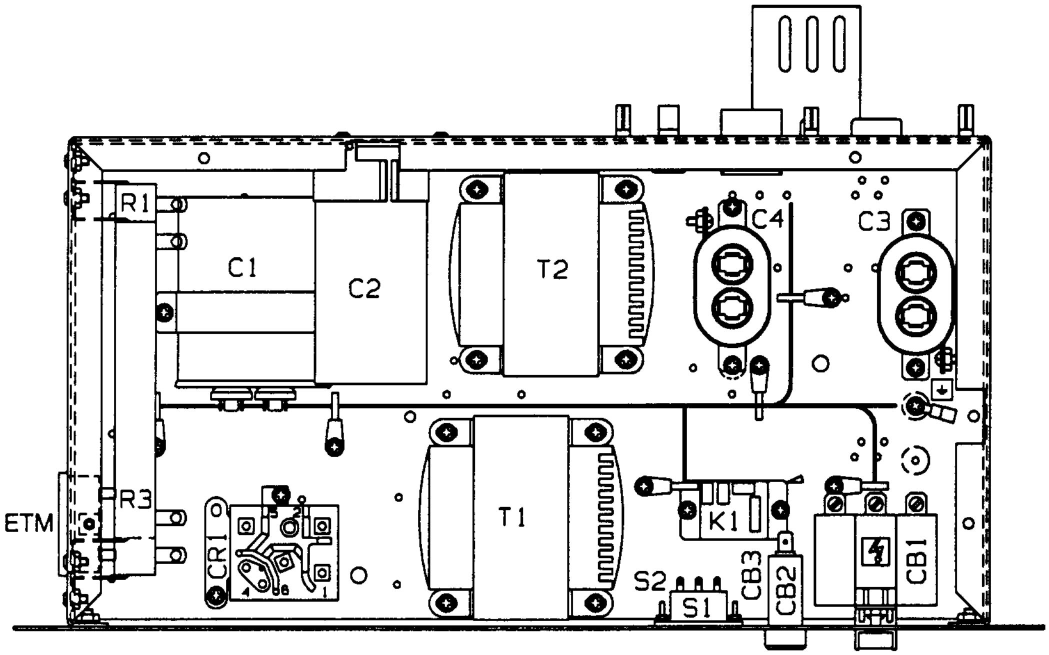
The following illustrations are shown in this chapter:

- Components in the Electrical Control Chassis of the 8200 Compressor Three-Phase Scott-T Configuration (this page)
- Components in the Electrical Control Chassis of the 8200 Compressor Single-Phase RC Configuration



1. Overtemperature ResistorR1
2. Run Capacitor, 35 µfC1
3. Start Capacitor, 119 µfC2
4. TransformerT2
5. Phase MonitorPM
6. Voltage Selector RelayK2
7. Main Circuit BreakerCB1
8. Circuit Breaker, 3ACB2
9. Circuit Breaker, 3ACB3
10. Voltage Selector SwitchS1
11. Frequency Selector SwitchS2
12. Overtemperature Trip RelayK1
13. TransformerT1
14. Motor Start RelayCR1
15. Meter, Elapsed TimeETM

Figure 6-3: Components in the Electrical Control Chassis of the 8200 Compressor Three-Phase Scott-T Configuration



1. Coldhead Phase-Shifting ResistorR3
2. Overtemperature Resistor R1
3. Run Capacitor, 35 µf C1
4. Start Capacitor, 119 µf C2
5. Transformer T2
6. Run Capacitor, 2 µf C4
7. Run Capacitor, 6 µf C3
8. Main Circuit BreakerCB1
9. Circuit Breaker, 3A
10. Circuit Breaker, 3ACB3
11. Voltage Selector SwitchS1
12. Frequency Selector SwitchS2
13. Relay, Trip RelayK1
14. TransformerT1
15. Motor Start RelayCR1
16. Meter, Elapsed TimeETM

Figure 6-4: Components in the Electrical Control Chassis of the 8200 Compressor Single-Phase RC Configuration

Appendix E: Flow Diagrams for 8200 Air-Cooled and Water-Cooled Compressors

Refer to Figure 6-5 on page 6-13 or Figure 6-6 on page 6-14 while reviewing this subsection.

Helium returning from the cold head enters the compressor, and a small quantity of oil is injected into the gas stream, thereby overcoming helium low specific head and inability to carry heat produced during compression. Helium is then compressed and passed through a heat exchanger for removal of compression-caused heat. The helium flows through a bulk oil separator, oil-mist separator, and helium filter cartridge, where oil and contaminants are removed.

A differential pressure relief valve in the compressor limits the operating pressure differential between the helium supply and return lines, thereby allowing compressor operating without cold head operation. When cold head operation reaches a steady-state condition, further pressure regulation is unnecessary.

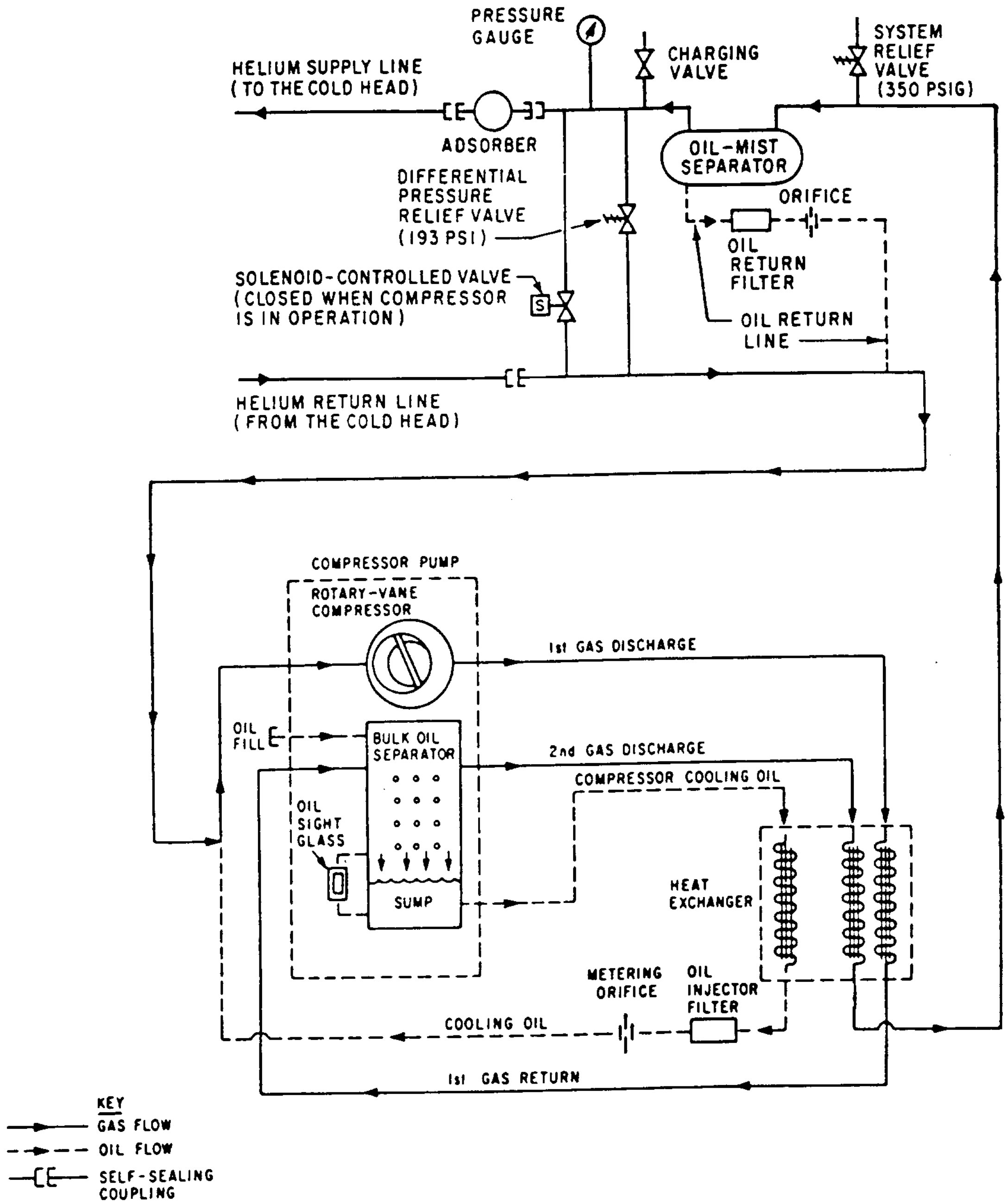


Figure 6-5: Flow Diagram of the 8200 (Air-Cooled) Compressor

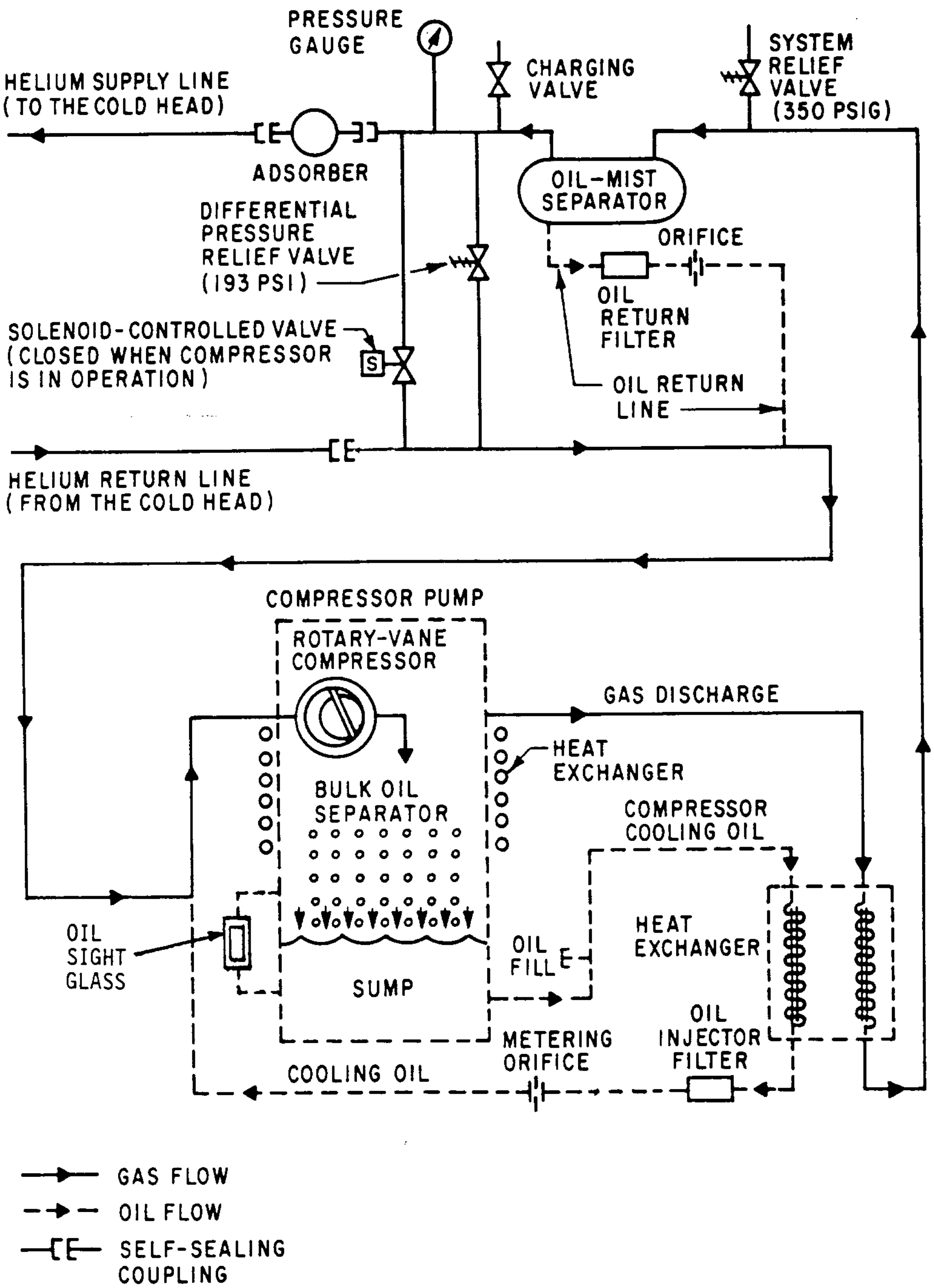


Figure 6-6: Flow Diagram of the 8200 (Water-Cooled) Compressor

Appendix F: Additional Cooling Water Quality Parameters

Table 6-2: Additional Cooling Water Quality Parameters

Water Constituent	Unit	Acceptable Limits
Saturation-Index SI (delta pH-value)		-0.2 < 0 < +0.2
Total hardness	°dH	6 - 15
Conductivity	mg/l	10...500
Filtered substances	mg/l	<30
Chlorides	mg/l	<500
Free chlorine	mg/l	<0.5
Hydrogen sulphide	mg/l	<0.05
Ammonia	mg/l	<2
Sulphates	mg/l	<100
Hydrogen carbonate	mg/l	<300
Hydrogen carbonate / sulphates	mg/l	>1.0
Sulphide	mg/l	<1
Nitrate	mg/l	<100
Nitrite	mg/l	<0.1
Iron	mg/l	<0.2
Manganese	mg/l	<0.1
Free agressive carbonic acid	mg/l	<20

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9600 Compressor Installation, Operation, and Maintenance Instructions

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Safety Conventions

Introduction

Follow all safety precautions during installation, normal operation, and when servicing CTI-Cryogenics products.

This chapter explains the safety conventions used throughout this manual. CTI-Cryogenics uses a specific format for cautions and warnings, which includes standard signal words and safety shapes.

See also the *Customer Support* appendix or call your local Customer Support Center for assistance.

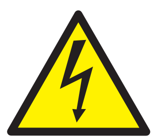
Signal Word Descriptions

All cautions and warnings contain signal words, which call attention to safety messages and designate the degree of hazard seriousness. The following table shows the signal words and their meanings that may be used in this document.

Term	Example	Definition
CAUTION	⚠ CAUTION	A signal word accompanied by a safety shape that indicates a potentially hazardous situation or unsafe practice. If not avoided, the action may result in **minor or moderate personal injury or equipment damage**. A CAUTION is highlighted in yellow.
CAUTION	CAUTION	A signal word that indicates a situation or unsafe practice, which if not avoided may result in **equipment damage**. A CAUTION is highlighted in yellow.
WARNING	⚠ WARNING	A signal word accompanied by a safety shape that indicates indicates a potentially hazardous situation. If not avoided, the action may result in **serious injury or death**. A WARNING is highlighted in orange.

Safety Shape Descriptions

All cautions and warnings contain safety shapes, which have specific safety meanings. The following table shows some of the safety shapes used in this document and their meanings.

Example	Term	Shape Definition
	General Warning	Indicates a general hazard. Details about this hazard appear in the safety notice explanation.
	High Voltage	Indicates a high voltage hazard.
	Hot Surface	Indicates a surface is hot enough to cause discomfort or a burn.

References

For more information about safety standards, see the following documents:

- ISO 7010: 2003(E), Graphic symbols - Safety colours and safety signs - Safety signs used in workplaces and public areas
- ISO 3864-1: 2002(E), Graphic symbols - Safety colours and safety signs - Part 1: Design principles for safety signs in workplaces and public areas

Section 1 - 9600 Compressor Description

General

This manual provides the information required to install, operate, and maintain the CTI-CRYOGENICS 9600 Compressor.

NOTE: *All personnel with installation, operation, and maintenance responsibilities should become familiar with the contents of both the 9600 Compressor Installation, Operation, Maintenance, and appropriate cryopump manuals to ensure safe, high quality, and reliable system performance.*

CAUTION

Refer to “Appendix A - Customer Support Information” to contact the local Customer Support Center for information on connecting 9600 Compressors to a manifold with other CTI-CRYOGENICS compressors.

Compressor Configurations

The 9600 Compressor supports either On-Board or Cryo-Torr Cryopumps. For multiple cryopump installations, an On-Board Splitter Box or Cryo-Torr Interface can be used for cold head power distribution that reduces total cable requirements as shown in Figure 1-5 and Figure 1-6.

System Documentation

The manuals for a *system* cover two basic components: the cryopump and the Compressor. A manual is shipped with each system component to

provide information for installation and operation of that component. A loose-leaf binder with index tab separators is also provided so you can compile a complete set of tabulated manuals.

CTI-CRYOGENICS Helium Refrigeration System

The operation of CTI-CRYOGENICS’ cryopumps is based upon a closed loop helium expansion cycle. The *system* is made up of two major components: the cryopump, which contains the cold head, and the helium Compressor which compresses the helium gas.

Refrigeration is produced in the cryopump cold head through periodic expansion of high pressure helium in a regenerative process. The high pressure helium is provided by the Compressor. Low pressure helium returning from the cold head is compressed into the necessary high pressure to be returned to the cold head. The energy required to compress the helium is rejected as heat through the cooling water.

High pressure room temperature helium is transferred to the cold head through the supply lines. After expansion, low pressure helium is returned to the Compressor (at or near room temperature) to repeat the cycle in a closed loop fashion. Large separation distances can be accommodated between the Compressor and the cryopump.

In the Compressor, helium is compressed using a highly reliable oil lubricated commercial Compressor. Helium purification takes place via several stages of oil removal. The final stage of purification is performed with a replaceable adsorber cartridge. In order to maintain peak efficiency, the adsorber must be replaced every three years. The 9600 Compressor is shown in Figure 1-1.

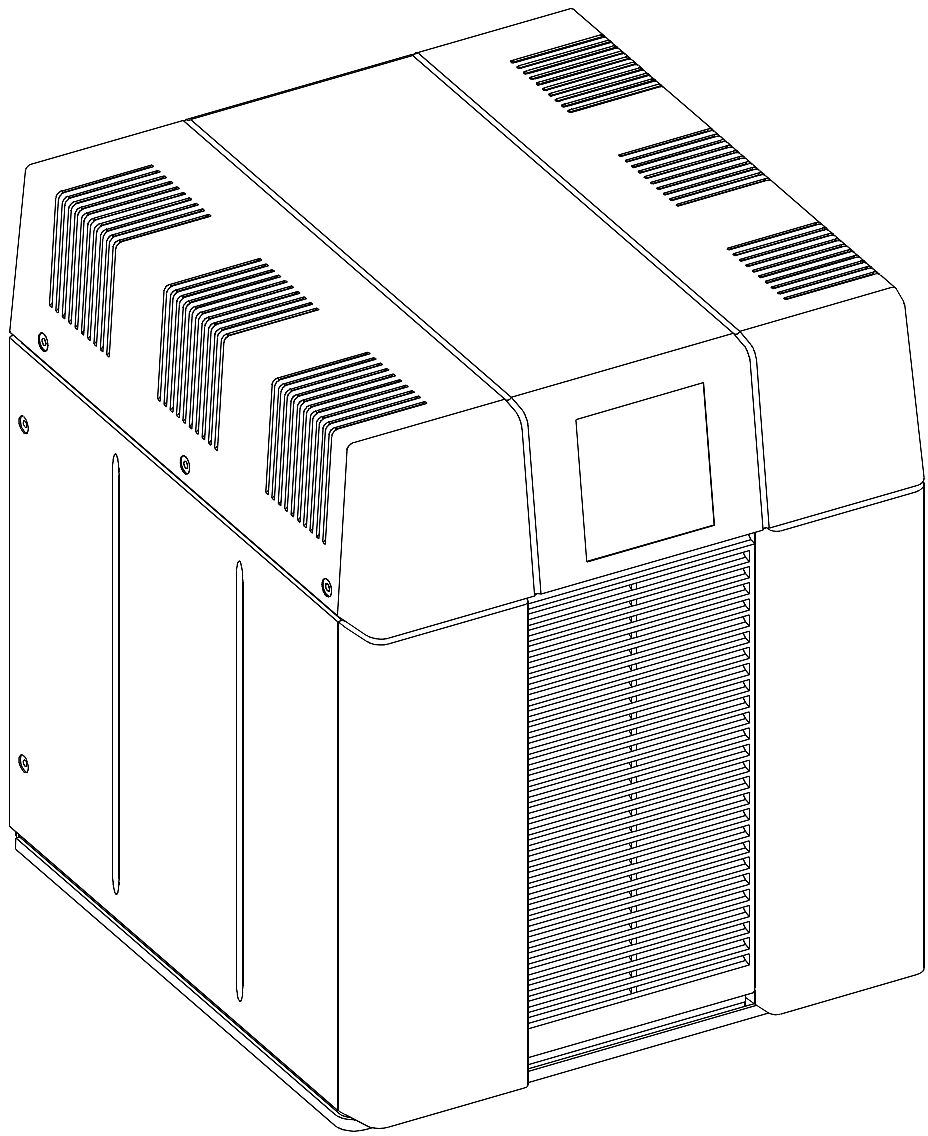


Figure 1-1: 9600 Compressor

Specifications

Dimensions

The dimensions of the Compressor are shown in Figure 1-2.

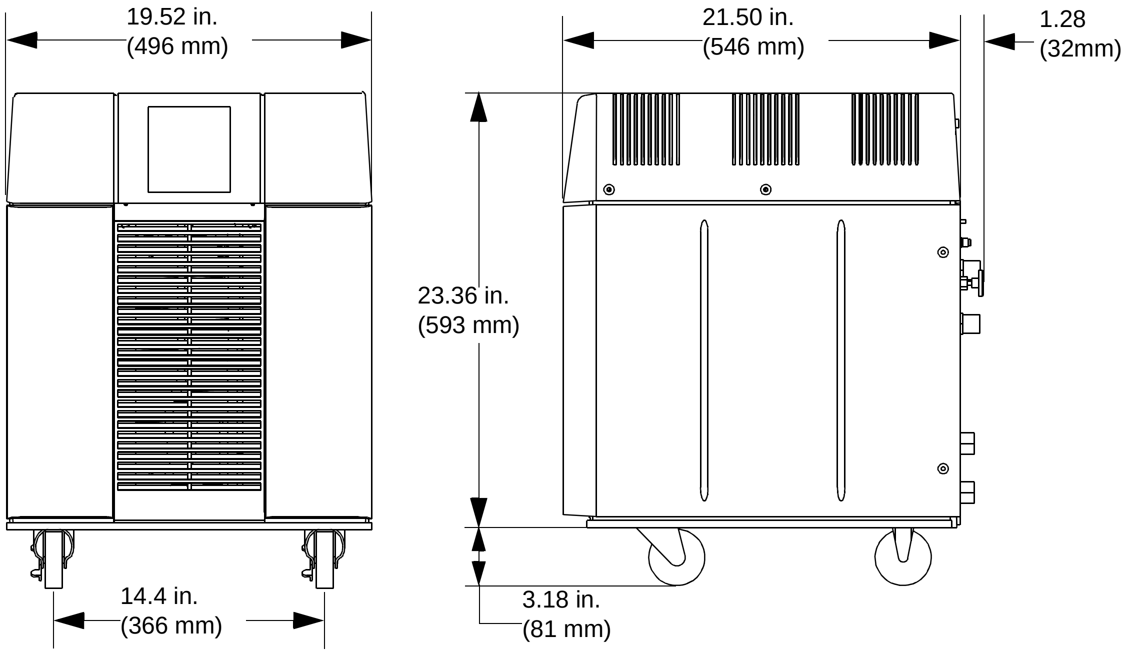


Figure 1-2: 9600 Compressor Dimensions

CAUTION
Do not place a weight greater than 75 lbs. (34Kg) on top of the Compressor.

Weight

The weight of the Compressor is listed in Table 1-1.

Table 1-1: Compressor Weight

Weight lbs./kg
250/114kg

Electrical

The electrical specifications of the Compressor are listed in Table 1-2.

Table 1-2: Electrical Input Specifications

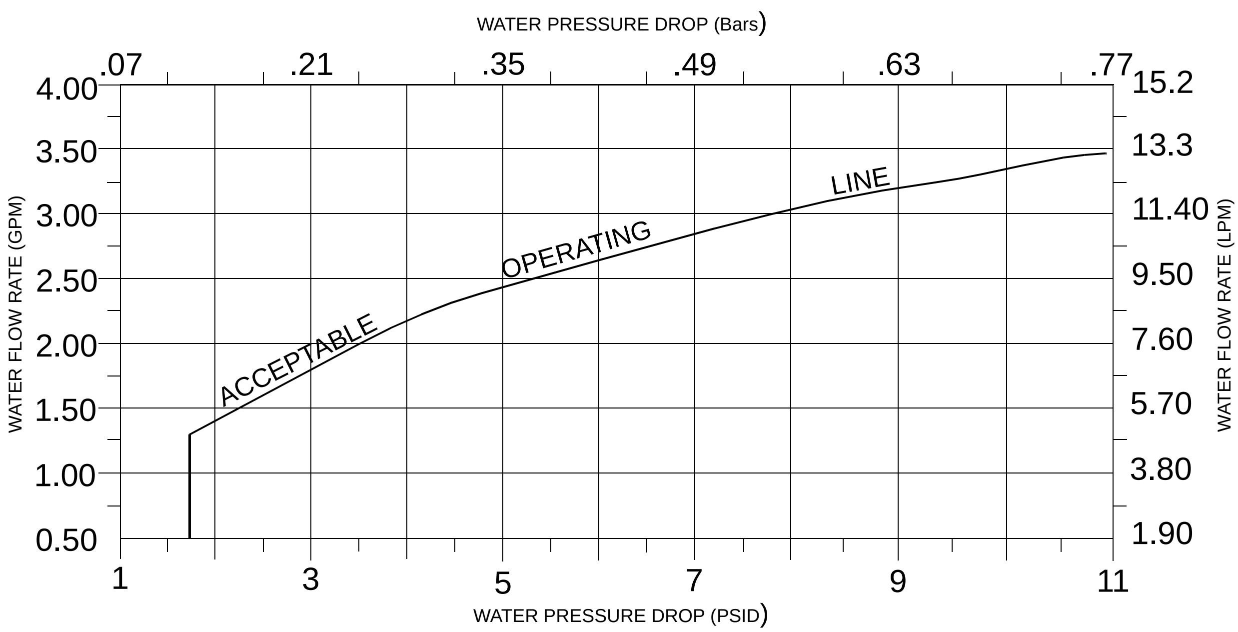
Parameter	Value
Operating Voltage Range	180 - 253 VAC
Line Frequency	50/60 Hz
Phase	3
Nominal Input Power	5.5 KW
Nominal Power Factor	0.85
Rated FL/LR* Current	16.2/80
Minimum Electrical Service	30 Amps
*FL/LR = Full Load/Locked Rotor	

Cooling Water

The water used to cool the Compressor must meet the specifications shown in Table 1-3 for proper system operation.

Table 1-3: Cooling Water Specifications

Parameter	Value
Maximum Inlet Temperature	90°F (32°C)
Minimum Inlet Temperature	50°F (10°C)
Flow Rate	2.75 ±1.25 gpm (10.4 ± 4.7 lpm)
Pressure Drop (inlet-to-outlet)	See Figure 1-3
Maximum Inlet Pressure	100 psi (6.9 bars)
Alkalinity	6.0 - 8.0 pH
Calcium Carbonate	< 75 ppm
NOTE: Water conditioning may be required for applications not meeting these requirements.	



NOTE: *Figure 1-3 defines the water flow rate through the Compressor as a function of the pressure drop from water inlet to water outlet. You must provide the correct pressure drop in your water supply system to ensure that the water flow condition meets the requirements specified in Table 1-3.*

Figure 1-3: Water Flow Rate versus Pressure Drop

General

The information in Table 1-4 provides general Compressor operating specifications.

Table 1-4: General Compressor Operating Specifications

Specification	Values
Part Numbers	8135900G001 8135908G001
Input Power Cable (Customer Supplied)	600 VAC 10 Gauge, 3 conductor wire with ground Must conform to local electrical codes
Nominal Helium Pressure	Refer to Table 4-1
Ambient Operating Temperature Range	50 - 100º F (10 - 38º C)
Interface Gas Supply Connector Gas Return Connector Remote Control Receptacle	Cryopump Power Receptacles: mates with the CTI-CRYOGENICS supplied cryopump power cable for single pump use. Mates with remote junction box power cable for multiple cryopump use. 1/2 in. Aeroquip self-sealing coupling 1/2 in. Aeroquip self-sealing coupling 24VAC, 2.7A inductive mates with P5 connector P/N MS3106A*
Adsorber Service Schedule	3 Years
* Supplied by CTI-CRYOGENICS	

NOTE: *The 9600 Compressor is designed for continuous operation and should remain ON when the cryopumps are in a regeneration cycle.*

Component Description

The components of the 9600 Compressor that are accessible from the rear panel are shown in Figure 1-4 and described in the following paragraphs.

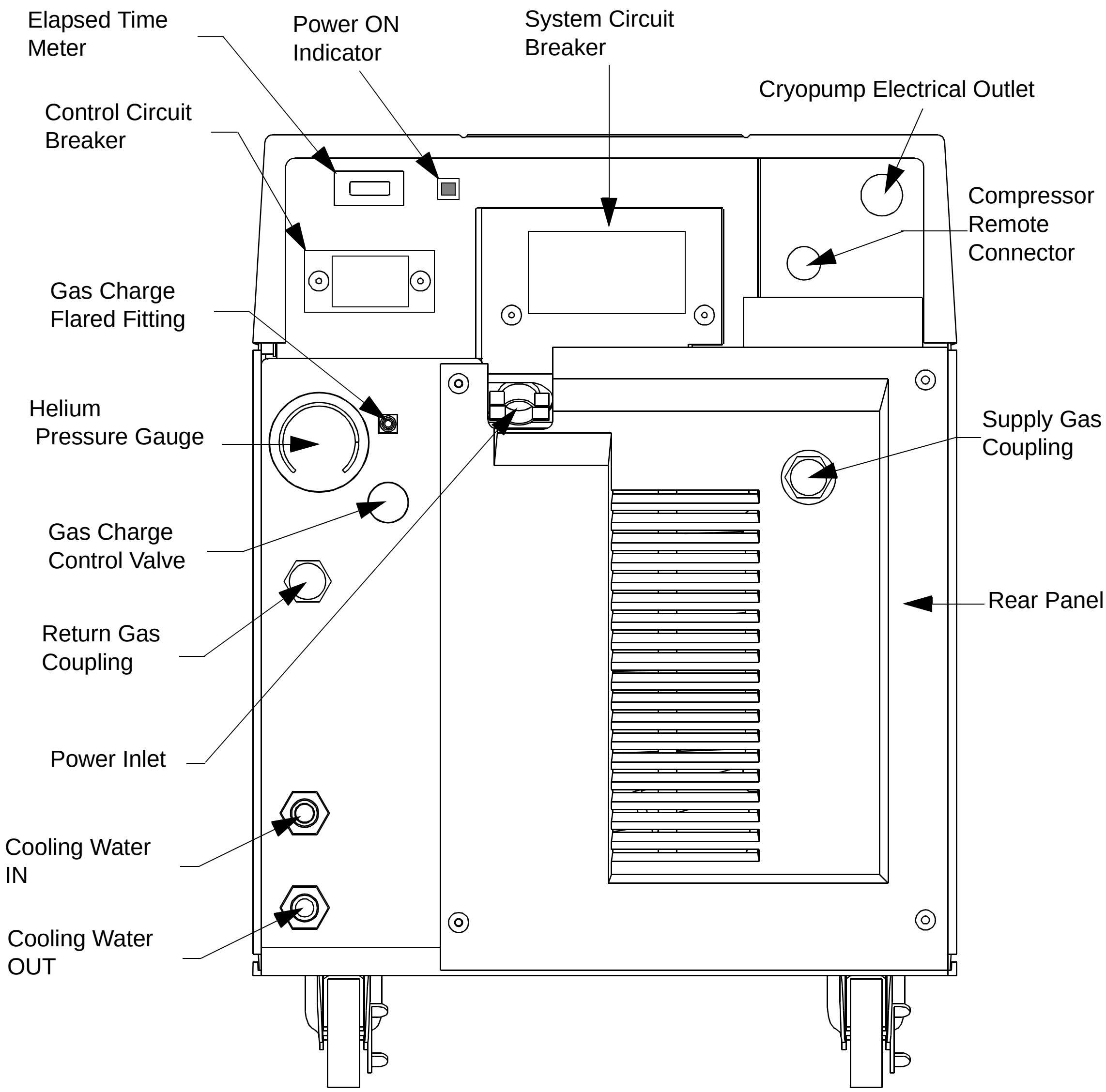


Figure 1-4: 9600 Compressor Rear View Component Locations

System Circuit Breaker

The System Circuit Breaker protects main input power to the Compressor pump and module. The circuit breaker positions are labeled ON (1), which is in the UP position, and OFF (0), which is in the DOWN position.

NOTE: *The phase monitor in the Compressor will cause the system circuit breaker to open when input power phases are incorrect.*

Elapsed Time Meter

The Elapsed Time Meter records the number of Compressor operating hours. Since the meter is digital, it is not illuminated unless the system circuit breaker is in the ON position and power is connected to the Compressor. The Elapsed Time Meter maintains the correct accumulated operating hours while system power is turned OFF.

NOTE: *The meter cannot be reset.*

Control Circuit Breaker

The Control Circuit Breaker provides current overload protection for all internal components of the Compressor except the Compressor motor. The Compressor motor is protected by a separate overload protector. The Control Circuit Breaker opens automatically and must be reset manually.

Power ON Indicator

The Power On Indicator illuminates when the system circuit breaker is placed in the ON position. The Compressor pump is energized when the power indicator is illuminated and the elapsed time meter records system

operation time.

Gas Charge Flared Fitting

The Gas Charge Flared Fitting is used to connect a 99.999% pure helium supply to the Compressor when helium charging is required. The fitting has a 45º flare and 7/16 in. x 20 threads/inch.

Refer to “Section 5 - Maintenance” for information on adding helium to the Compressor.

Helium Pressure Gauge

The Helium Pressure Gauge indicates system ("OFF" Condition) helium charge pressure when the Compressor and cryopumps are OFF and Compressor suction or inlet pressure when the Compressor is ON. Refer to Table 4-1 for the appropriate ("OFF" Condition) helium charge pressure.

Power Inlet

The Power Inlet is used to connect your power cable to the Compressor. Refer to “Section 3 - Installation” for information on power cable installation.

Return Gas Coupling

The Return Gas Coupling returns the helium, which has been cycled through the cryopump, back to the Compressor. Refer to “CTI-CRYOGENICS Helium Refrigeration System” in this section for more information.

Cooling Water IN

The Cooling Water IN connector provides water to the Compressor from your facility to cool the Compressor during operation. The connector thread size is a 1/2 in. female pipe thread. The water must meet the specifications outlined in Table 1-3. Refer to “Section 3 - Installation” for more information on cooling water connections.

Cooling Water OUT

The Cooling Water OUT connector returns the water that has been used to cool the Compressor to your facility. The connector thread size is a 1/2 in. female pipe thread. Refer to “Section 3 - Installation” for more information on cooling water connections.

Cryopump Electrical Outlet

The Cryopump Electrical Outlet provides power to a single On-Board or Cryo-Torr Cryopump, an On-Board Splitter Box, or a Cryo-Torr Interface. The Compressor requires the use of an On-Board Splitter Box or

Cryo-Torr Interface for multiple cryopump system connections. Refer to Table 1-5 for connector pin identification. Refer to “Multiple On-Board Cryopump Connections” or “Multiple Cryo-Torr Cryopump Connections” in this section for more information.

Table 1-5: Cryopump Electrical Outlet Pin Assignments

Identifier	Function
A and B	Heater Power - 208 VAC nominal
C	Center tap for D and E
D and E	24 VCT @ 4.6 Amps
F-G and G-H	Cold Head Voltage Output 130-160 VAC @ 4.5 Amps
J	Chassis Ground
K	Not Used

Compressor Remote Connector

The Compressor Remote Connector is a two-pin connector that can be used in conjunction with the On-Board setpoint relays, relays in the Cryo-Torr Interface, or a signal from the vacuum system to turn the Compressor ON or OFF. Refer to Table 1-6 for connector pin identification. Switching contacts must be rated at 24VDC, 2.7A inductive.

NOTE: *The Compressor is shipped with a mating plug which must remain installed in the Compressor Remote Connector to ensure Compressor operation when the Compressor remote feature is not being used.*

Table 1-6: Compressor Remote Connector Pin Assignments

Identifier	Function
A and B	Compressor Remote Control - Make = ON, Break = OFF

Supply Gas Coupling

The Supply Gas Coupling provides a connection for high pressure compressed helium to the cryopump cold head. Refer to “CTI-CRYOGENICS Helium Refrigeration System” in this section for more information.

Multiple On-Board Cryopump Connections

The On-Board Splitter Box permits the connection of multiple On-Board Cryopumps or Waterpumps to one 9600 Compressor as shown in Figure 1-5. Refer to "Section 3 - Installation" for more information on connecting single or multiple On-Board Cryopumps or Waterpumps to the Compressor.

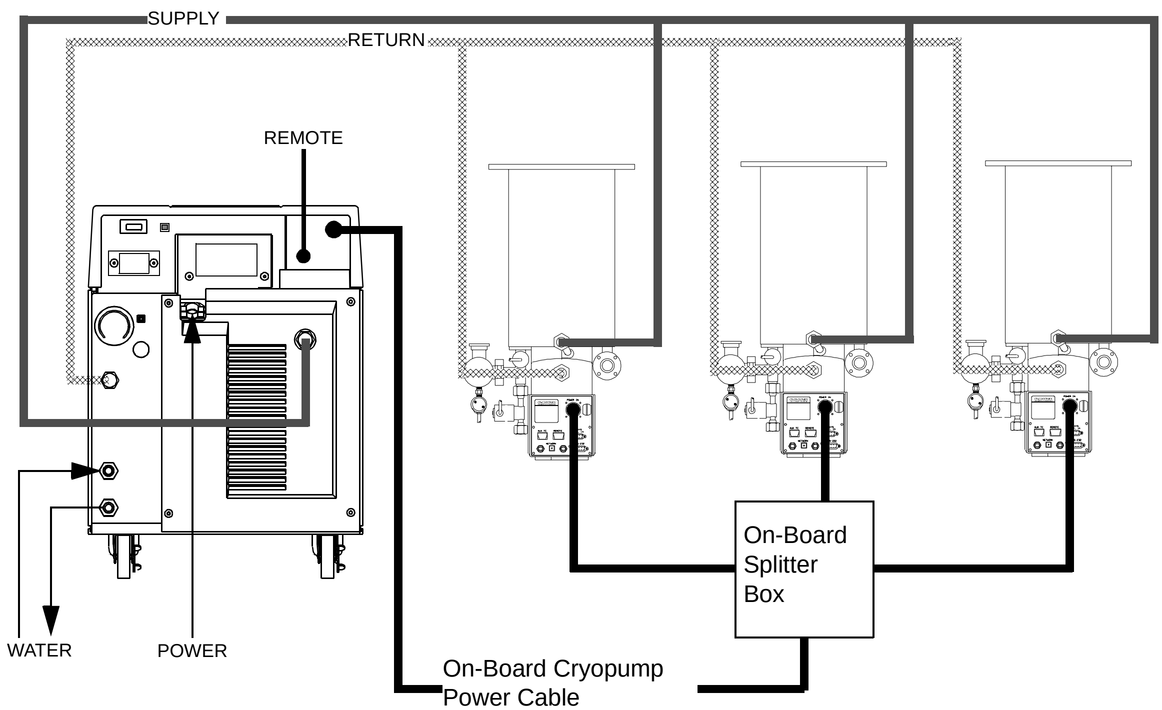


Figure 1-5: 9600 Compressor Connected to Multiple On-Board Cryopumps

NOTE: *Your installation (number of pumps per compressor) will vary based upon the On-Board Cryopumps or Waterpumps used. Refer to "Appendix A - Customer Support Information" to consult your local CTI-CRYOGENICS Customer Support Center for information on specific compressor/pump applications.*

Multiple Cryo-Torr Cryopump Connections

The Cryo-Torr Interface permits the connection of multiple Cryo-Torr Cryopumps to one Compressor as shown in Figure 1-6. Refer to "Section 3 - Installation" for more information on connecting single or multiple Cryo-Torr Cryopumps to the Compressor.

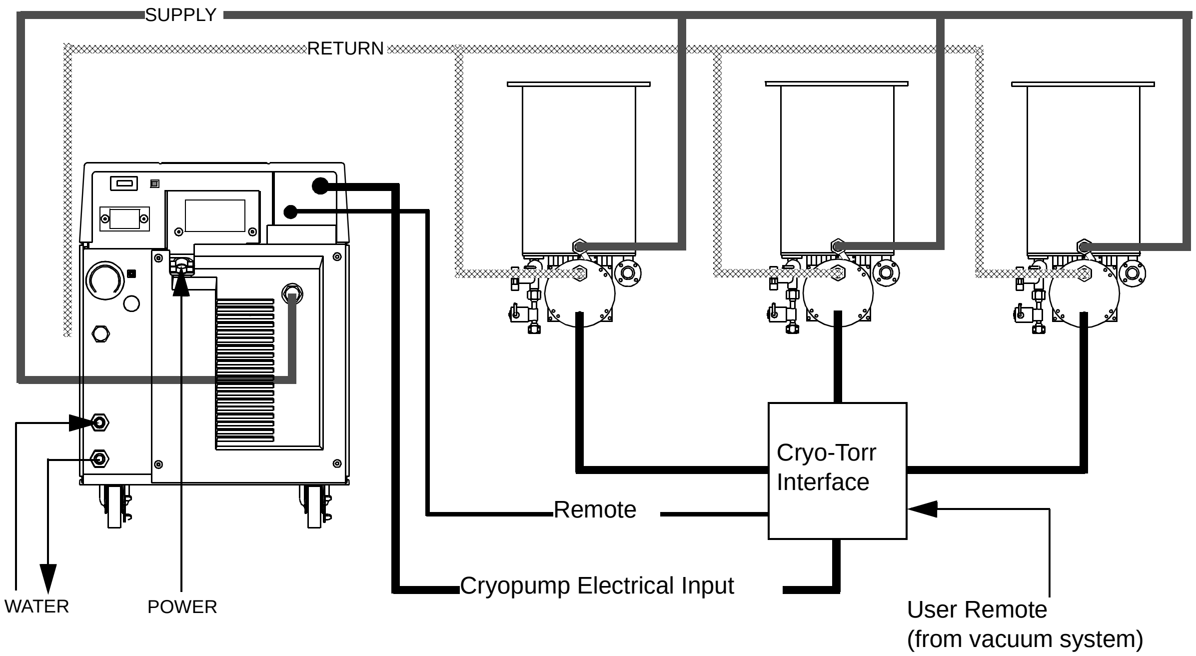


Figure 1-6: 9600 Compressor Connected to Multiple Cryo-Torr Cryopumps

NOTE: *Your installation (number of pumps per compressor) will vary based upon the Cryo-Torr Cryopump models used. Refer to* “Appendix A - Customer Support Information” *to consult your local CTI-CRYOGENICS Customer Support Center for information on specific compressor/ cryopump applications.*

Section 2 - Unpacking and Inspection

Introduction

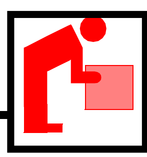
The 9600 Compressor is shipped in a shipping carton incorporating a ramp system which makes removing the Compressor from the carton safe and easy.

Shipping Carton Inspection

Inspect the exterior of the shipping carton for visible signs of damage before opening the shipping carton. Report any damage to the shipping company at once.

Removal from Shipping Carton

1. Cut the two straps on the exterior of the shipping pallet.
2. Lift the cardboard carton straight up and remove it from the pallet.
3. Cut the tape which holds the ramp in the vertical position.
4. Swing the ramp down until the end touches the floor.
5. Remove any excess shipping material from around the Compressor.



WARNING

Maintain control over the movement of the Compressor as it rolls down the ramp. Injury to personnel may result if the Compressor is allowed to roll freely down the ramp.

CAUTION

Maintain control over the movement of the Compressor as it rolls down the ramp. Damage to the Compressor may result if the Compressor is allowed to roll freely down the ramp.

6. Carefully roll the Compressor down the ramp and onto the floor.

Compressor Inspection

Inspect the Compressor for visible signs of damage as indicated in the following paragraphs.

Compressor

Inspect the exterior of the Compressor for visible signs of damage, evidence of an oil leak, and check the Helium Pressure Gauge for proper helium pressure. Report any damage to the shipping company at once.

Helium "OFF" Condition Pressure Verification

Refer to “Section 4 - Operation” for more information on the "OFF" Condition helium charge pressure of the 9600 Compressor.

Shipping Carton Contents

The shipping carton should contain the following items:

- Compressor
- Two barbed fittings for flexible water lines
- Installation, Operation, and Maintenance manual
- Compressor remote start connector and strain relief

Section 3 - Installation

Introduction

Section 3 provides you with the information required to install the 9600 Compressor and connect it to single or multiple On-Board or Cryo-Torr Cryopump configurations. Figure 3-1 highlights the major tasks for Compressor installation and refers to the appropriate installation procedures in this section.

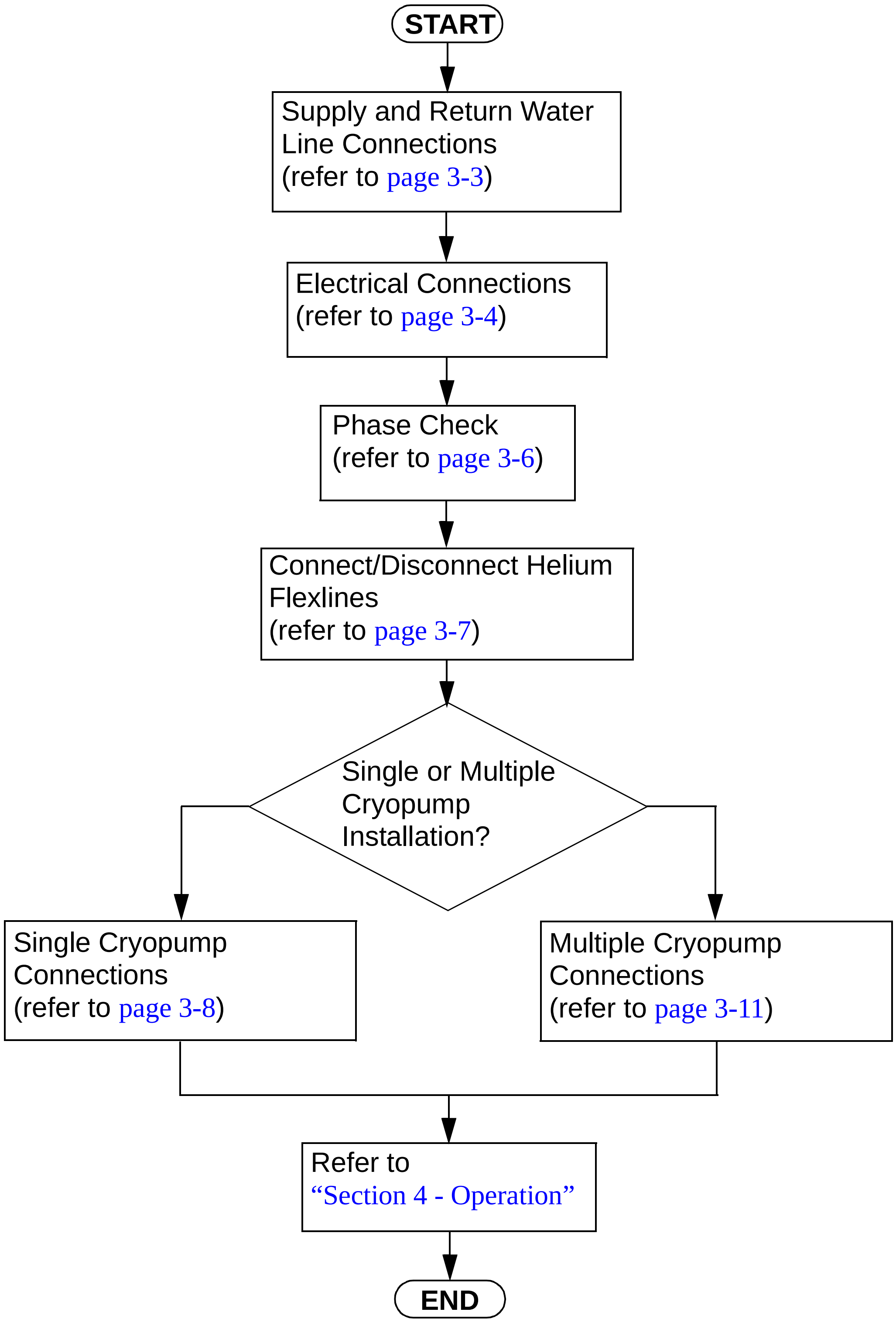


Figure 3-1: 9600 Compressor Installation Flowchart

Supply and Return Water Line Connections

NOTE: *The water used for cooling the Compressor must meet the specifications outlined in* "Section 1 - 9600 Compressor Description".

Hard Water Lines

1. Apply a light coating of standard plumbing thread sealant to the hard line pipe threads.
2. Install the Supply hard line into the INPUT connection on the rear panel of the Compressor. Tighten the fitting by hand.
3. Install the Return hard line into the OUTPUT connection on the rear panel of the Compressor. Tighten the fitting by hand.

CAUTION

Do not overtighten the ferrules. Damage to the input and output connector threads may occur.

4. Using a wrench, tighten the fittings.
5. Allow water to flow and check for leaks at the rear of the Compressor.

Flexible Water Lines

1. Apply a light coating of standard plumbing thread sealant to the barbed fitting threads.
2. Install the barbed fittings into the INPUT and OUTPUT connections on the rear panel of the Compressor.

CAUTION

Do not overtighten the barbed fittings. Damage to the INPUT and OUTPUT connector threads may occur.

3. Using a wrench, tighten the barbed fittings.
4. Connect the Supply flexible water line to the INPUT barbed fitting and secure with a hose clamp.
5. Connect the Return flexible water line to the OUTPUT barbed fitting and secure with a hose clamp.

6. Allow water to flow and check for leaks at the rear of the Compressor.

Electrical Connections

The following procedures provide information for making all three phase (180 - 250 VAC) electrical connections to the Compressor.

Power Cable Preparation

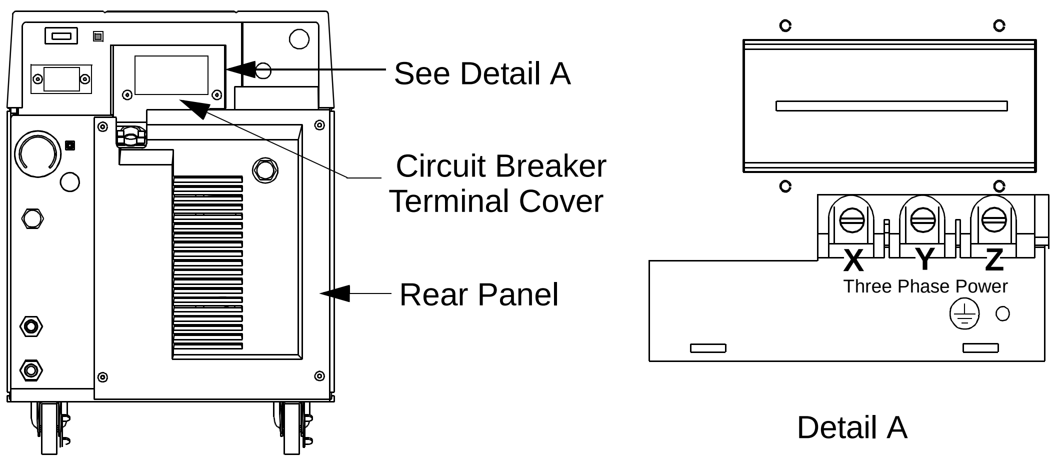
WARNING

Follow all local high voltage safety precautions when performing this procedure to reduce the possibility of electrical shock. Make sure all electrical power is OFF before proceeding with this procedure.

CAUTION

The cable used for making the Compressor power cable must be 10 gauge, 3 conductor cable with ground rated at 600 VAC.

1. Cut a 10 AWG (6.00 mm^2), 3 conductor cable with ground to an appropriate length.
2. Strip the cable jacket back 4 in. (101.6 mm).
3. Strip the insulation back 3/8 in. (9.3 mm) on each individual conductor.
4. Install a #10 ring tongue terminal on the end of each conductor using the appropriate size double crimping tool.
5. Remove the rear panel as shown in Figure 3-2.
6. Remove the circuit breaker terminal cover as shown in Figure 3-2.
7. Install the cable into the Compressor through the cable strain relief.
8. Remove the 10-32 nut and install the grounding wire on the ground stud. Install the nut and tighten to 18 in.-lbs (0.21m-kg).



NOTE: *Use a slotted screwdriver which is capable of holding a screw when performing steps 9 and 10.*

9. Remove the screws from the Compressor circuit breaker terminals X, Y, and Z as shown in Figure 3-2.

Figure 3-2: 9600 Compressor Circuit Breaker Terminals (Cover Removed)

NOTE: *The phase order in which the conductor terminal lugs are connected to circuit breaker terminals X, Y, and Z will be determined during the Phase Check Procedure.*

NOTE: *For installation where one of the three phase legs is at or near ground potential, connect that leg to terminal Y on the Compressor as shown in* Figure 3-2.

10. Install the conductor terminal lugs to the circuit breaker terminals X, Y, and Z as shown in Figure 3-2.
11. Torque the screws to 12 in.-lbs (0.14m-kg).
12. Allow enough cable to stay in the electrical enclosure to prevent strain on the electrical connections and tighten the screws on the cable strain relief.
13. Install the power source end of the power cable according to the local electrical codes.
14. Install the circuit breaker terminal cover.
15. Proceed with **Phase Check**.

Phase Check

WARNING

Follow all high voltage safety precautions when performing this procedure to prevent the possibility of electrical shock.

1. Make sure power is applied to compressor circuit as described in Table 1-2.

NOTE: *The circuit breaker will trip immediately during step 2 if the power phase connections are not correct.*

2. Turn the Compressor circuit breaker to the ON position. If the circuit breaker trips, refer to step 3. If the circuit breaker does not trip, refer to step 4.
3. If the circuit breaker trips, perform the following steps:
   a. Turn the Compressor circuit breaker to the OFF position.
   b. Disconnect the power cord from the power source.
   c. Remove the circuit breaker terminal cover.
   d. Reverse the wiring order of Compressor circuit breaker terminals X and Y.
   e. Torque the circuit breaker terminal screws to 12 in.-lbs.
   f. Install the circuit breaker terminal cover.
   g. Repeat steps 1- 2 of this procedure.
4. Install the rear panel.
5. Proceed with appropriate cryopump connections.

Connecting/Disconnecting Helium Flex Lines

CAUTION

Make sure the helium flex lines are connected and disconnected from the 9600 Compressor using the following procedure and as shown in Figure 3-3. Failure to follow this procedure could damage connector O-ring seals or cause a helium circuit leak.

Connecting

1. Remove all dust plugs and caps from the Gas Supply and Return lines, and the Compressor and cryopump Supply and Return connectors. Check for the presence of a flat gasket in the male connector, and no gasket in the female connector.
2. Connect the Gas Return line to the GAS RETURN connector on the rear of the Compressor and then to the GAS RETURN connector on the cryopump. Using two wrenches as shown in Figure 3-3, tighten the connector.
3. Connect the Gas Supply line to the GAS SUPPLY connector on the rear of the Compressor and then to the GAS SUPPLY connector on the cryopump. Using two wrenches as shown in Figure 3-3, tighten the connector.
4. Attach the Supply and Return line identification labels to each end of the appropriate lines.

Disconnecting

1. Using two wrenches as shown in Figure 3-3, disconnect the two self sealing coupling connectors quickly to minimize helium

leakage.

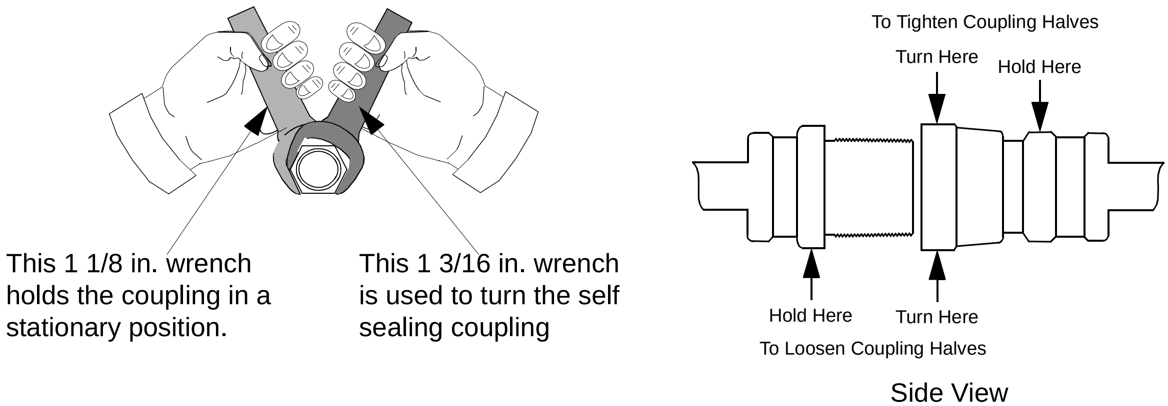


Figure 3-3: Connecting/Disconnecting Helium Flex Line Couplings

Single On-Board Cryopump Connections

> **CAUTION**
> Make sure the Compressor power is OFF before making any connections to the rear panel.

1. Connect the Supply and Return lines to the 9600 Compressor as described in "Connecting/Disconnecting Helium Flex Lines" in this section.
2. Connect one end of the Cryopump cold head cable to the CRYOPUMP ELECTRICAL OUTLET on the rear panel of the Compressor as shown in Figure 3-4.
3. Connect the opposite end of the cold head cable to the cryopump cold head cable connector.

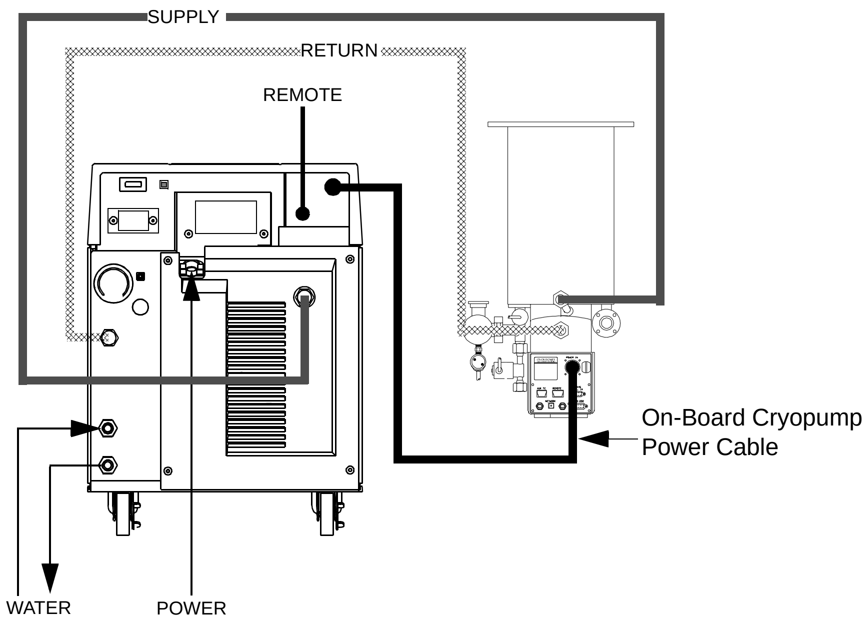


Figure 3-4: Single On-Board Cryopump Connections

Single Cryo-Torr Cryopump Connections

> **CAUTION**
> Make sure the Compressor power is OFF before making any connections to the rear panel.

1. Connect the Supply and Return lines to the 9600 Compressor as described in "Connecting/Disconnecting Helium Flex Lines" in this section.
2. Connect one end of the Cryopump cold head cable to the CRYOPUMP ELECTRICAL OUTLET on the rear panel of the Compressor as shown in Figure 3-5. Connect the opposite end of the cold head cable to the cryopump cold head cable connector as shown in Figure 3-5.

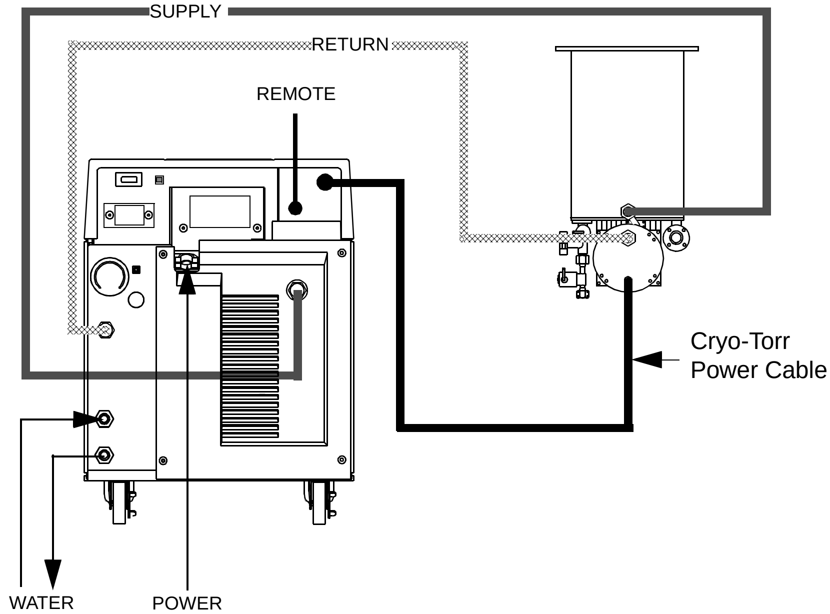


Figure 3-5: Single Cryo-Torr Cryopump Installation

Multiple On-Board Cryopump Connections

Helium Line Connections

CAUTION

Make sure the Compressor power is OFF before making any connections to the rear panel.

CAUTION

The use of several compressors on a single manifold feeding a common supply header and a common return header requires special precautions. Contact CTI-CRYOGENICS for a review of the intended installation and for specific technical instructions. The use of a 9600 compressor on a manifold with other CTI-CRYOGENICS compressor models requires a reduction of the helium charge pressure to 200 - 210 psig charge pressure to avoid helium safety valves from inadvertently venting. Refer to “Section 4 - Operation” and “Section 5 - Maintenance” for more information.

1. Connect the Supply and Return lines to the 9600 Compressor as described in “Connecting/Disconnecting Helium Flex Lines” in this section.
2. Connect the Gas Return Line to the customer supplied helium manifold and then to the GAS RETURN connector on the On-Board Cryopump.
3. Connect the Gas Supply Line to the customer supplied helium manifold and then to the GAS SUPPLY connector on the On-Board Cryopump.

Power Cable Connections

1. Connect the On-Board Splitter Box power cable between the CRYOPUMP ELECTRICAL OUTLET on the rear panel of the Compressor and the On-Board Splitter Box power connector as shown in Figure 3-6.
2. Connect the On-Board Cryopump or Waterpump power cables to the CRYOPUMP 1, 2, or 3 connectors on the On-Board Splitter Box and the respective cryopumps as shown in Figure 3-6.

NOTE: Your installation (number of pumps per compressor) will vary based upon the On-Board Cryopump models used. Refer to "Appendix A - Customer Support Information" to consult your local CTI-CRYOGENICS Customer Support Center for information on specific compressor/pump applications.

NOTE: The On-Board Splitter Box can be installed at the process tool containing the pumps as shown in Figure 3-6, or on the rear of the Compressor as shown in Figure 3-7. CTI-CRYOGENICS recommends that the On-Board Splitter box be installed near the process tool to reduce cable requirements.

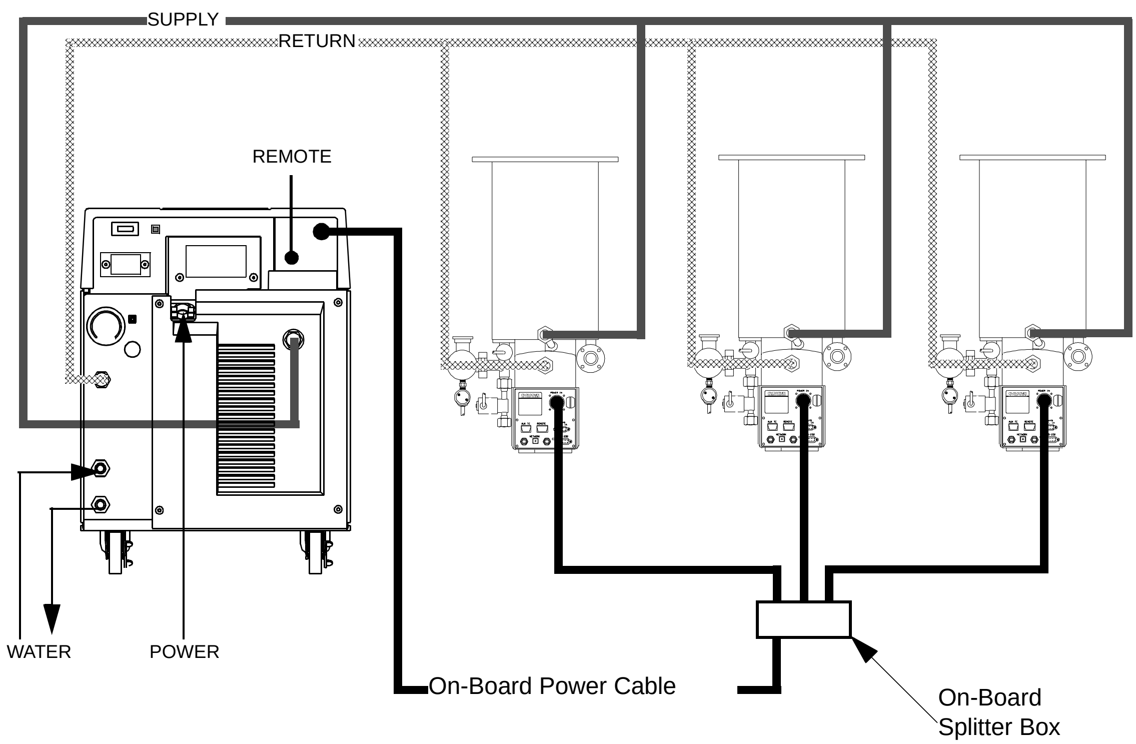


Figure 3-6: Recommended Multiple On-Board Cryopump or Waterpump Installation (Splitter Box located at Process Tool)

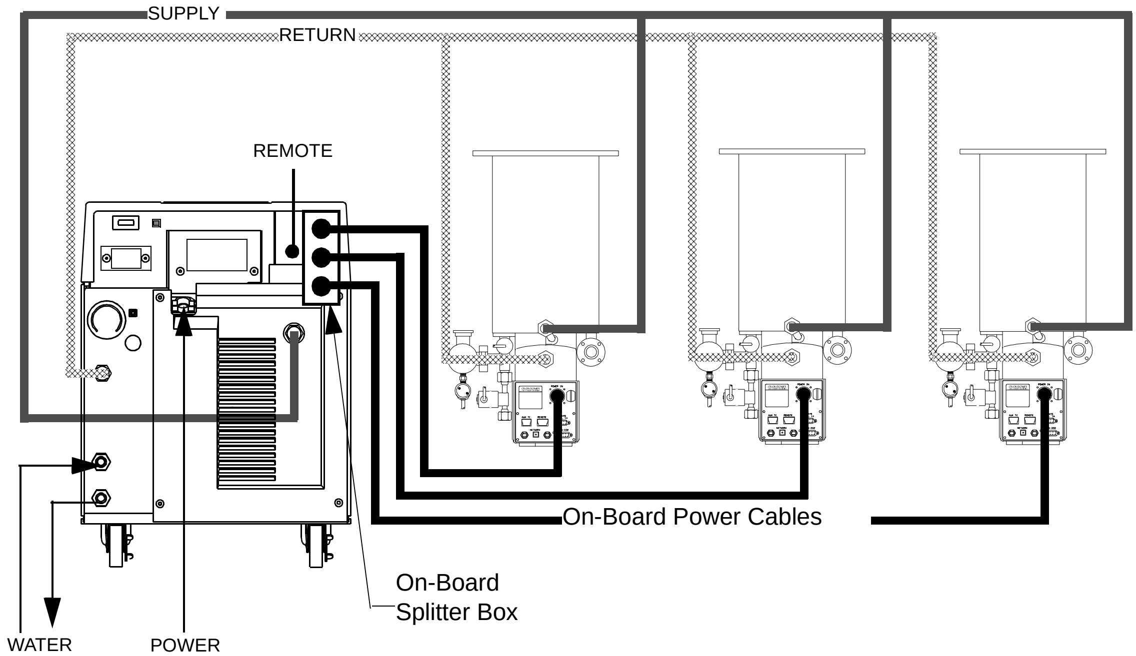


Figure 3-7: Alternative Multiple On-Board Cryopump or Waterpump Installation (Splitter Box located at Compressor)

Multiple Cryo-Torr Cryopump Connections

> **CAUTION**
> Make sure the Compressor power is OFF before making any connections to the rear panel.

Helium Line Connections

> **CAUTION**
> The use of several compressors on a single manifold feeding a common supply header and a common return header requires special precautions. Contact CTI-CRYOGENICS for a review of the intended installation and for specific technical instructions.
>
> The use of a 9600 compressor on a manifold with other CTI-CRYOGENICS compressor models requires a reduction of the helium charge pressure to 200 - 210 psig charge pressure to avoid helium safety valves from inadvertently venting. Refer to "Section 4 - Operation" and "Section 5 - Maintenance" for more information.

1. Connect the Supply and Return lines to the 9600 Compressor as described in "Connecting/Disconnecting Helium Flex Lines" in this section.
2. Connect the Gas Return Line to the customer supplied helium manifold and then to the Gas Return connector on the Cryo-Torr Cryopump.
3. Connect the Gas Supply Line to the customer supplied helium manifold and then to the Gas Supply connector on the Cryo-Torr Cryopump.

Power Cable Connections

1. Connect the Cryo-Torr power cable between the CRYOPUMP ELECTRICAL OUTLET on the rear panel of the Compressor and the CRYOPUMP ELECTRICAL INPUT on the Cryo-Torr Interface as shown in Figure 3-8 or Figure 3-9.

2. Connect the Cryo-Torr Power Cables between the CRYOPUMP 1, 2, or 3 connectors on the Cryo-Torr Interface and the respective Cryo-Torr Cryopumps as shown in Figure 3-8 or Figure 3-9.
3. Connect the User Remote cable to the Cryo-Torr Interface as shown in Figure 3-8 or Figure 3-9.
4. Connect the Remote cable between the Cryo-Torr Interface and the Compressor as shown in Figure 3-8 or Figure 3-9.

NOTE: *Your installation may vary based upon the Cryo-Torr Cryopump models used. Refer to "Appendix A - Customer Support Information" to consult your local CTI-CRYOGENICS Customer Support Center for information on specific compressor/cryopump applications.*

NOTE: *The Cryo-Torr Interface can be installed at the process tool containing the cryopumps as shown in Figure 3-8 or near the Compressor as shown in Figure 3-9. CTI-CRYOGENICS recommends that the Cryo-Torr Interface be installed at the process tool to reduce cable requirements.*

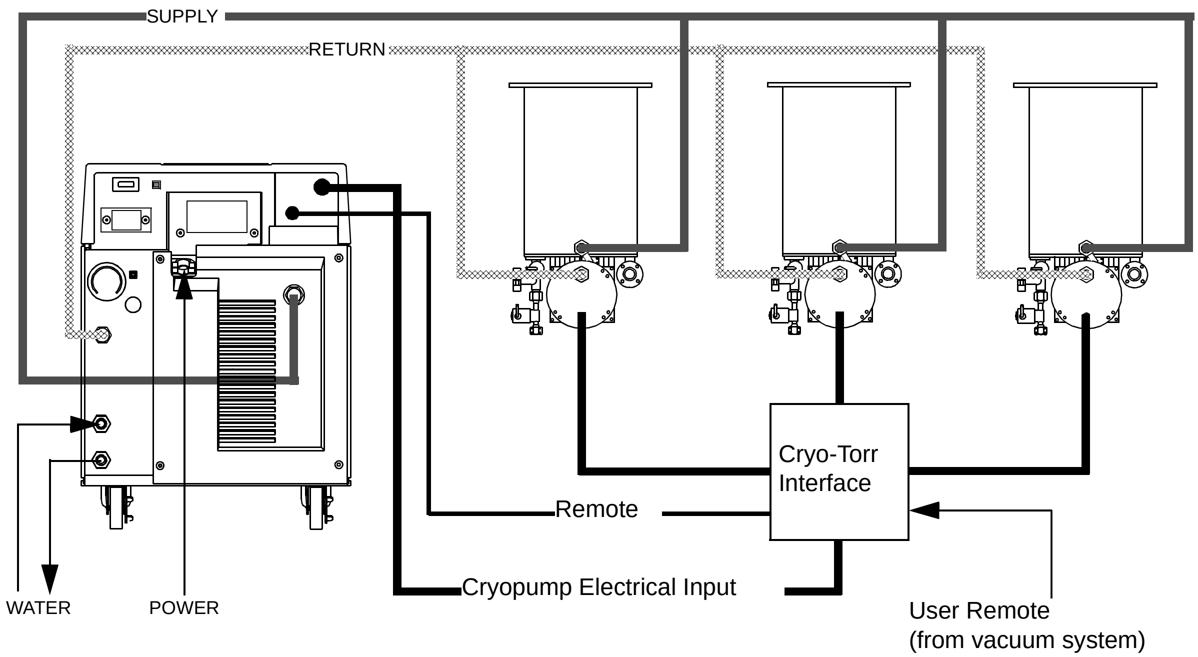


Figure 3-8: Multiple Cryo-Torr Cryopump Installation

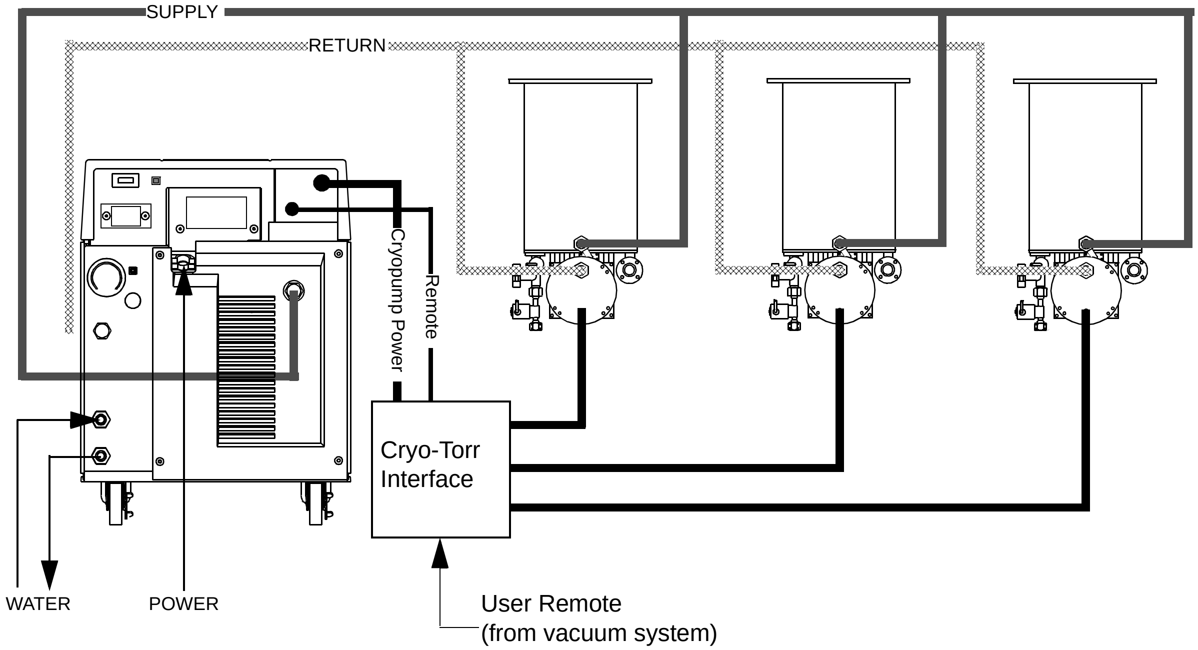


Figure 3-9: Multiple Cryo-Torr Cryopump Installation

Section 4 - Operation

Adjusting System Helium Pressure

Your CTI-CRYOGENICS high vacuum pump system is comprised of several pressurized components i.e. compressor, flex lines, and cryopumps. Each component is charged with helium before shipment. After all cryopumps, helium lines, and manifolds are attached to the compressor, the system *("OFF" Condition) helium charge pressure* must be verified *before* system operation. Once the ("OFF" Condition) helium system pressure has been verified, the system is ready for operation. After cooldown, the *normal system operating pressure* is recorded.

NOTE: *The 9600 Compressor is designed for continuous operation and should remain ON even when the cryopumps are in a regeneration cycle.*

"OFF" Condition Helium System Pressure Verification

The proper system ("OFF" Condition) helium charge pressure is necessary so that the cryopumps operate at maximum performance as well as to assure that the compressor will operate below the maximum design motor winding temperature which will maximize the life of the compressor motor.

1. Make sure the Compressor and Cryopump(s) are OFF.
2. Make sure all system components are connected together as described in “Section 3 - Installation”.
3. Allow all system components to acclimate to a temperature between 60º F and 80º F (15.5º C - 26.6º C).
4. Read the compressor helium pressure gauge located on the compressor rear panel as shown in Figure 1-4. Compare the gauge reading to the appropriate 50/60 Hz line frequency value (depending upon your system installation) indicated in Table 4-1.

Table 4-1: 9600 Compressor Helium ("OFF" Condition) Charge

Line Frequency	Helium ("OFF" Condition) Charge Pressure
60 Hz	240 - 250 psig (16.5 - 17.2 bars)
50 Hz	255 - 265 psig (17.6 -18.3 bars)

***NOTE:** The use of a higher helium charge pressure for 50 HZ operation is necessary in order to compensate for the slower speed at which the compressor operates at 50 HZ. The ("OFF" Condition) charge level for 60 Hz remains at 240-250 PSIG.*

CAUTION

Exceeding the recommended system ("OFF" Condition) helium charge pressure will result in the compressor and cryopump safety relief valves opening and releasing excess helium gas.

5. If the ("OFF" Condition) helium charge pressure is not in the ranges as indicated in Table 4-1, then adjust the charge pressure as described in "Section 5 - Maintenance".

Compressor Operation

CAUTION

While the 9600 Compressor is operating, the helium pressure gauge indicator should never be in the red zone. If the gauge indicator is below 65 psig, then the system must be checked for insufficient helium or helium leaks. If the gauge indicator is above 160 psig, then the system has been over pressurized. Refer to "Section 5 - Maintenance"and either add or remove helium before operating the 9600 Compressor.

The system may be operated once the helium charge pressure is correct.

Perform the following steps to start the compressor:

1. Set the System Circuit Breaker to the ON (UP) position.
2. Set the Control Circuit Breaker to the ON (UP) position.
3. Close all Cryopump gate valves.
4. Refer to the **On-Board Module Programming and Operation** manual or **Cryo-Torr Cryopump Installation and Service** manual (that came with your cryopump) and perform the cryopump start-up procedure.

5. Once the second stage temperature for all cryopumps is below 17K, record the compressor pressure gauge reading as the *normal system operating pressure*.

NOTE: *During compressor operation, the compressor gauge reads the pressure of the gas entering the compressor prior to it being compressed.*

6. Affix a copy of the data next to the compressor gauge on each compressor. This data is to be verified for each tool installation and whenever a configuration change is made affecting the amount of system helium gas and line volume.

The compressor pressure reading will decrease from the normal system operating pressure during cryopump regeneration or if fewer cryopumps are being operated. These are normal variations in the compressor pressure reading and should not be cause for concern.

If you have concerns about system performance changing, then check the *normal system operating pressure* which was determined in “Compressor Operation” in this section. If the normal system operating pressure is not correct, check the system for leaks.

Once the leaks have been repaired, helium must be added to return the system to *normal operating system pressure* as described in “Section 5 - Maintenance”.

Replacement of Helium Circuit Components

On occasion, it may be necessary to replace components such as cryopumps, helium gas lines or compressors, or change the configuration of the system. Whenever any of these conditions occur, **"OFF" Condition Helium System Pressure Verification** should be performed to ensure that ("OFF" Condition) helium pressure has not changed.

CAUTION

The use of several compressors on a single manifold feeding a common supply header and a common return header requires special precautions. Contact CTI-CRYOGENICS for a review of the intended installation and for specific technical instructions.

The use of a 9600 compressor on a manifold with other CTI-CRYOGENICS compressor models requires a reduction of the helium charge pressure to 200 - 210 psig charge pressure to avoid helium safety valves from inadvertently venting.

Section 5 - Maintenance

Scheduled Maintenance

Suggested Maintenance Equipment

It is recommended to have the following equipment and disposable supplies available as listed in Table 5-1.

Table 5-1: Suggested Maintenance Equipment

Supply	CTI-CRYOGENICS P/N
Helium, 99.999% pure	-
Pressure regulator (0-3000/0-400 psi) Assy.	8031403
Helium charging line terminating in a 1/4-inch female flare fitting	7021002P001
Lint-free gloves and cloth	-
Oakite or equivalent detergent soap	-
Denatured alcohol	-
Refer to "Appendix A - Customer Support Information" and contact the local Customer Support Center to obtain the CTI-CRYOGENICS parts listed in this table.	

Adsorber Replacement

Use the following procedure to change the adsorber every three years.

1. Set the System Circuit Breaker, on the rear of the 9600 Compressor, to the OFF position.
2. Remove the 4 screws which secure the rear panel to the Compressor and remove the rear panel.

NOTE: *Use two wrenches in Step 3 to prevent loosening the body of the coupling.*

3. Using a 1-3/16 in. wrench, and a 1-1/8 in. wrench, as shown in Figure 5-1, disconnect the two self sealing coupling connectors quickly to minimize helium leakage.

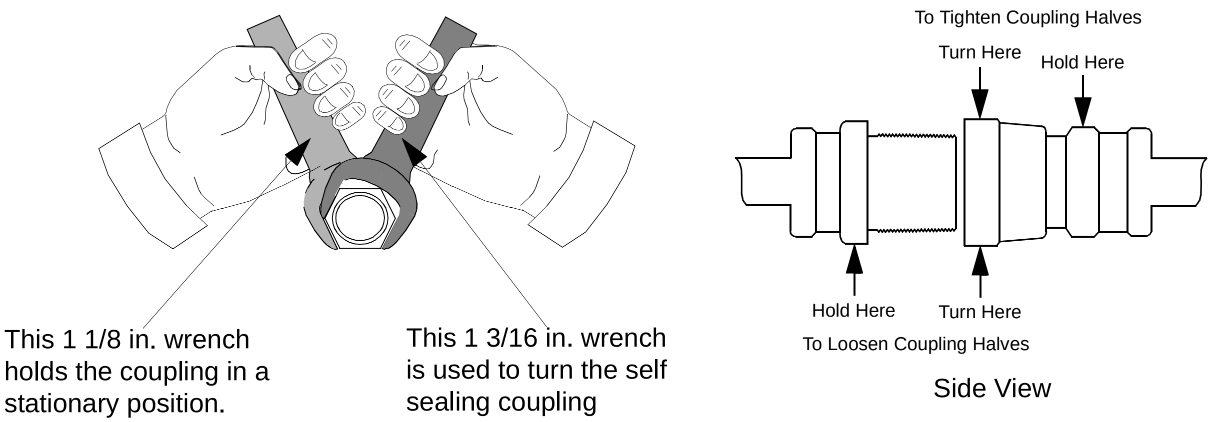


Figure 5-1: Disconnecting Self Sealing Couplings

4. Using a 7/16 in. (11mm) wrench, remove the adsorber mounting bolt as shown in Figure 5-2.
5. Move the adsorber from under the mounting tabs in the base as shown in Figure 5-2 and remove the adsorber from the Compressor.
6. Install the replacement adsorber under the mounting tabs and secure it into place with the bolt removed during Step 4.
7. Using two wrenches as shown in Figure 5-1, connect the two self sealing couplings quickly to minimize helium leakage.
8. Install the Compressor rear panel.

9. Ensure that the pressure gauge reads the proper value as shown in Table 4-1. If additional gas pressure is required, refer to “Adding Helium” in this section. If gas pressure needs to be reduced, refer to “Reducing Helium Pressure” in this section.
10. Record the adsorber replacement date on the label as shown in Figure 5-2, and also note that the next adsorber replacement should be performed every three years.

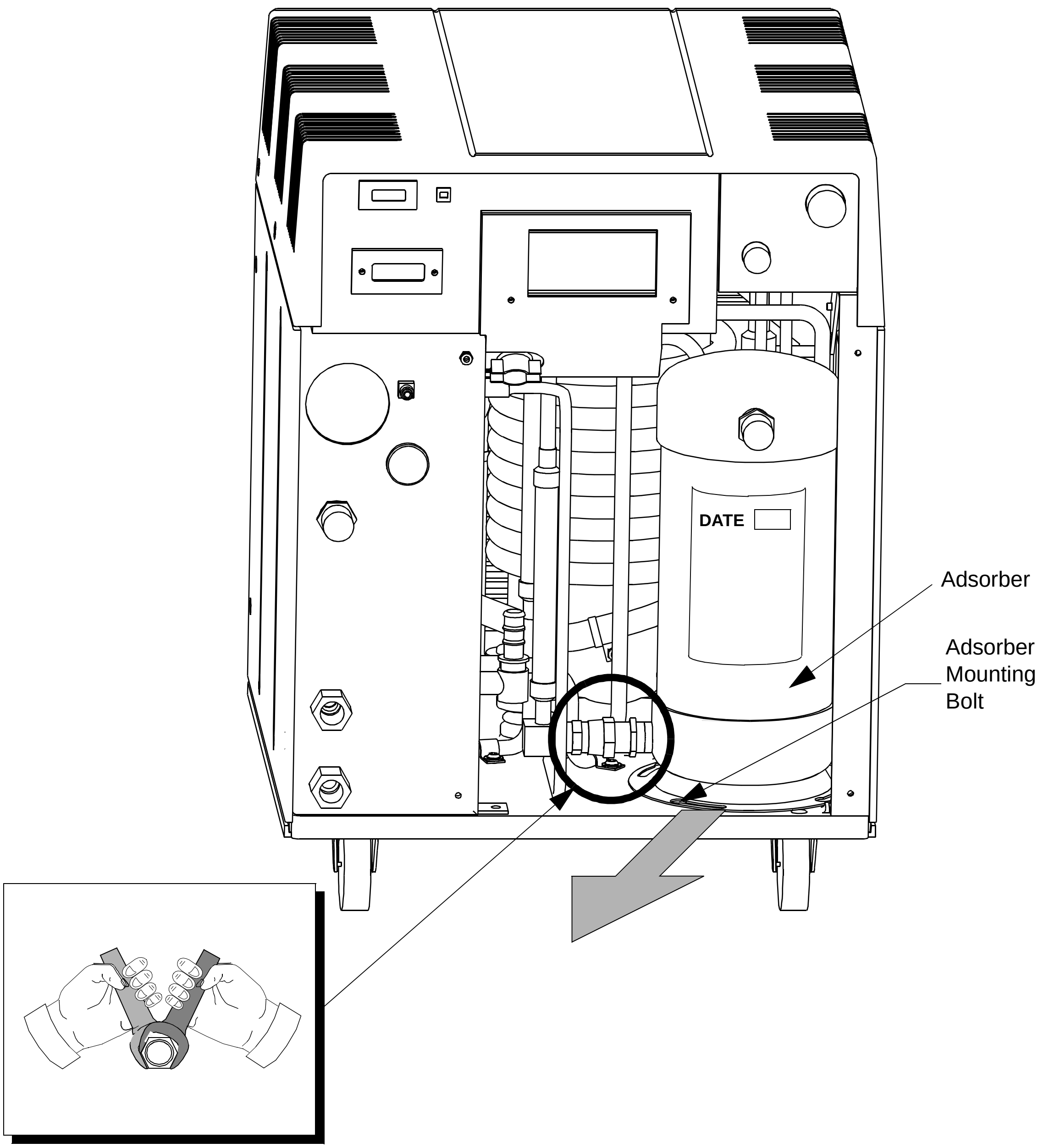


Figure 5-2: Adsorber Location, 9600 Compressor (Rear Panel Removed)

Adjusting System Helium Pressure

NOTE: *These procedures can be performed on a compressor that is turned ON or OFF. However, the helium pressure gauge should be set to the ("OFF" Condition) helium charge pressure value if the compressor is turned OFF or set to the normal system operating pressure if the compressor is turned ON. Refer to* "Section 4 - Operation" *for more information.*

Reducing Helium Pressure

NOTE: *You must obtain the normal system operating pressure from the* "Compressor Operation" *procedure in* "Section 4 - Operation" *in order to perform this procedure. If the normal system operating pressure is unknown, then shut the compressor OFF and perform the* ""OFF" Condition Helium System Pressure Verification" *procedure in* "Section 4 - Operation" *instead.*

1. Remove the flare cap from the gas charge fitting as shown in Figure 5-3.

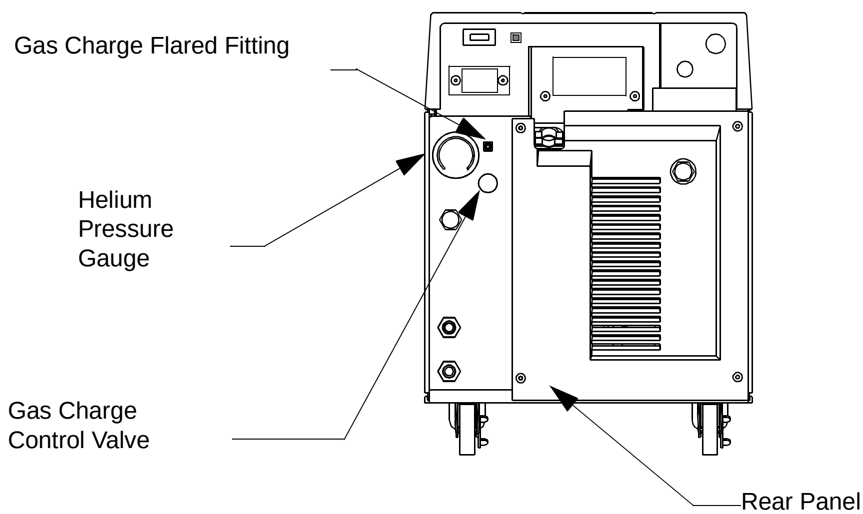


Figure 5-3: Helium Pressure Control Components

2. Open the gas charge control valve *very slowly* to allow a slight amount of helium to escape. Leave the valve open until the helium pressure gauge indicates one of the following:

   - To the appropriate value in Table 4-1 if the compressor is OFF and acclimated to a temperature between 60º F and 80º F (15.5º C - 26.6º C).

- To the value previously recorded in the “Compressor Operation” procedure in “Section 4 - Operation” if the compressor is ON.

3. Close the gas charge control valve and install the flare cap.

Increasing Helium Pressure

Use the following procedure to increase the helium pressure if the indicated pressure is below the appropriate value as shown in Table 4-1.

> **CAUTION**
> If helium is being added more than once every several months, check for leaks caused by improperly connected self-sealing connections or any mechanical joint in the Compressor.

Adding Helium

NOTE: *You must obtain the normal system operating pressure from the “Compressor Operation” procedure in “Section 4 - Operation” in order to perform this procedure. If the normal system operating pressure is unknown, then shut the compressor OFF and perform the “"OFF" Condition Helium System Pressure Verification” procedure in “Section 4 - Operation” instead.*

This procedure ensures that both the regulator and the charging line will be purged of air and that the air trapped in the regulator will not diffuse back into the helium bottle. For best results, CTI-CRYOGENICS suggests a dedicated helium bottle, regulator, and line, which are never separated, for adding helium.

NOTE: *You are required to supply the helium charging line terminating in a 1/4-inch female flare fitting, and a two-stage pressure regulator rated at 0-3000/0-400 psig for this operation.*

> **CAUTION**
> Use only 99.999% pure helium gas. Helium circuit contamination may result if a lower quality of helium is used.

1. Attach a regulator (0-3000/0-400 psig) and charging line to a helium bottle (99.999% pure).

NOTE: *Do not open the bottle at this time.*

2. Purge the regulator and charging lines as follows:
    a. Open the regulator a small amount by turning the adjusting knob clockwise until it contacts the diaphragm, then turn approximately 1/8 to 1/4 turn more, so that the regulator is barely open.
    b. Loosely connect the charge line to the helium pressure regulator.
    c. Slowly open the bottle valve, and purge the regulator and line for 10 to 15 seconds. Turn the regulator knob counterclockwise until the helium stops flowing.
3. Remove the flare cap of the gas charge flared fitting on the rear of the Compressor.
4. Loosely connect the charging line from the helium pressure regulator to the 1/4-inch male flare fitting installed on the helium charge valve. Purge the charge line again, as in step a, for 30 seconds, and tighten the charge line flare fitting onto the gas charge fitting while the helium is flowing.
5. Set the helium pressure regulator to 300 psig (20.7 bars). If the compressor is ON, proceed with step a. If the compressor is OFF, proceed with step b.
    a. Obtain the previously recorded *normal system operating pressure* from the "Compressor Operation" procedure in "Section 4 - Operation". Open the gas charge control valve *very slowly* and allow helium to flow until the compressor gauge reading is the same as the value obtained from "Section 4 - Operation". Quickly close the gas charge control valve.
    b. Obtain the appropriate (50 or 60 Hz) *("OFF" Condition) system operating pressure* from Table 4-1. Open the gas charge control valve *very slowly* and allow helium to flow until the compressor gauge reading is the same as the appropriate value in Table 4-1. Quickly close the gas charge control valve.
6. Ensure that the helium charge valve on the Compressor is tightly closed. Shut off the helium pressure regulator on the helium bottle and remove the charging line from the male flare fitting. Reinstall the flare cap.

HELIX

Appendix A - Customer Support Information

Customer Support Center Locations

To locate a Customer Support Center near you, please visit our website ***www.helixtechnology.com*** on the world wide web and select *CONTACT* on the home page.

Guaranteed Up-Time Support (GUTS®)

For 24-hour, 7-day per week Guaranteed Up-Time Support (GUTS) dial:

1 800-367-4887 - Inside the United States of America

+1 ***508-337-5599*** - Outside the United States of America

Product Information

Please have the following information available when calling so that we may assist you:

- Product Part Number
- Product Serial Number
- Product Application
- Specific Problem Area
- Hours of Operation
- Equipment Type
- Vacuum System Brand/Model/Date of Manufacture

E-mail

For your convenience, you may also e-mail us at:

techsupport@helixtechnology.com

Appendix B - Flow Diagram

Figure B-1 shows the 9600 compressor flow diagram.

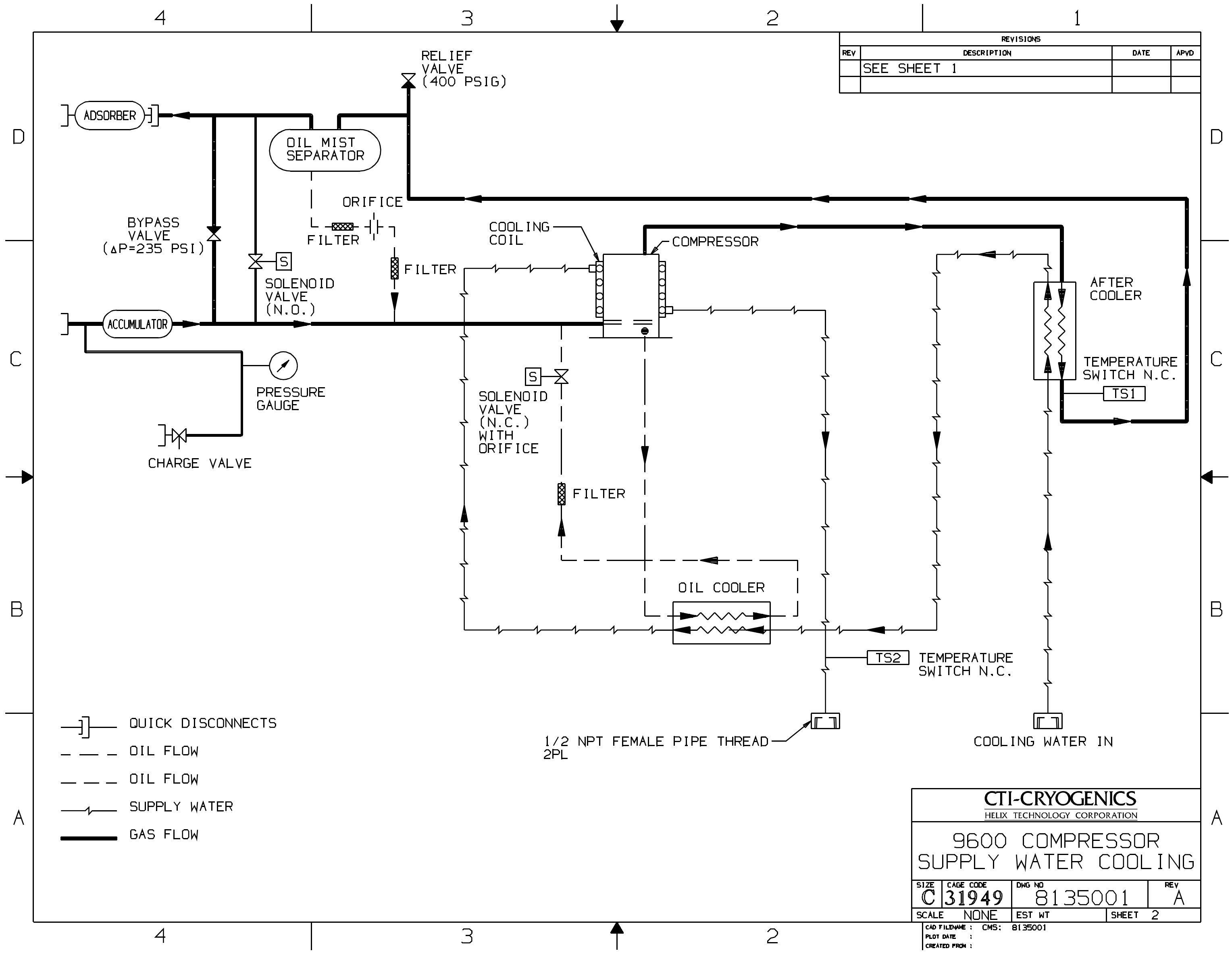


Figure B-1: 9600 Compressor Flow

Appendix C - Troubleshooting Procedures

Troubleshooting the Compressor

The compressor troubleshooting procedures are summarized in Table C-1.

Technical Inquiries

Please refer to "Appendix A - Customer Support Information" of this manual for a complete list of the

CTI-CRYOGENICS' world wide customer support centers.

WARNING

Disconnect the compressor before performing any troubleshooting procedures.The compressor pump is hot after operating. Wait for the pump to cool down before working on the inside of the compressor

Do not change or modify any compressor internal wiring circuits, this may cause failure of the compressor and cold head due to improper phasing.

Table C-1: Compressor Troubleshooting Procedures

Problem	Possible Cause	Corrective Action
1) System circuit breaker (CB1) trips immediately to the OFF (0) position when switched to the ON (1) position.	1) Incorrect phasing of input power.	1) Check phasing of input power. Refer to "Phase Check" in "Section 3 - Installation".
2) System (CB1) and Control Circuit (CB2) circuit breakers remain in the ON (1) position when switched ON but the compressor will not run.	1) No power coming from source.	1) Check source fuses, circuit breakers, and wiring associated with the power source. Repair as needed.
	2) Insufficient power	2) Verify adequate phase-to-phase input voltage. Refer to Table 1-2.
	3) Remote control jumper plug not in place. This will apply only if remote circuit *is not* being used.	3) Check to insure that remote jumper plug is fully seated. See Figure 1-4 for location. Refer to "Compressor Remote Connector" in "Section 1 - 9600 Compressor Description" for more information.
	4) Improperly wired external remote control circuit. **NOTE:** Only applies if remote control feature is being used.	4) Verify correct installation of remote control feature. Refer to Table 1-6.

Table C-1: Compressor Troubleshooting Procedures (Continued)

Problem	Possible Cause	Corrective Action
3) System circuit breaker (CB1) will not remain in the ON (1) position when switched ON. The Control Circuit circuit breaker (CB2) trips when excessive current is being drawn by the cold head or 24 volt compressor control circuits.	1) Damaged On-Board power cable, connectors, or drive motor. 2) Damaged component in the compressor power or control circuit.	1) Check for compressor operation with cryopump cable disconnected from compressor. Refer to “Appendix A - Customer Support Information” to contact the Customer Support Center if the compressor operates improperly. 2) Refer to “Appendix A - Customer Support Information” to contact the Customer Support Center.
4) System circuit breaker (CB1) remains in the ON (1) position and the compressor stops after several minutes of operation and remains OFF (0).	1) Thermal protective switches are open. 3) Very cold water has caused a restriction of oil flow through the oil injection orifice during start-up.	1) Check for inadequate water cooling. Refer to Table 1-3. 3) Recheck for proper cooling water temperature. Refer to Table 1-3. Restart compressor repeatedly until continuous operation is achieved.
5) System circuit breaker (CB1) trips after a period of running.	1) Loss or degradation of power from the source. 2) Defective motor windings.	1) Check that line voltage is correct on all phases. 2) Check running current on all phases. 3) Refer to “Appendix A - Customer Support Information” to contact the local Customer Support Center.

Appendix D - Schematic

Introduction

The schematic in Appendix C supports the 9600 (Low Voltage) Compressor CTI-CRYOGENICS P/N 8135164P001.

Table D-2: Basic Control Assembly Legend

Identifier	Description
1M	Compressor Motor
J15	Module Power Receptacle
J1/P1	Autoset Power Connector
J2/P2	Unload Solenoid Connector
J3/P3	Oil Solenoid Connector
J4/P4	
J5/P5	
J6/P6	Compressor Contactor Coil
J7/P7	Output Connector
CB1	Main Circuit Breaker (25A)
CB2	Control Circuits Circuit Breaker (7A)
ETM1	Elapsed Time Meter
M1	Contactor 7.5 HP IEC
M1OL	Relay, Overload (16-24A)
PM1	Phase Monitor OMRON RDR-TFY-M
PWB1	PWB Autoset
T4	Transformer Assembly Control
LT1	Lamp, 24-28V LED Green
J8/P8	ETM1 Connector
J9/P9	LT1 Connector
J10/P10	T3 Input Connector

Table D-2: Basic Control Assembly Legend (Continued)

Identifier	Description
J11	Open
J12	Module Signal Connector
J13/P13	Phase Monitor
J14	Open
J15	Cryo Power Output
K2	Over Temperature Lockout Relay

Table D-3: On-Board/Cryo Electrical Module P/N 8135127G001 Legend

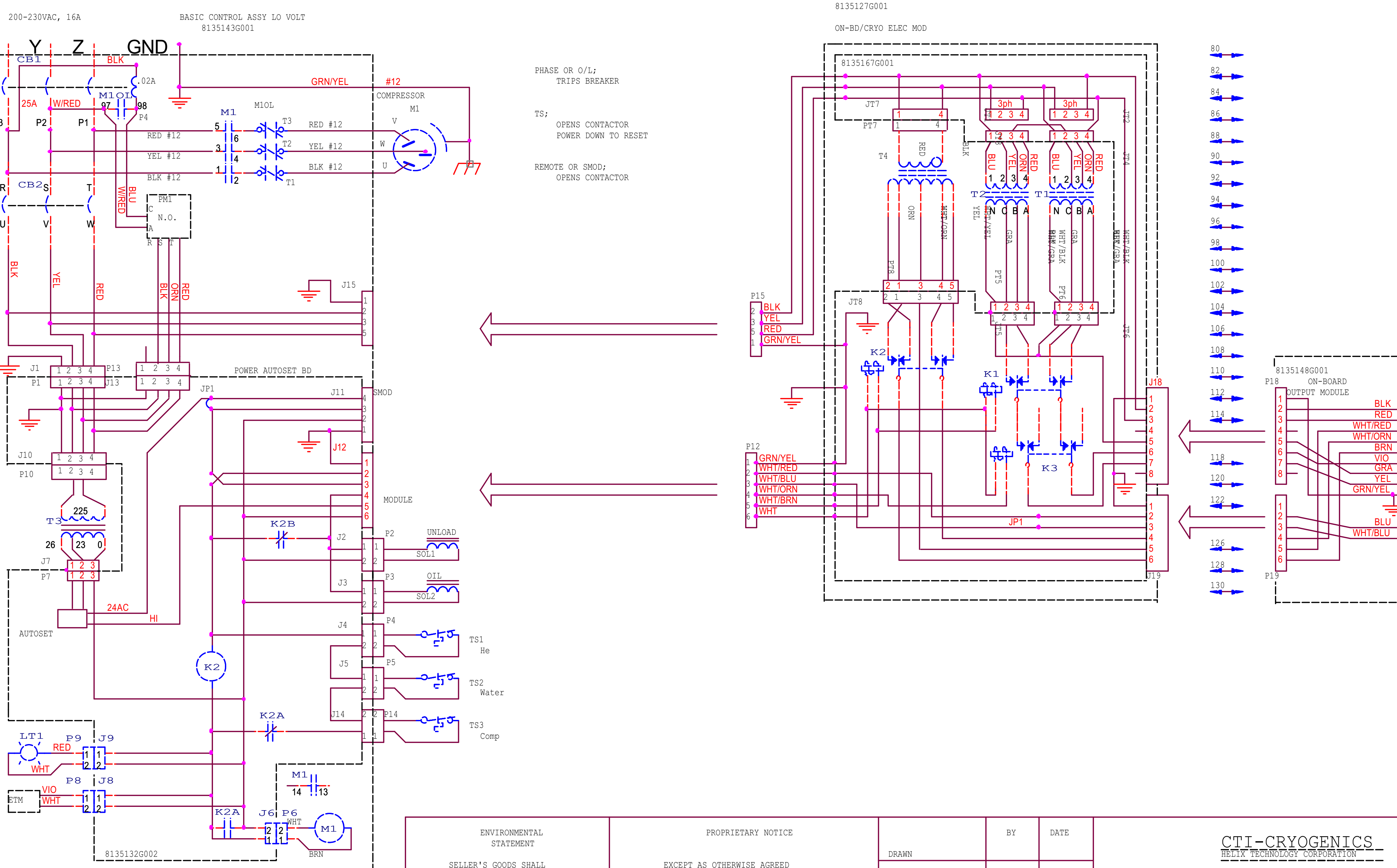
Identifier	Description
JT1	Open
JT2	Open
JT3/PT3	T2 Cold Head Supply, 2 phase
JT4/PT4	T1 Cold Head Supply, 2 phase
JT5/PT5	T2 Cold Head Transformer Output
JT6/PT6	T1 Cold Head Transformer Output
JT7/PT7	T3 Supply
JT8/PT8	T3 Low Voltage Output (23/26 VCT)
J18	Power Output
J19	Signal Output
P12	Signal Connector
P15	Power Connector
K1	Cold Head Voltage Relay
K2	Signal Voltage Relay
K3	Cryo Power Relay
T1	Cold Head Supply
T2	Cold Head Supply
T3	Low Voltage Supply

Table D-4: On-Board Output Module P/N 8135148G001 Legend

Identifier	Description
J30	On-Board Output Receptacle
J31	Remote Control Receptacle
P18	Power Connector
P19	Signal Connector
P31	Remote Jumper

REVISIONS

REV		DESCRIPTION		DATE
100		REVISED PER ECO 16163	HH	1/04



ENVIRONMENTAL STATEMENT	PROPRIETARY NOTICE
SELLER'S GOODS SHALL NOT BE MANUFACTURED WITH OR CONTAIN CLASS I ODS'S AS DEFINED UNDER SECTION 602 OF THE FEDERAL CLEAN AIR ACT (42 USC SECTION 7671A) OR ANY NEW APPLICABLE REGULATIONS.	EXCEPT AS OTHERWISE AGREED IN WRITING, THE INFORMATION AND DESIGN DISCLOSED HEREIN ARE THE PROPERTY OF CTI-CRYOGENICS AND MUST NOT BE COPIED OR DISTRIBUTED OUTSIDE CTI-CRYOGENICS EXCEPT TO AUTHORIZED PERSONS WITH A GENUINE NEED-TO-KNOW WHO BY THE USE HEREOF ACKNOW-LEDGE CTI-CRYOGENICS OWNER-SHIP AND AGREE TO MAINTAIN THIS INFORMATION AND DESIGN

	BY	DATE
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CHECKED		
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ENG APPVL	VG	
ENG APPVL		
PRE-PROD		
PROD	GW	

CTI-CRYOGENICS
HELIX TECHNOLOGY CORPORATION

SCHEMATIC, 9600
COMPRESSOR, LOW VOLT

SIZE	CAGE CODE	DWG NO
		8135164P

ORCAD V7.11

CAD FILENAME: 8135164P001.DSN

Index

O

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W

Acme Electric Corporation

INSTRUCTION SHEET
SPS/CPS SERIES

FEATURES

- Voltage adjustment potentiometer
- Fold back current limiting
- 115/230 Vac, 47-440 Hz input
- ±0.1% line regulation
- ±0.1% load regulation
- Temperature compensated circuitry
- 0.1% ripple
- Optional overvoltage protection
- Optional square current limiting

DESCRIPTION
The SPS and CPS Series are series regulated, solid state power supplies designed to provide closely regulated DC voltages in all popular voltage and current levels. The output is floating, hence any voltage may be plus or minus or referenced to another voltage.

OPERATING PROCEDURE
For 115 Vac, 47-440 Hz, connect input leads to terminals 1 and 4 of transformer or input terminal block. Terminals 1 & 3 and 2 & 4 will be jumpered. (Factory connection.)

For 230 Vac input, remove jumpers between 1 & 3 and 2 & 4. Then jumper terminals 2 and 3 together and connect ٦ Vac to terminals 1 and 4. Suggest twisted AC input wires ectrical noise reduction is prime concern.

Output terminals identified in figures on back of this sheet are marked + and -. Load should be connected to these terminals with due care to proper wire size and solid electrical connection for best results. Output voltages may be adjusted with the potentiometers identified in the figures located on the back of this sheet.

SUGGESTED TEST PROCEDURE
Connect AC input power as outlined in operating procedure. Place a variac between Vac source and input to transformer. Place an AC voltmeter across transformer input terminals 1 and 4. Set input voltage for nominal 115 Vac with variac.

Place resistive load across output, check Vdc output specifications. DC voltmeter should be connected directly across output terminals. Greatest test errors are made at this point.

LINE REGULATION
With output adjusted to rated load voltage, reduce input Vac to 104 volts and record or note output voltage. Then increase input Vac to 126 Vac and note output voltage. Total ıt voltage change should not exceed .2% or ±.1%.

LOAD REGULATION
Set AC input voltage to 115 Vac. Place DC voltmeter across output terminals and record or note output voltage. A load resistor, equal to the rated load of the supply at selected DC voltage setting, is then applied to output terminals. The voltage change should be noted. This differential change should not exceed .2% or ±.1% of DC output voltage.

Output current adjust is accomplished by placing a load resistor of the desired value across output terminals: adjust current limit potentiometer identified in figures on back of this sheet until voltage starts to drop. This is the fold back point of current limiting. This control is factory set to 120% of rated output and sealed.

RIPPLE
With voltage set at 115 volts and full load across DC output terminals, the measurable AC voltage on output should not exceed 0.1% peak to peak.

OVERVOLTAGE PROTECTION
Optional overvoltage protection is available on most models. Consult the catalog selection guide or the listing on the next page for appropriate models or contact the factory of application note.

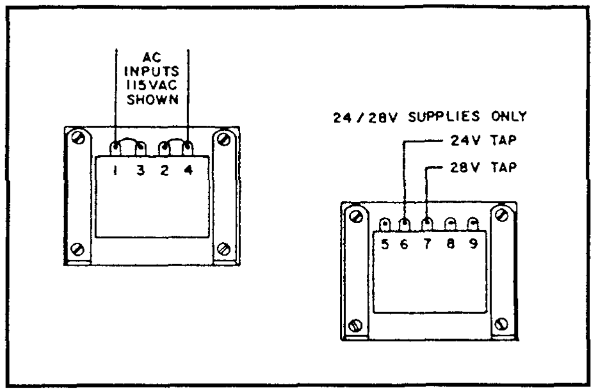
Load generating high back EMF voltages should be checked with parallel diode, zener, or series diode to reduce detrimental effects on pass elements. It is recommended that the AC input circuit be fused. A suggested fuse rating is listed on the reverse side of this sheet.

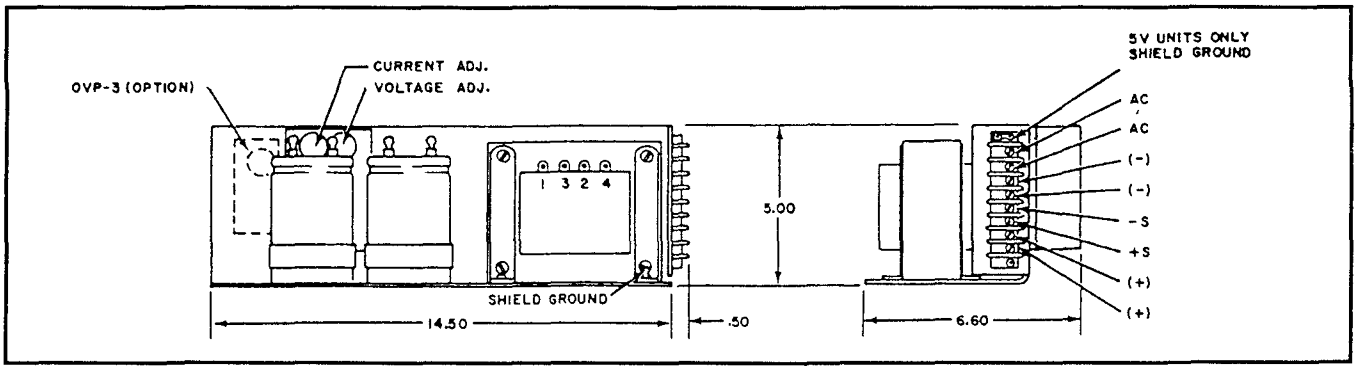
SUGGESTED PRACTICES
Moving air is desirable when mounting in a confined area. Chassis may be attached to other heat dissipating surfaces to improve cooling characteristic at maximum ratings.

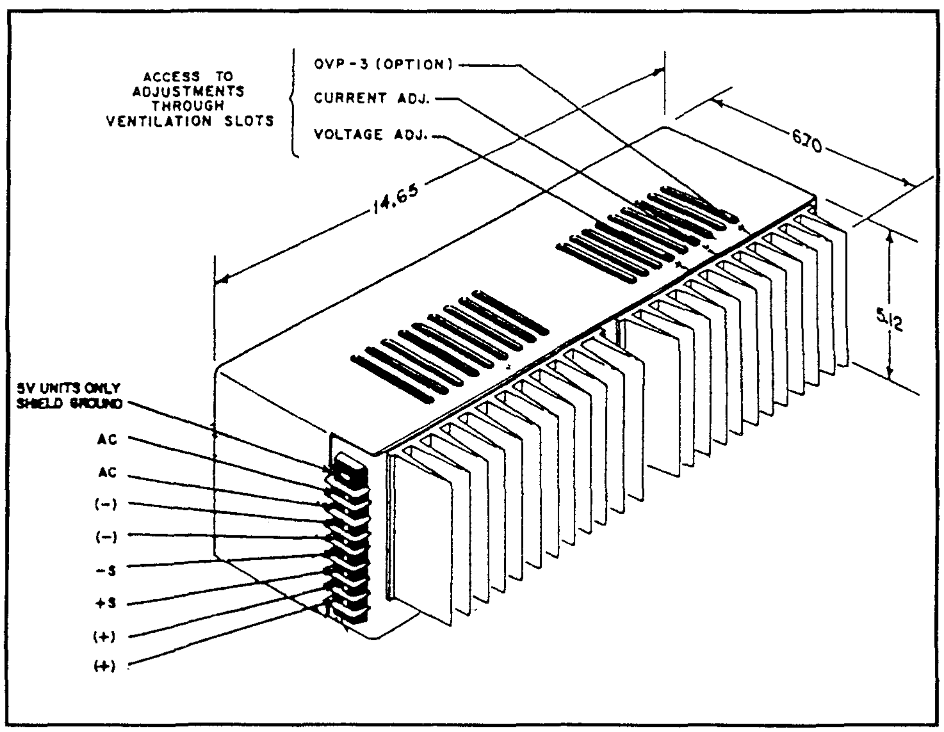
9962 Route 446, Cuba, New York 14727; Telephone (716) 968-2400; Fax (716) 968-3948

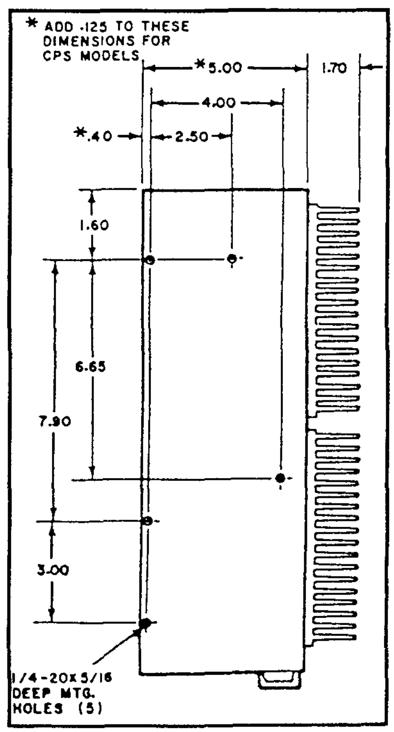
NOTES:

1. Recommended input fuse: SPS/CPS 220 6A
2. OVP-3 is compatible with 5 volt through 28V SPS/CPS 220 models. OVP-12 is for use with 5V units only.
3. Remote sense is provided on all models. Factory installed jumpers on the output terminal block are provided for the local sense mode.



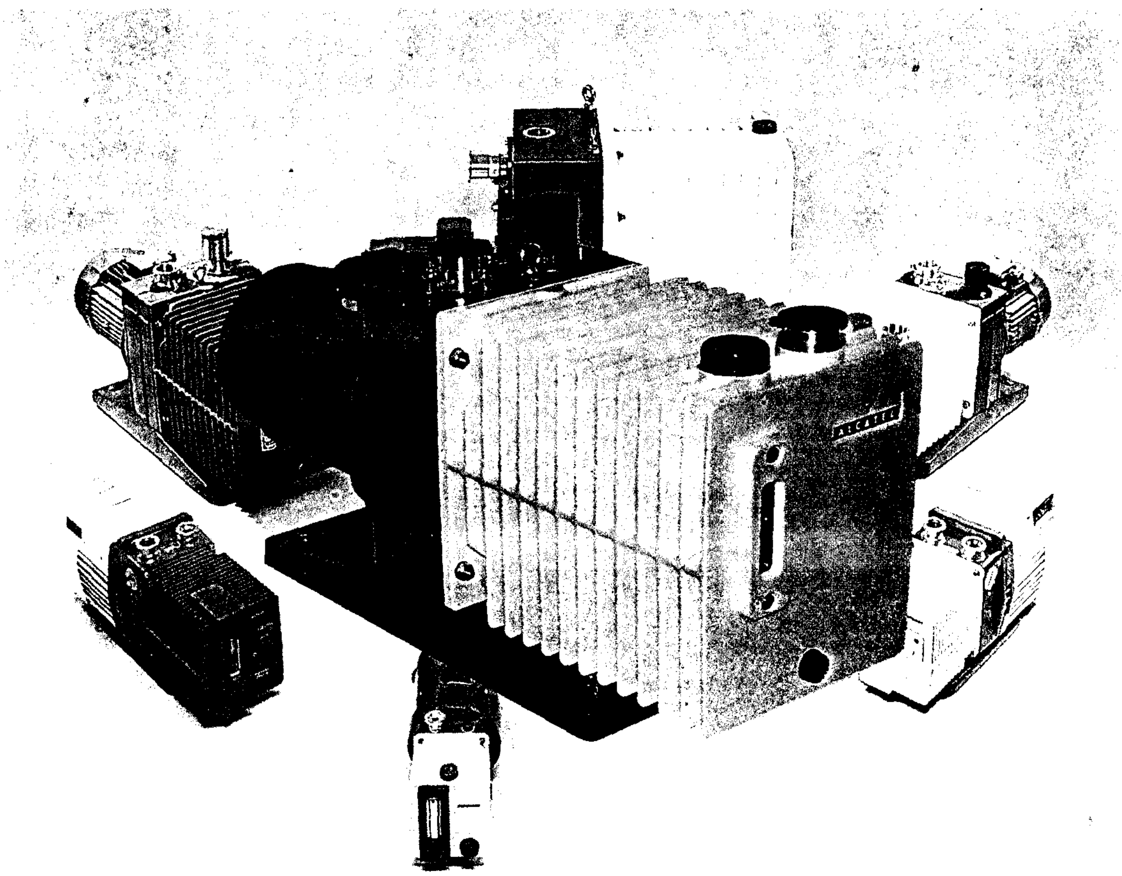






33 - 63 m³/h Pascal Series
SD, C1, C2 Series

LES POMPES PRIMAIRES À PALETTES
ROTARY VANE PUMPS
DREHSCHIEBERPUMPEN



Manuel de l'Utilisateur
User's Manual
Bedienungsanleitung

ALCATEL

Contents

Presentation of the product range

A wide range

Specific solutions adapted to various applications

Alcatel oil seal rotary vane pumps are used in many vacuum technology applications.

They can be used on their own to achieve a maximum vacuum of 10^{-3} Torr (10^{-3} mbar), or in pumping assemblies, e.g. at the exhaust of a diffusion pump or turbomolecular pump.

SD Series

Standard pumps for several purposes (non-corrosive applications).
Manufacture of light bulbs, production of TV tubes, manufacture of electronic tubes, metallurgy, centrifuges, etc.

C1 Series

Pumps suited to the pumping of corrosive gases.
R&D, laboratories, freeze-drying, pumping of solvents, etc.

C2 Series

Pumps with increased resistance to meet the requirements of the more aggressive processes of the semiconductor industry.
Ion implantation, sputtering, etc.

H1 Series

Sealed pumps offering maximum tightness (separate instruction manual).
Pumping of pure or precious gases.

Nom. fl. rate m^3/h		30	60
SD Series	1 stage	1033SD	1063SD
	2 stages	2033SD	2063SD
C1 Series	1 stage	1033C1	1063C1
	2 stages	2033C1	2063C1
C2 Series	2 stages	2033C2	2063C2
H1 Series	2 stages	2033H1	2063H1

33 and 63 m^3/h rotary vane pumps.
SD, C1, C2 Pascal series

Th. , and 63 m^3/h pump models with the following main characteristics:

- A **direct drive motor** makes them very compact.

- An **anti-suckback system** ensures the tightness of the pump during accidental or voluntary shutdowns.

- A **gas ballast** enables the pumping of condensable vapours.

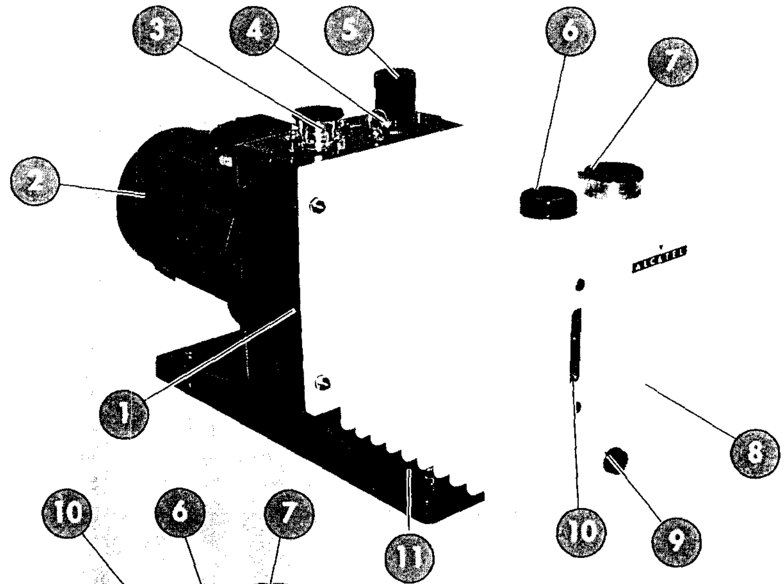
- The three-phase **motor** can be disassembled **independently** of the rest of the pump, without the need to drain the oil case.

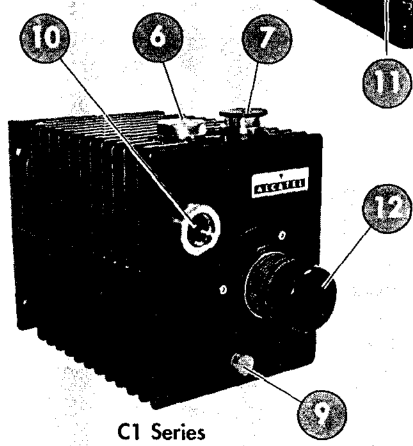
- On the oil case, a **vertical sight glass** (circular on C1 Series) can be used to inspect the oil level easily when filling the oil case and during the operation of the pump.

- A **neutral gas purge** is used to c oil and dilute pumped gases on C1 and C2 series models.

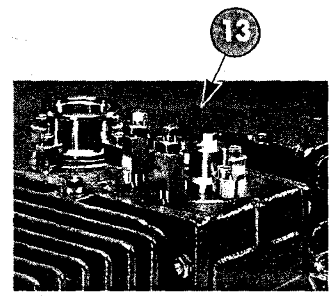
- An **oil casing purge** is used to dilute the pumped gases on C2 series models.

- Sensor connections for pump operation monitoring are available on C2 series models.





C1 Series



Sensor connections on 2033 C2

1. Central housing
2. Electric motor
3. Inlet end fitting
4. Lifting eyes
5. Gas ballast control
6. Filling plug
7. Exhaust end fitting
8. Oil case
9. Draining plug
10. Oil level sight glass
11. Base
12. Oil filter (C1 series)
13. Sensor connections (C2 series)

The inlet and exhaust end fittings are PNEUROP DN40 ISO-KF standard. They are fitted vertically on the pump. They can also be used to connect many of our accessories (***see page 73***).

The main remplacement parts are interchangeable: This enables easier disassembly-assembly operations and replacement without changing the pump's performance.

Various accessories can be used to adapt the pump to meet the requirements of your application.

The cast iron pump central housing supports the pumping module and the motor. Pumps C1 and C2 series are free of zinc, copper and cadmium.
Pumps SD series include carbon steel, elastomers like nitril (NBR) and bearings in copper alloy.
The other construction materials include cast iron, aluminium alloy, stainless steel, fluorocarbons (FPM) and chemically resistant polymers.

Operating principle of the rotary vane pump

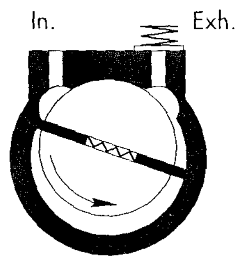
Single-stage rotary vane pump

This is a volumetric pump, with a functional part composed of:

- A hollow cylindrical stator with inlet and exhaust valves.
- A rotor mounted eccentrically inside the stator for pumping.
- Two vanes sliding in the rotor, forced against the stator by centrifugal force and springs.

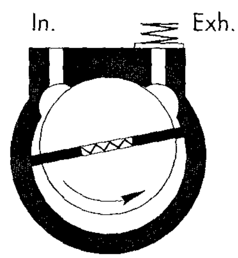
The pumping cycle is given below:

Inlet



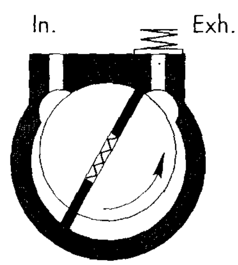
As the vane passes in front of the inlet orifice, an increasing space is formed into which the gas from the chamber to be evacuated expands. When the second vane passes, the space is closed.

Transfer



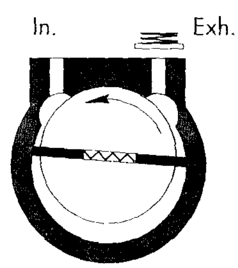
The gas trapped in the space between the two vanes is transferred to the exhaust orifice as the rotor rotates.

Compression



The space communicates with the exhaust, which is fitted with a valve: the gas is compressed until the safety valve is opened.

Exhaust

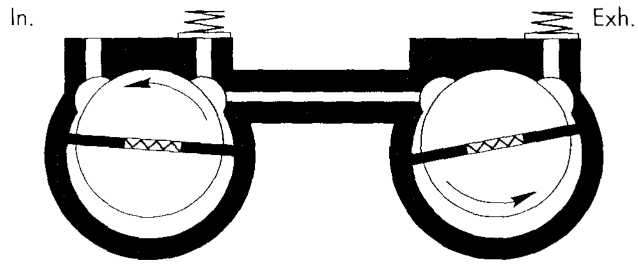


The gas is expelled into the oil casing when the pressure is sufficient to open the valve.

Application Single stage rotary vane pumps are the best choice for continuous pressures above 1.0 Torr (1.3 mbar), as well as applications where large amounts of condensable gases are present.

Two-stage rotary vane pump

To improve the backing pressure and flowrate at low pressure, two stages are connected in series. The second is similar to the first both structurally and operationally. The gases pulled in by the first (low pressure) stage are transferred to the second (high pressure) stage and discharged through the high pressure (HP) valve.



Low pressure stage **High pressure stage**

Application

Two stage rotary vane pumps are the best choice for application requiring an ultimate vacuum as low as 5 x 10^{-3} mbar.
Note : when operating a two stage vane pump continously, greater than half an hour, above 1.0 Torr, the unit should be eventually equipped with an oil mist eliminator and oil return system (**consult us**), or a single stage pump should be used.

Oil

Its function

Oil has several important functions in the pump:
- It lubricates mechanical components (bearings, seals, rotor, vanes, etc.).
- It makes moving parts relatively tight by limiting internal leakage.
- It carries away the heat produced by the compressed gases.

Choosing the right oil

Not all oils produce the same ultimate pressure in a given pump. Ultimate pressure depends on the saturated vapour pressure of the oil, its viscosity and its ability to dissolve gases.
Good pumping conditions are related to the type of oil used.
The choice depends on:
- Expected pump performance.
- Chemical aggression and corrosion of pumped gases.
- Accessories used.
- Desired maintenance intervals and total operating cost.

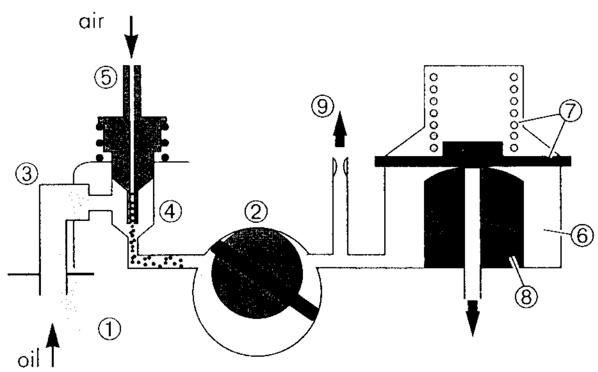
ALCATEL has selected various types of oil for its pumps (***see page 77***).

Lubrication / Anti-noise / Anti-suckback

Lubrication

The pump is equipped with a lubrication system which regulates the oil flow rate required in the vacuum pump. In addition this system also ensures the gasing of the lubrication oil and therefore the low noise level of the pump at ultimate pressure (without gas introduction).

When the pump begins to operate, the cooled oil (from the bottom of the oil casing) is pulled in by the oil pump (2) and drawn in through the oil inlet tube (3). It is then agitated by a venturi tube (4) and forced into the chamber (6) which is adjusted by the diaphragm spring system (7).
The discharge pressure of the oil pump (2) lifts the diaphragm off its seats (8) allowing oil to reach the functional block via the oil injection line (through seats) (8). An orifice (9) equipped with a jet located in the oil lubrication system allows trapped gases to be expelled out of the chamber (6).



C1 series pumps are equipped with an automobile type oil filter, which traps particles from the oil pumps exhaust. Due to its construction, its life time is reduced when pumping on corrosive products in large quantities. In this case, an auxiliary oil filtering system is recommended (***see page 73***) and the filter is replaced by a stainless steel short-circuit stopper.

Anti-noise

Parallel to the oil flow, there is a small orifice in the venturi tube (5), which reduces the noise level at ultimate pressure. Because of the negative pressure created at the end of the venturi tube (5), gases are entrained into the moving layers of oil dampening pump noise, allowing the fluid to become more compressible.
The added gases will affect the ultimate pressure, therefore, a compromise between sound level and ultimate pressure has to be reached as follows:

- Tightening down air intake tube (5) decreases the oil flowrate at the intake of the oil pump (2) and increases the amount of gas mixture in the oil. The sound level decreases but the ultimate pressure increases.
- Unscrewing tube (5) increases the oil flowrate at the intake of the oil pump (2) and decreases the amount of air mixture with the oil. The sound level increases but the ultimate pressure decreases.

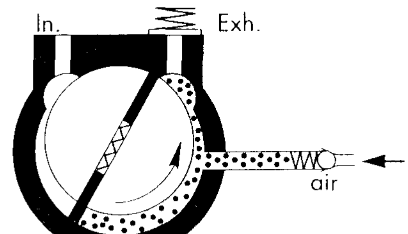
This adjustment can be performed via the oil fill port while the pump is in operation at ultimate pressure.(a plug is designed for this purpose on the oil case single stage pump).

Anti-suckback

When the pump is stopped or the power is turned off, the anti-suckback device (6), (7) and (8) isolates the functional block of the pump against air or oil returning to the chamber being evacuated..
When the pump stops, the discharge pressure of the oil pump (2) drops rapidly through the jet (9). Diaphragm (7) under pressure from spring and the difference of pressure is forced againts its seat (8) thus closing off the injection line through the seat (8).
The seal is also ensured by flush-mounted o-rings between the faces of the functional parts (stators, flanges, housing...) and by spring loaded check valves in the discharge ports.

Gas ballast

When condensable vapours are being pumped, gas is compressed beyond its saturated vapour pressure in the "compression" phase and can condense, impairing pump performance and life.



COMPRESSION

The gas ballast can be used to inject a certain quantity of air (inert or dry gas) into the last stage of the pump during the "compression" phase so that the partial pressure of the pumped gas is less than its saturated vapour pressure at the temperature of the pump. Condensation is therefore impossible if this limit is not reached. The maximum admissible vapour pressure is obtained at pump inlet for this value.

At the end of "compression", the pressure in the exhaust chamber is greater than atmospheric pressure. An anti-suckback device (valve + spring) prevents the gases and oil from being draw back into the inlet.

The saturated vapour pressure of a body is higher when the system is hot than when it is cold; therefore, the pump must reach operating temperature before pumping condensable vapours.

- Using the gas ballast increases the ultimate pressure of the pump as well as the temperature.
- The gas ballast control, located on the frame cannot be used to set the gas injection flow rate.
- When the gas ballast control is open, the pump is not tight when stopped. To guarantee this tightness, install an automatic gas ballast. **(*see page 73*)**

- C1 and C2 series: because of the danger present if the gas ballast was to be opened to atmosphere, remove the plug and connect the port to a neutral gas supply line.

Technical characteristics

For industry: SD Series

Two-stage pumps

Characteristics	Unit	2033 SD		2063 SD	
Frequency	Hz	50	60	50	60
Number of stages		2		2	
Rotation speed	rpm	1500	1800	1500	1800
Nominal flow rate	m3/h	**30**		**60**	
	cfm		23.3		42.4
Flow rate Pneurop method	m3/h	**27**		**55**	
	cfm		18.8		38
Partial ultimate pressure [1]	Torr/mbar	**1.5x10^{-4} / 2x10^{-4}**		**2.25x10^{-4} / 3x10^{-4}**	
with Alcatel 120 oil	/Pa	**2x10^{-2}**		**3x10^{-2}**	
Ultimate pressure	Torr/mbar	**2.25x10^{-3} / 3x10^{-3}**			
with gas ballast closed	/Pa	**3x10^{-1}**			
Ultimate pressure	Torr/mbar	**1.5x10^{-2} / 2x10^{-2}**			
with gas ballast open	/Pa	**2**			
Oil capacity	l	3.6		7	
Weight (pump + motor) [2]	kg (lbs)	61 (134)		93 (205)	
Maximum water vapour pumping	mbar	**30**		**25**	
capacity	Pa	3x10^{3}		25x10^{2}	
Water vapour pumping capacity	g/h	700		1200	
Inlet and exhaust end fittings	ISO-KF	DN 40			

Corrosive applications C1 Series

Two-stage pumps

Characteristics	Unit	2033 C1		2063 C1	
Frequency	Hz	50	60	50	60
Number of stages		2		2	
Rotation speed	rpm	1500	1800	1500	1800
Nominal flow rate	m3/h	**30**		**60**	
	cfm		23.3		42.4
Flow rate Pneurop method	m3/h	**27**		**55**	
	cfm		18.8		38
Partial ultimate pressure [1]	Torr/mbar	**1.5x10^{-4} / 3x10^{-4}**			
with Alcatel 120 oil	/Pa	**3x10^{-2}**			
Ultimate pressure	Torr/mbar	**2.25x10^{-3} / 3x10^{-3}**			
with gas ballast closed	/Pa	**3x10^{-1}**			
Ultimate pressure	Torr/mbar	**1.5x10^{-2} / 2x10^{-2}**			
with gas ballast open	/Pa	**2**			
Oil capacity	l	3.6		7	
Weight (pump + motor) [2]	kg (lbs)	74 (163)		98 (216)	
Maximum water vapour pumping	mbar	**30**		**25**	
capacity	Pa	3x10^{3}		25x10^{2}	
Water vapour pumping capacity	g/h	700		1200	
Inlet and exhaust end fittings	ISO-KF	DN 40			

(1) Partial ultimate pressure measured according to Pneurop 6602 specifications with Alcatel 120 oil charge. It may vary if other oils are used ***(See page 77).***
(2) These values are for pumps equipped with three-phase motors.

Note: The pressure measurements were made with a capacitive diaphragm pressure gauge measuring a total pressure in the absence of a cold trap. Measurements using a Pirani type gauge can give different pressure values.

Corrosive applications

C2 Series

Two-stage pumps

Characteristics	Unit	2033 C2		2063 C2	
Frequency	Hz	50	60	50	60
Number of stages		2		2	
Rotation speed	rpm	1500	1800	1500	1800
Nominal flow rate	m3/h	**30**		**60**	
	cfm		23.3		42.4
Flow rate Pneurop method	m3/h	**27**		**55**	
	cfm		18.8		38
Partial ultimate pressure (1)	Torr/mbar	**3.75×10^{-4} / 5×10^{-4}**			
with Alcatel 113 oil	/Pa	5×10^{-2}			
Ultimate pressure	Torr/mbar	**2.25×10^{-3} / 3×10^{-3}**			
with gas ballast closed	/Pa	3×10^{-1}			
Oil capacity	l	3.6		7	
Weight (pump + motor) (3)	kg (lbs)	76 (167)		98 (216)	
Inlet and exhaust end fittings	ISO-KF	DN 40			

(1) P... ultimate pressure measured according to Pneurop 6602 specifications with Alcatel 113 oil charge. It may vary if other oils are used *(S... 77).*

(2) ... values are for pumps equipped with three-phase motors.

Note: The pressure measurements were made with a capacitive diaphragm pressure gauge measuring a total pressure in the absence of a cold trap. Measurements using a Pirani type gauge can give different pressure values.

For industry SD Series
Single-stage pumps

Characteristics	Unit	1033 SD		1063 SD	
requency	Hz	50	60	50	60
Number of stages		1		1	
Rotation speed	rpm	1500	1800	1500	1800
Nominal flow rate	m3/h	**30**		**60**	
	cfm		23.3		42.4
Flow rate Pneurop method	m3/h	**27**		**55**	
	cfm		18.8		38
Ultimate pressure [1]	Torr/mbar	**$3.75x10^{-2}$ / $5x10^{-2}$**			
with gas ballast closed	/Pa	**5**			
Ultimate pressure	Torr/mbar	**3.75 / 5**			
with gas ballast open	/Pa	**$5x10^{-2}$**			
Oil capacity	l	4.1		8.7	
Weight (pump + motor) [2]	kg (lbs)	68 (150)		90 (198)	
Maximum water vapour pumping	mbar	**45**		**35**	
capacity	Pa	$45x10^{2}$		$35x10^{2}$	
Water vapour pumping capacity	g/h	1000		700	
Inlet and exhaust end fittings	ISO-KF	DN 40			

Corrosive applications C1 Series
Single-stage pumps

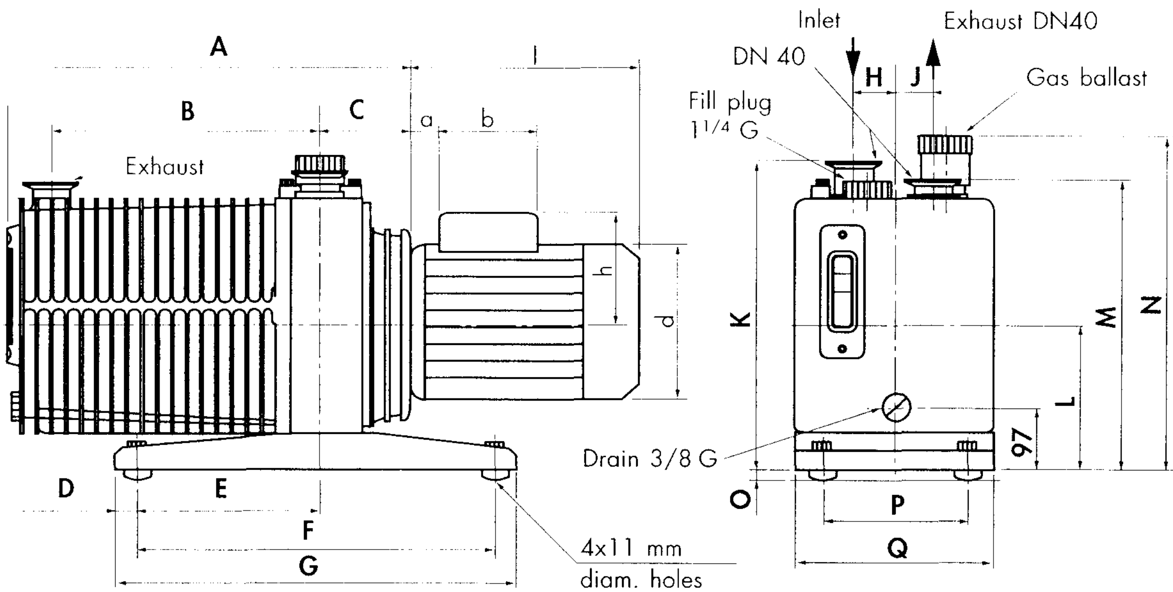
Characteristics	Unit	1033 C1		1063 C1	
equency	Hz	50	60	50	60
Number of stages		1		1	
Rotation speed	rpm	1500	1800	1500	1800
Nominal flow rate	m3/h	**30**		**60**	
	cfm		23.3		42.4
Flow rate Pneurop method	m3/h	**27**		**55**	
	cfm		18.8		38
Ultimate pressure [1]	Torr/mbar	**$3.75x10^{-2}$ / $5x10^{-2}$**			
with gas ballast closed	/Pa	**5**			
Ultimate pressure	Torr/mbar	**3.75 / 5**			
with gas ballast open	/Pa	$5x10^{-2}$			
Oil capacity	l	4.1		8.7	
Weight (pump + motor) [2]	kg (lbs)	68 (150)		90 (198)	
Maximum water vapour pumping	mbar	**45**		**35**	
capacity	Pa	$45x10^{2}$		$35x10^{2}$	
Water vapour pumping capacity	g/h	1000		1700	
Inlet and exhaust end fittings	ISO-KF	DN 40			

(1) Pressure measured according to Pneurop 6602 specifications with Alcatel 120 oil charge. It may vary if other oils are used ***(See page 77).***
(2) These values are for pumps equipped with three-phase motors.

The pressure measurements were made with a capacitive diaphragm pressure gauge measuring a total pressure in the absence of a cold trap. Measurements using a Pirani type gauge can give different pressure values.

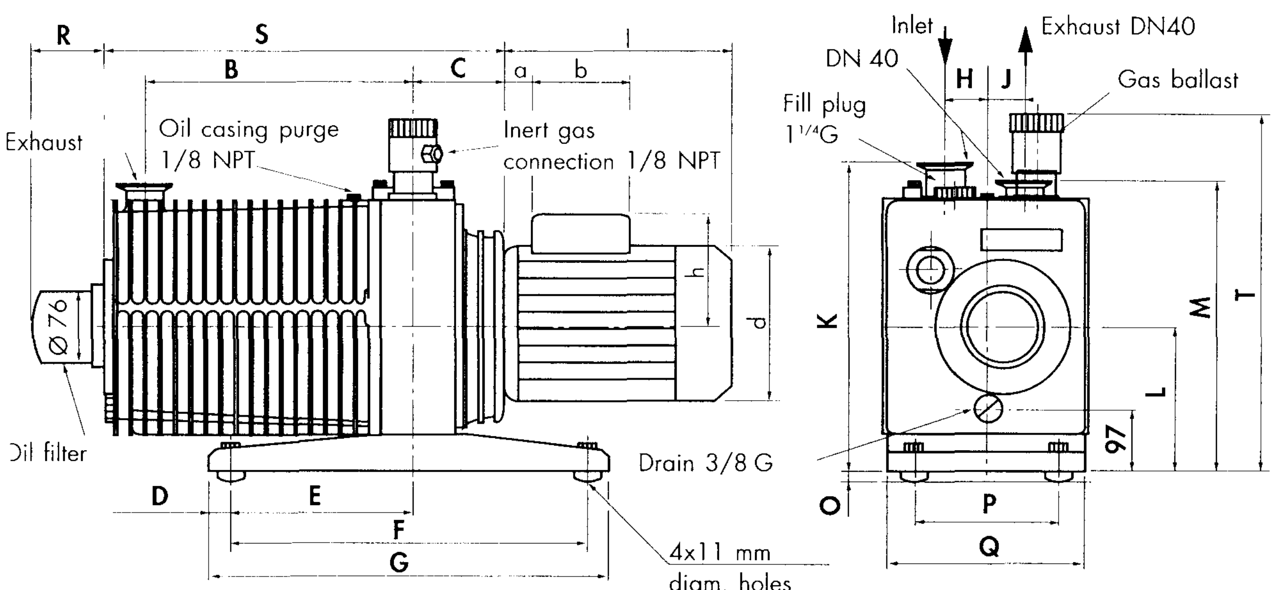
Pump dimensions

SD Series



Pump dimensions: see table below
Motor dimensions: see table page 72

C1 Series



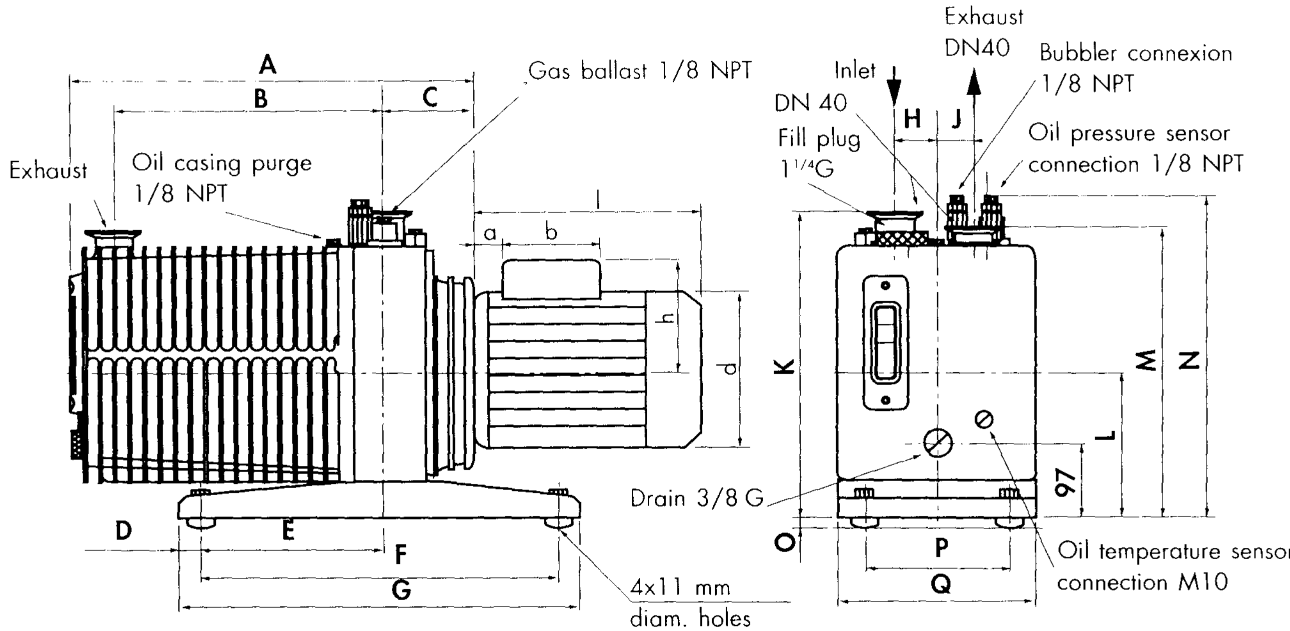
Pump dimensions: see table below
Motor dimensions: see table page 72

Model	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	R	S	T
33	17.7	11.2	4	1.2	8	14.6	17	2	1.6	13.1	6.3	12.5	14.1 to 15	0.46	5.4	8.3	3.5	17.6	15.1 to 15.5
63	**20.6**	**13.3**	**4.6**	**1.13**	**8.9**	**17.9**	**20.3**	**2.1**	**1.7**	**15**	**7.2**	**14.4**	**15.9 to 16.4**	**0.46**	**7.4**	**10.2**	**3.5**	**20.5**	**17 to 17.4**

nensions in inch
nensions in mm (see page 13)

Pump dimensions

C2 Series



Model	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q
33	17.7	11.2	4	1.2	8	14.6	17	2	1.6	13.1	6.3	12.5	13.7	0.46	5.46	8.3
63	**20.6**	**13.3**	**4.6**	**1.1**	**8.9**	**17.9**	**20.3**	**2.1**	**1.7**	**15**	**7.2**	**14.4**	**15.6**	**0.46**	**7.4**	**10.2**

Dimensions in inch
Dimensions in mm see page 14

Motor dimensions: see table below

Specific dimensions according to motors

Model	Motor type	l mm	d mm	h mm	a mm	b mm	Model	Motor type	l mm	d mm	h mm	a mm	b mm
	VDE	224	180	135	25.5	86		VDE	290	196	140	26.5	86
2033	CSA	212	184	132	26	87	**2063**	CSA	285	195	140	25	87
1033	JIS	246	180	135	25,5	86	**1063**	JIS	290	196	140	26.5	86
	UL/CSA CE	240	185	142	26	87		UL/CSA CE	285	195	149	25	87

Accessories

NAME	PART NUMBER	LOCATION	FUNCTIONS
Oil mist eliminator OME 40 S - C1 - C2	OME 40 S 104887 OME 40 C1 068795 OME 40 C2 068492	Exhaust	• Separates oil droplets and particles contained in exhaust gases emitted by the pump.
Oil level switch OLS 36	104377	On oil casing	• Provide information about oil level inside oil casing of RVP, whenever the pump is located in an unaccessible area.
Dust filter DFT 40	104889	Inlet	• Prevents dust particles larger than 6 microns from entering the pump.
Liquid nitrogen trap LNT 40	786537	Inlet	• Protects the pump against condensable vapours. • Prevents oil from backstreaming into pumped chamber.
Sorption trap ST 40	115 V - 104371 220 V - 053380	Inlet	• Prevents oil backstreaming when pumping in a "clean" vacuum.
Automatic gas ballast AGB 36*	068391 230V 50/60Hz 104367 115V 60Hz	Gas ballast	• Remote control for gas ballast. • Allows the gas ballast to be closed when the pump is off, ensuring that the pump is tight.
Oil filter DE1/DE2	DE1 110/115 V 068991 220/230 V 068990 DE2 110/115 V 104375 220/230 V 104374	External device	• Filters and/or neutralizes oil when pumping gases which are corrosive and could rapidly degrade oil quality.
Shock mount	082691 LAX 100 model D	Between base and machine frame	• Helps isolate pump vibration. • Allows pump to be mounted on a frame.
Oil short-circuit adaptor	054273	On the wessel pipe fitting	• Allows to remove the oil filter cartridge and replace it by an oil filtration system type DE1 or DE2.

* Other voltages and frequencies available in the Alcatel catalog.

⚠ In general, use accessories in which the tightness and materials are compatible with the pumped gases and the required safety conditions at both the inlet and the exhaust.

At the pump exhaust, the discharge circuit must be such that the resulting excess pressure in the oil case is as low as possible.

The maximum excess pressure recommended for correct pump operation is 0.5 bar (7PSI).

A slight negative pressure in the oil case (0.1 to 0.2 bar - 1 to 3 PSI), at the exhaust, will prevent gases from accumulating and reduce pump corrosion and pollution.

⚠ If the exhaust orifice is connected to an extraction duct or an oil mist eliminator, **you must remove the exhaust safety valve mounted in the pump's exhaust orifice.**

Safety instructions concerning the installation and operation of pumping systems

Before switching on the equipment, the user must read all of the start-up and operation sections of this manual and observe the safety instructions listed in the booklet of declarations of compliance supplied with the unit.

Unpacking

When you receive the equipment, unpack it carefully. Do not discard the packaging until you have ensured that the pump has not been damaged during transport. Otherwise, take the necessary measures with the transporting company and, if necessary, notify ALCATEL.

For all handling, only use the devices provided for this purpose (lifting rings, handle, etc.).

The pump is not supplied filled with oil. The oil is contained in separate bottles. Similarly, it is recommended to drain the pump before redispatching the equipment.

C2 series

In order to prevent moisture from entering the pump before its installation, it is pressurized beforehand with nitrogen and sealed with blank-off flanges. Remove the clamps and blank off flanges from inlet and exhaust ports only before installation.

Storage

New pump:

C2 series

If the pump is new and has not been unpacked, store it as received since it has been pressurized with neutral gas at factory.

Other series

• If the pump is to be stored, we guarantee the reliability of our equipment without particular storage precautions for up to 3 months (ambient temperature between 41°F and 149°F or 5 and 65°C).

• For storage periods of over 3 months, we recommend to fill the pump with oil during storage. For this, fill the pump and run it at ultimate vacuum (inlet orifice blocked) for approximately 1 hour in order to lubricate all the parts of the functional block (***see page 86***).
Then, stop the pump and store it with the inlet and exhaust orifices sealed: clamping ring, centring ring, plug, etc.
The shaft should be rotated by hand or by starting the pump every six months following this storage procedure.

• After 6 months storage without oil, factors such as temperature, degree of humidity, salt air, etc. may cause the deterioration of the pump components, particularly the hardening of O-rings and the "sticking" of lip seals on shafts and the gumming of oil. In this state, a pump may have operational problems, particularly oil leaks. Before any start-up (new pump as well as used), the pump must be disassembled (***see page 100***), and all the seals changed.

All series **Pump which have been used:**

If the pump is not new, drain and rinse it (***see page 97***). Fill it with new oil, then pump a dry inert gas through it to remove all traces of dampness in the pumping system and oil casing.
Pump in dry inert gas as fallows:
- 10 minutes at above 2.25 Torr (30 mbar)
- 10 minutes at ultimate pressure with gas ballast open
- 10 minutes at ultimate pressure

Stop the pump and seal the inlet and exhaust orifices tightly with quick connect clamps, centering rings, blank-off flanges...

Note 1:
The seal kits must be stored with caution. Keep them away from heat and light (sunlight and ultraviolet light) in order to prevent the elostomers from hardening (AFNOR standard FD T 46.022).

Installation and start-up

• The machines must be connected to an electrical installation in compliance with decree 88-1056 dated 14th November 1988, as well as any local electrical codes that apply.

• It is important to isolate the machine from the power source before any intervention on the equipment (for maintenance purposes).

• When switching off the power of equipment containing capacitors loaded with over 60 VDC or 25 VAC, take precautions when accessing the connector pins (single-phase motors, equipment with mains filter, frequency converter, monitor, etc.).

• Vane roughing pumps use lubricants (oils), it is recommended to request information from the manufacturer on the safety data sheets concerning the product used.

• Our pumps are tested in the factory with ALCATEL 120 oil (ALCATEL 119 for the US - Alcatel 113 oil for the C2 series). It is recommended to use the same oil during operation.
If changing the type of oil, refer to the chapter concerned for the procedure and the type of lubricant required.

• Our pumps are designed to prevent any thermal risk for user safety. However, specific operating conditions may generate temperatures which may justify particular attention on the part of the user (outer surfaces > 158° F / 70°C).

Table of recommended oils

Recommended oils

In the vane pumps, we recommend to use only the ALCATEL oils in the table below:

Oil	APPLICATION	SD	C1	C2	Total ultimate pressure* (mbar)	Viscosity mm^2/s (cst)	Vapour tension 25°C (mbar)	Flash point/ self-ignition temperature
ALCATEL 102	Anti-emulsion mineral oil - Drying - Pumping water vapour - Freeze-drying				$\leq 3.10^{-2}$	40°C/98 100°C/11,1	$< 1.10^{-3}$	230°C / 260°C
ALCATEL 111	Hydro-carbon based synthetic oil with good heat resistance: - Pumping at high pressures - Operating at high ambient temperatures				$\leq 1.10^{-2}$	40°C/100 100°C/7,8	$< 1.10^{-3}$	212°C / 245°C
ALCATEL 113	Highly stable synthetic oil. Perfluoropolyether. - Highly inert to chemicals - Pumping oxygen - Plasma etching				$\leq 5.10^{-3}$	40°C/90 100°C/11	$< 3.10^{-5}$	none / none
ALCATEL 119	Mineral oil distilled under vacuum - Pumping non-corrosive products - Low viscosity				$\leq 3.10^{-3}$	40°C/54 100°C/8,1	$< 4.10^{-5}$	213°C / 244°C
ALCATEL 120	General-purpose paraffin-based refined mineral oil - Good ultimate pressure - Low backstreaming				$\leq 2.10^{-3}$	40°C/120 100°C/12,5	$< 4.10^{-5}$	260°C / 295°C
ALCATEL 121	Special hydrocarbon based mineral oil				$\leq 3.10^{-3}$	40°C/64 100°C/10	$< 1.33.10^{-7}$	268°C / 296°C
ALCATEL 200	Mineral oil distilled under vacuum: - Pumping corrosive products - Low backstreaming				$\leq 2.10^{-2}$	40°C/58 100°C/8,5	$< 1.10^{-5}$	223°C / 259°C
ALCATEL 300	Hydrocarbon-based mineral oil distilled under vacuum: Pumping corrosive products - Plasma etching - Operating at high temperatures				$\leq 5.10^{-3}$	40°C/56 100°C/8,9	$< 1.10^{-5}$	243°C / 270°C

* Ultimate pressure measured according to Pneurop 6602 specifications on 2033 ALCATEL pump.
These values are given as a rough guide only. They may vary according to the type of pump and the pumping conditions.
(shaded) Requires special preparation of pump (*see page 98*).

However, the following replacement fluids can be used:

Mineral oil:
ELF MOVIXA PV 100, TURBELF SA 100,
BP CS 100 (BP registered trademark)
SHELL VITREA 100 (SHELL registered trademark)
TOTAL CORTIS PV 100 (TOTAL registered trademark)
INLAND 19, INLAND 20 (INLAND registered trademark)
MR 200 (MATSUMURA registered trademark)

Mineral-based synthetic oils:
ELF BARELF F 100, ELF BARELF C 68 (ELF registered trademark)
INVOIL 20 (INLAND registered trademark)
INLAND TW (INLAND registered trademark)
ELITE Z (CAMBRIGE MILL PRODUCTS, INC. reg. trademark)

Ester type synthetic oils:
ANDEROL 555 (HÜLS registered trademark)
ANDEROL RCF 96 N (HÜLS registered trademark)

Fluorocarbon synthetic oils:
FOMBLIN YL VAC 25-6 (MONTEDISON registered trademark)
KRYTOX 15-25 (DU PONT DE NEMOURS registered trademark)
HALOVAC 100 (HALOCARBON registered trademark)
AFLUNOX 15.25 (SCM registered trademark)

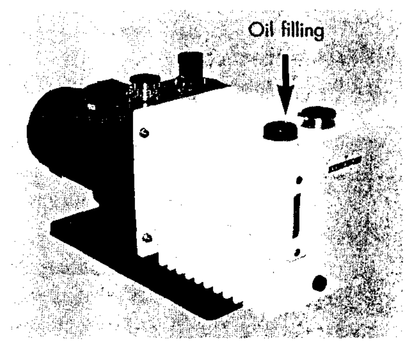
Note: In this case, pump performances may be slightly different from those given in pages 68,69,70.

Filling with oil

Alcatel 33 and 63 m³/h SD, C1 series pumps are tested in the factory with **ALCATEL 120** oil (**Alcatel 119** for the US).
Alcatel 33 and 63 m³/h C2 series pumps are tested in the factory with **Alcatel 113** oil.
At delivery, there is some oil remaining in the functional block.

⚠ Our pumps are tested in the factory with Alcatel oil: it is recommended to use the same oil during operation. To change the type of oil, refer to the Maintenance Chapter, "replacement of type of oil" section.
In all cases, follow the recommendations of the pump specifier for the choice of oil to be used.

If necessary, carry out the special preparation procedure for the pump, then, remove the filling cap and fill with oil:
- until the oil is between the maximum and minimum levels (SD, C2 Series),
- until the oil reaches the middle of the sight glass (C1 Series).
This operation must be performed with the pump switched off.



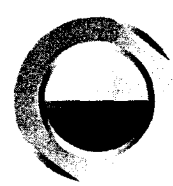
Checking the oil level

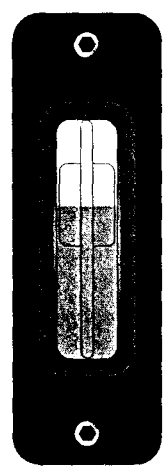
To use the pump in optimum conditions, the oil level must be observed and checked regularly. This level is checked with the pump switched off, hot and on a horizontal plane.

Oil level sight glass

C1 series **SD and C2 series**

maximum level





maximum level

minimum level

Note: Optimum pump performance and service life are obtained when the oil level is between the maximum level and the minimum level.

C2 series: if the pump is equipped with an oil temperature sensor, the installation must be made with the pump drained of oil.

Mechanical connections

⚠ For a given application, pump performance, vacuum characteristics, temperature and reliability depend on the following:
- assembly conditions, accessory filters.
- the oil used.
- mechanical connections: pipes, etc.
- maintenance frequency and quality.

For the assembly of the vacuum circuit, provide the necessary accessories required for maintenance: valves, purges, etc.

Mounting on a frame

The pump can be mounted on a frame using the 4 attachment holes on the base and the special shock mounts.

Note: Special shock mounts, effective against the pump's own vibrations, can also be used but they do not ensure correct attachment during the transfer of equipment. In this case, the pump should be clamped onto its support.

Ventilation

The pump and the motor are each equipped with a ventilation system. During pump installation, the pump should be placed in ventilated place. Provide a minimum gap of 25 mm around the pump.
The vents on the pump and the motor should be checked regularly to ensure that they are not blocked.
33/63 m³/h ALCATEL pumps are designed for operation at an ambient temperature between 53°F and 113°F (12 and 45°C).

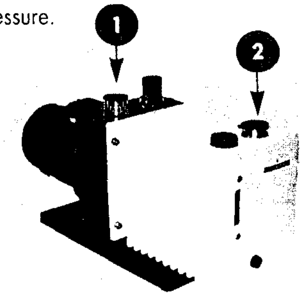
Inlet and exhaust fitting

⚠ Remove the protective caps on the inlet and exhaust orifices; these components prevent foreign bodies from entering the pump during transport and storage. **It is dangerous to leave them on the pump during operation.**

The pump inlet and exhaust orifices are equipped with DN 40 ISO-KF end fittings which can be used to fit various line components made of stainless steel, plastic, etc. (see Alcatel catalog).

Inlet (1)

⚠ Make sure that the all components and chamber connected to the pump inlet withstand a negative pressure of 1 bar (15PSI) relative to atmospheric pressure.



⚠ Also make sure that the maximum exhaust pressure does not exceed 1 bar (15PSI) relative to atmospheric pressure (for security).

Exhaust (2)

⚠ It is recommended to connect the pump exhaust to a smoke evacuation duct.

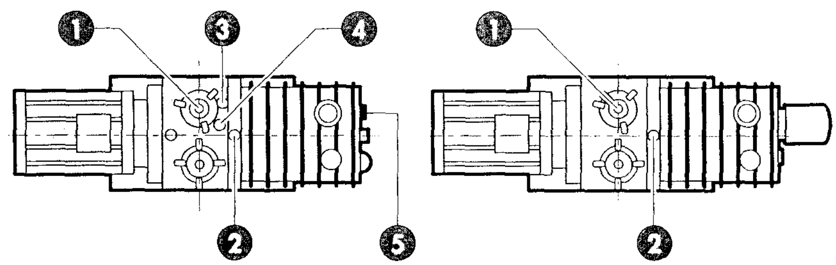
- If the pump exhaust orifice is connected to an extraction duct or an oil mist eliminator, the exhaust stop valve fitted in the pump exhaust orifice must be removed (SD series).
- At the pump exhaust, the evacuation circuit must be such that the resulting excess pressure in the oil case is as low as possible: for correct pump operation the max. exhaust pressure recommended should be 1.125 Torr (1.5 bar - 21.75PSI) absolute pressure.

Start-up

Purge and indicator connections

Series	Item	Description	Connection
C1	1	Gas ballast purge	1/8' NPT
	2	Oil casing purge	1/8' NPT
C2	3	Oil pressure sensor	M10 x 1
	4	Bubller	1/8' NPT
	5	Oil casing temperature sensor	M12 x 1

C2 Series C1 Series



To operate the information delivered by the sensors, contact Alcatel.

Specific equipment: HP valve (C2 Series only)

The C2 pumps are equipped with HP and LP elastomer valves (FPM™ according to standard NFT 40-002). In certain applications with fluorinated gases, HP valve may harden and become brittle and compromise pump performances. Alternatively, the pump may be equipped with a plastic, corrosion-resistant HP valve on request.
On request Alcatel can supply these specific components depending on your needs.

Equipment	HP Valve material	Tightness	Part Number
Standard	Elastomer	installation tight	053443
On request	Plastic*	installation not tight	065057
	Plastic + special o-ring	installation tight	065160

⚠ * If a plastic valve is used, the pump's anti-suckback operation cannot be guaranteed and an anti-suckback device must be installed in the pumping line to ensure tightness when the pump is not operating.

Electrical connections

⚠ The pumps must be connected to an electrical installation in compliance with the decree 88-1056 dated 14 November 1988, as well as any local electrical codes that apply.

• Our products are designed to meet current EEC regulations. **Any modification on the part of the user** is liable to cause non-compliance with regulations or even affect the EMC (Electromagnetic compatibility) performance and safety of the product. Alcatel cannot be held responsible for consequences resulting from such an intervention.

• Before any maintenance is performed on a product by a maintenance operator who has not been trained on safety regulations (EMC, electrical safety, chemical pollution, etc.), isolate the product from its various energy sources (electricity, compressed air, etc.).

• **As a general rule, it is recommended to protect the motor for 120% of its nominal current (*see page 80*).**

• Check that the electrical wiring of the motor corresponds to the line voltage, before starting up the pump.

• Ensure that the electrical installation conforms with your local safety requirements. It must include the appropriate fuse and reliable earthground.

Three-phase version

All three phase motors (protection level IP 43. TEFC type) must be protected by a customer supplied starter consisting of a suitably rated contactor and thermal overload. The pumps can be equipped with different types of motors in compliance with the electrical standards (UL, CSA, VDE, JIS). In all the cases, the pumps are delivered with their motors connected to maximum voltage (*see page 83*).

Wire the motor according to the line voltage. The connections to be made are shown on a diagram inside the terminal box or on its lid (***see page 83***).
Check the direction of rotation of the motor (direction of arrow located on the motor cover). For this:
- Remove the protective caps on the inlet and exhaust orifices.
- Vent the pump to atmospheric pressure.
- Switch on the pump for 2 to 3 seconds, with your hand on the inlet orifice if suction is felt, the wiring is correct.

Otherwise, invert 2 consecutive phases.
The earth terminal must be connected correctly.

Different types of motors are available in accordance to the major international standards CEI / VDE / UL / CSA / JIS. The three phase motors are compatible with the following voltages:

Motors	Frequencies	50 Hz			60 Hz			
VDE and CSA type	Low voltage	220 V	230 V	240 V	230 V	220 V	255 V	280 V
	High voltage	380 V	400 V	415 V	460 V	380 V	440 V	480 V
UL/CSA/CE Type	Low voltage	190 V	220 V	—	—	200 V	—	230 V
	High voltage	380 V	—	—	—	—	—	460 V
JIS Type	High voltage	200 V	220 V	—	200 V	220 V	—	—

Motor characteristics, connection, protection

The information below is given as a recommendation.
The user must comply with the electrical standards or recommendations (IEC, VDE, UL, CSA, etc.) applicable in the country in which the pump is used.
The use of electrical protection for the pump motor makes it possible to protect:
- The motor: in the event of excess voltage or rotor blocking, the resulting excess current may destroy the coil and possibly the start-up system (for a single-phase motor).
- The pump: in the event of a lubrication fault (contaminated oil, presence of particles), increased resistance will draw excessive motor current.

Differential thermal circuit-breakers should be used, in which the mechanism contains an instantaneous disconnection controlled by a bi-metal blade.

Never protect a three-phase motor with fuses not equipped with a differential system: if three phase motors are powered on 2 phases without a differential system, the motor could burn.

▸ three-phase motor:
The table on the following page gives, for each pump, the electrical characteristics in permanent operation and the proposed circuit breaker.

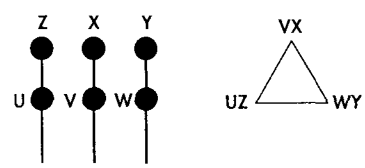
Three-phase motors

Electrical connections

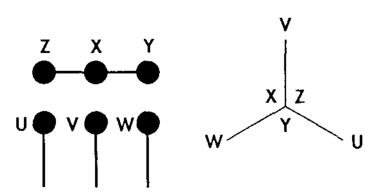
The pumps are equipped with 6, 9 or 12 wire terminal box motors, the wiring diagram of the terminals is given as a rough guide only. In the event of doubt, only the plate in the terminal box should be used as a reference.

Terminal box CEI / VDE (Europe)

Low voltage connection
220/240 V 50 Hz
220/280 V 60 Hz
Parallel coupling

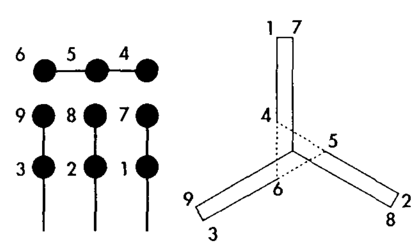


High voltage connection
380/415 V 50 Hz
380/480 V 60 Hz
Serial coupling

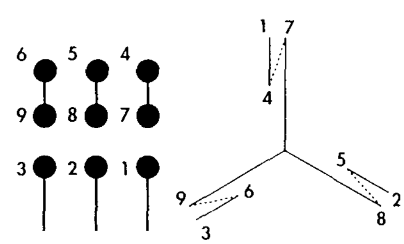


Terminal box (9 wires)

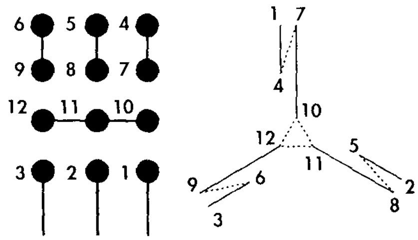
Low voltage connection
220/240 V 50 Hz
230/280 V 60 Hz
Parallel coupling

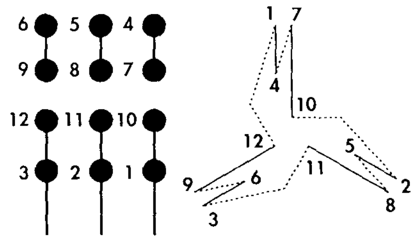


High voltage connection
380/415 V 50 Hz
380/480 V 60 Hz
Serial coupling



NEMA Terminal box (USA) (12 wires)	Low voltage connection 190 to 220 V 50 Hz 200 or 230 V 60 Hz Parallel coupling	High voltage connection 380 ou 460 V 50 ou 60 Hz Serial coupling





Pumps for 50 Hz (European pumps)

Serie		Motor	Power	Voltage	Size
33	1033 SD C1 2033 SD - C1 C2 - H1	Three phase Three phase	1.1 kW 1.1 kW	220 V 380 V	6 A 4 A
63	1063 SD C1 2063 SD - C1 C2 - H1	Three phase Three phase	2.2 kW 2.2 kW	220 V 380 V	10 A 6 A

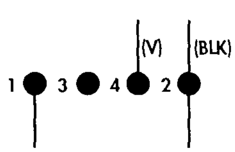
Pumps for 60 Hz (US pumps)

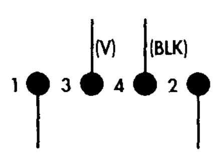
Serie		Motor	Power	Voltage	Size
33	1033 SD C1 2033 SD C1 H1 - C2	Three phase 60 Hz Three phase 60 Hz Three phase 60 Hz	1.1 kW 1.1 kW 1.1 kW	200 V 220 V 460 V	6 A 6 A 4 A
63	1063 SD C1 2063 SD C1 C2 H1	Three phase 50 Hz Three phase 60 Hz Three phase 60 Hz Three phase 60 Hz	2.2 kW 2.2 kW 2.2 kW 2.2 kW	200 V 200 V 220 V 460 V	10 A 10 A 10 A 6 A

Single Phase motors for 33 m^3/hr pump model (USA only)

Serie		Motor	Power	Voltage	Size
33	1033 SD C1 2033 CD C1 H1 - C2	Single phase 60 Hz	1.3 kW	115 V 460 V	13.8 A 1 A

Low voltage connection	High voltage connection





Preliminary precautions

• The performance and operating safety of this product can only be guaranteed if it is operated according to normal conditions of use.

• The vacuum pump is also a compressor: incorrect operation may be dangerous. Study the user manual before starting up the pump.

• The pumps are designed to prevent any thermal risk for user safety. However, specific operating conditions may generate temperatures which may justify particular attention on the part of the user > 70°C).

• Product tightness is guaranteed for normal operating conditions when the product leaves the factory. It is the user's responsibility to maintain the level of tightness particularly when pumping dangerous products (on C series pumps).

• Be sure to fill the pump with oil **(*see page 78*).**

Operating temperature

- **At start-up**, before switching on the motor, check that the oil bath temperature is greater than 53°F (12°C).

- **The ambient operating temperature** for the pump must be between 53°F (12°C) and 113°F (45°C).

- Under these conditions, **the stabilized pump temperature** (at the front of the oil case) will be between 140°F and 158°F (60 and 70°C) (depending on operating conditions).

Special case - Synthetic oils
Synthetic oils are much more viscous when cold than mineral oils.
Do not start up the pump at ambient temperatures below 59°F (15°C).
For the same reason and to facilitate lubrication of the pump, pour a few drops of oil (l to 2 cm^3) through the inlet orifice before starting.

Before starting-up the pump

Check that the exhaust orifice is not blocked.

In certain cases, when the pump is started up in cold ambient conditions, or with slightly contaminated oil, the current after start-up may remain high until the oil in the pump is heated up. These conditions are sufficient for the internal thermal protection to be activated, making start-up impossible (*see page 81 and 82*).

Start-up

• When using a three phase motor, **check the direction of rotation of the motor** (see electrical connections ***start-up chap. page 81***).

• **Check the oil level** (*see page 78*).

• **Start-up the pump.**

• **Allow the pump to run for one hour with the inlet blocked at ultimate vacuum:**
During this operation, make sure that the oil circuit is operating. Remove one of the oil fill plugs to listen to the pump.

At start-up, the oil enters the lubrication circuit of the vacuum pump. As a result, noises will be heard (first irregularly, then regularly) which will reduce as the oil heats up. These noises will no longer be heard when the fill plug has been replaced.

Under normal temperature conditions, the oil circuit should start less than 1 minute after start-up (this time may vary with the type of oil and its degree of contamination).

• **Using the gas ballast:**
- to decontaminate the pump's oil;
- to accelerate heating. It is normal for the oil level to change (as can be seen through the oil sight glass) when the pump is hot, due to expansion of the oil, starting of the oil circuit and the operating conditions of the pump (inlet pressure). If necessary, stop the pump and adjust the oil level between the "max" and "min" levels on the sight glass.

In the event of a malfunction, refer to the "Troubleshooting and corrective actions" table (see ***page 94***).

Operation of gas ballast

Regeneration of pump oil

In a pump stored with the same oil for a long time, condensed vapours may contaminate the oil bath and affect performance. This is also the case after pumping vapours and when the oil appears cloudy or discolored through the sight glass.

- Run the pump, shutting it off from the system at the inlet by a valve or a plug.
- Open the gas ballast and allow the pump to operate for 1/2 hour to 1 hour, or longer if the oil remains cloudy. This operation accelerates the temperature rise of the pump while eliminating residual vapours present in the oil bath.

Pumping condensable vapours

To pump with condensable products, it is necessary to operate with a hot pump. For this, isolate the pump from the system and allow it to operate for 1/2 hour with the gas ballast open, or 1 hour (if possible) with the gas ballast closed. When the oil bath is hot, the condensation of vapours in the pump is reduced or prevented.

Choice of pump and system

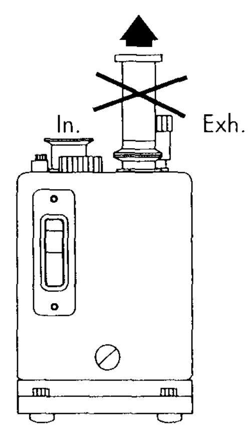
The pump's capacity to eliminate condensable vapours is related to their type, the pump temperature and the quantity of air introduced by the gas ballast. Thus, for high vapour levels in a system, the single-stage pump is more suitable. However, when not pumping vapours, its ultimate pressure is higher. Care should be taken to limit the inlet pressure of the pump to its maximum admissible water vapor pressure with the pumped product. This is obtained by reading the pump characteristic table for water vapour.
The use of cold traps or condensers are recommended when large quantities of vapours are to be extracted. Excessively intense or prolonged pumping may cause the products condensed in the trap to be evaporated a second time.

Choice of oil

Choose an oil which facilitates the separation of pumped products which may be condensed in the oil bath (anti-emulsion oil for water-based compounds, etc.) (***see page 77***).

Assembly

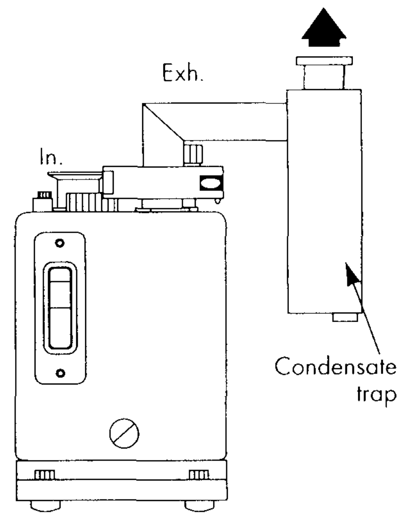
The condensation of vapours at the pump exhaust is reduced if:
- the pump and oil temperature are high;
- the pressure at the exhaust is as low as possible (removal of the oil mist eliminator...);
- the condensates are collected separately from the oil bath and do not block the exhaust duct.



For this:
- avoid using any vertical ducting which promotes the condensation of products and the return of these products to the pump.
- use a condensate collector;

Assembly (continued)

- we do not recommend an oil mist eliminator when pumping condensable vapors: if it is essential, do not connect it directly to the pump exhaust but place it outside the condensation zone.
- remove the stop valve from the pump exhaust (SD Series);
- if possible, connect the exhaust to a mechanical device creating a negative pressure from 0.75 Torr to 1.5 Torr (0.1 to 0.2 bar).



Vapor pumping procedure

- Valve off the pump from the system and increase the pump temperature, 30 minutes with gas ballast (***see page 86***).
- Start pumping and check the oil level:
  - The level drops, oil is being lost;
  - The level rises, condensates have been added to the oil.
- After pumping, regenerate the oil using gas ballast if it is cloudy or discoloured.
  - if the level is too high, change the oil and regenerate.
- Change the oil as soon as inlet pressure characteristics drop and are not improved by regeneration.

Purges for pumping condensable, corrosive, and hazardous gases

,I and C2 series

Purges

The use of vane pumps may result in pumping gases or vapours which are flammable or that could contaminate the oil. In this case, these products must be diluted using purges supplied with dry gases, such as nitrogen to avoid undesirable reactions.
For this purpose, a filtered dry nitrogen supply or other inert gas with the same characteristics is required:
- condensation point < 72°F/22°C,
- dust < 1µm,
- minimum absolute pressure 2 bar.

Oil case purges

The purge dilutes pumped gases with a inert gas:
it makes it possible to limit corrosion in the oil case, condensation and accumulation of gases in dead spaces of the pump.

Connect the dry nitrogen supply on the specific connector (1/8 NPT) located on the top of the frame.
Set the nitrogen pressure to approximately 15.4 PSIG (1.1 absolute bar) (average flow 300 SCCM) (***see table page 90***), and the flowrate so as to satisfy the dilution conditions.
Caution: do not generate an excess pressure > 14 PSIG (1 relative bar).

Purge with gas ballast

Because of the danger present if the gas ballast was to be opened to astmosphere the manual gas ballast doesn't operate. Connect the dry nitorgen on the specific connector (1/8 NPT). The nitrogen flowrate should be from 1500 to 1700 l/h with a pressure of 3.5 PSIG (0.25 relative bar) (***see table page 90***) .

Serie C2

Use of the bubbler

The bubble device is composed of an air tube with several holes, located at the bottom of the oil case, which releases bubbles of inert gas in the oil. In this way, the oil is saturated with neutral gas, which reduces its capacity to dissolve pumped gases. The bubbles of inert gas released make it possible to eliminate the volatile vapours or acids condensed in the oil. The bubbler flow also lowers the pumps temperature which slows corrosion.

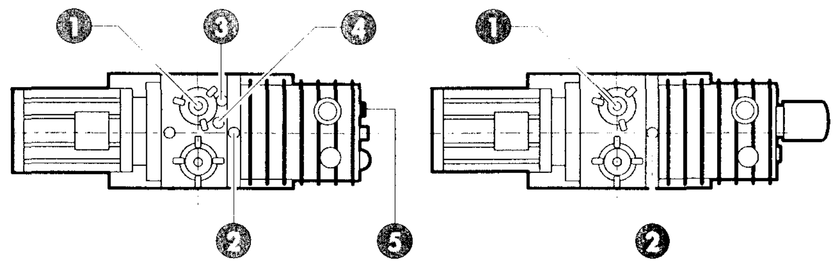
Setting

The gas flow rate is adapted according to the application and the installation, taking the following criteria into account (middle flow 300 SCCM - ***see table page 90***):

• When pumping high quantities of gas, a highly corrosive gas or an easily condensable gas, it is recommended to use a high nitrogen flow rate.
Caution ! It is assumed that a sufficient quantity of nitrogen is available.
• The pump exhaust circuit must be such that, for discharged flow rates, pressure drops do not cause an abnormal excess pressure in the oil case.
• The nitrogen flow rate must be such that oil losses have no effect on the operation of the pump throughout the pumping cycle (the oil level must be above the lower limit of the sight glass at the end of pumping).

Settings (continued) Run the pump at ultimate vacuum for one hour and set the nitrogen flow rate as follows (at atmospheric pressure and at 60°F/20°C).

C2 series C1 series



Purge and sensors setting table

Serie	Item	Description	Item	Neutral gas flow (l/h) Min	Average	Maxi	Pressure (bars) Starting	Operating	Problem	T° (°C)	Corresponding absolute pressures (bars)
C1	1	Gas ballast purge	**2033**	1200	1500	2000		—		—	1.25
			2063	1500	1700	2500					
	2	Oil casing purge	**2033**	60	300	700		—		—	1.1 to 1.25
			2063	70	300	900					1.15 to 1.25
C2	3	Oil pressure sensor	**2033**		—		0.9	1.2 ± 0.1	< 0.8	—	—
			2063								
	4	Bubbler	**2033**	60	300	700		—		—	1.1 to 1.25
			2063	70	300	900					1.15 to 1.25
	5	Oil temperature sensor	**2033**		—			—		< 95°	—
			2063								

Note: these characteristics apply for pumps operating at a constant inlet pressure (1 to 5 mbar): they are adapted for each case of pumping.

Start-up Start-up the pump at ultimate vacuum. When it is hot, run the nitrogen purge. Use it from the beginning and throughout pumping.

Using the two purges simultaneously (C2 series) When the bubbler and the oil casing purge are used simultaneously, the gas flow rate must be ajusted to suit the application and the installation. The adjustment data given in the table **corresponds to the adding flow adjustment data**.

Stop When pumping stops, allow the purge to operate for approximately 1 hour (depending on the quantity of pumped gas) at ultimate vacuum, with the purge, in order to degas the oil effectively and clean the pump with nitrogen to eliminate the traces of pumped gases.

Oxygen pumping

In certain applications, mixtures containing oxygen at different concentrations, or even pure oxygen, are used.

Oils of mineral origin are combustible. Exposure to pure oxygen at high temperatures may cause them to self-ignite. In addition, they are highly oxidized during pumping and quickly lose their lubricating properties. Mineral oils must not be used for oxygen levels of over 21 % in pumped gases. In this case, perfluorinated synthetic oils must be used, see list on ***page 77.***

The use of these oils requires a special pump preparation (***see page 98***).

The pump must be completely disassembled and all traces oil mineral oil removed. Flushing the oil case is not adequate.

⚠ In addition, it is strongly recommended not to use fluids such as tri-aryl-phosphate-ester which are know to cause accidents.

Any accumulation of oxygen in the installation should be avoided and the oxygen or combustible mixture should be diluted with an inert gas at the exhaust: the gas flow rate should be 4 times the oxygen flow rate.

Certain combustible or explosive gases require a higher degree of dilution. Our International Support Services and Customer Services can advise you to help solve problems of this kind.

Recovery of oil (high pressure and cycling)

When the pump operates at high pressure, the oil heats up, becomes more fluid and is flushed out of the functional block by the gas stream.
Oil losses at the exhaust are increased.

For intermittent pumping

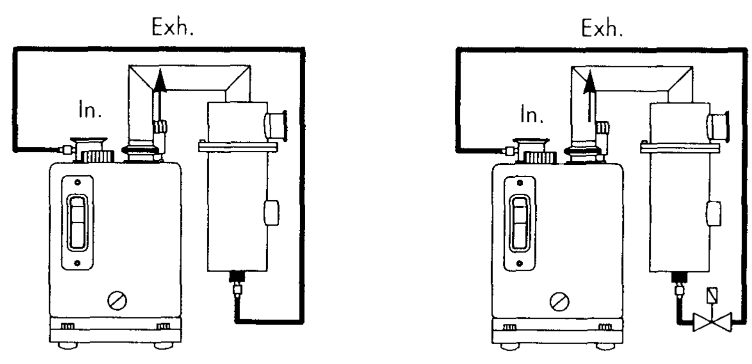
If the pump only operates for a very short time at high pressure, the lubricating oil is replaced when the pump returns to low pressure. The use of an oil mist eliminator prevents losses due to intermittent high pressure operation.

For cyclical pumping

If the pump operates at high pressure in a cyclical fashion, oil consumption may reach sufficiently high levels (according to the pumped volume and pumping cycle rates) causing the level to drop in the oil case.
There is then a risk of seizure due to a lack of oil. In addition, the high flow of gas passing through the eliminator prevents oil from returning to the oil case.

In order to pump in these conditions, the pump must be equipped with an oil mixt eliminator and an oil recovery device as shown here below (***contact Alcatel***).

Cyclical pumping:
Example of oil recovery device



⚠ **Device is not tight when switched off.**

An electrovalve ensures tightness when switched off.

For continuous pumping at high pressure

In this case, or when very large volumes (requiring several hours of pumping) are being pumped, it is recommended to recover the oil via the pump inlet.
In this case, please consult Alcatel directly.

General precautions

For normal operation, the maintenance of ALCATEL 33 and 63 m^3/h series pumps only require regular oil changes.

⚠ **Standard precautions before any maintenance operation:**
Before performing a maintenance operation, switch off the pump and disconnect the mains cable.

⚠ **Before any draining or maintenance operation, check the pumping conditions of the installation: potential toxicity, corrosion or radioacitivity of pumped gases.**
Depending on the case, we recommend:
- **to purge the pumping installation with dry nitrogen before maintenance;**
- **wear gloves, protective goggles and, if necessary, a breathing apparatus;**
- **ventilate the premises well and disassemble the equipment under a suction hood;**
- **not to dispose of used oils and residues using the standard system and, if necessary, have them destroyed by a specialized company.**

⚠ **Certain gases can become corrosives and toxic when trapped in oil. Always wear protective gloves when handling used and dirty pump oil, drain it into a closable container, and do not breathe the fumes of the oil. Always use fully self-contained breathing apparatus.**

⚠ **Always dispose of used dirty oil, or sub-products properly and in compliance with all local, state and federal environmental laws and regulations.**

⚠ **After a complete maintenance operation, it is recommended to perform a helium leak tightness test. Alcatel can provide specific training to know the tightness test methods and supply helium Leak detectors. Contact us.**

Troubleshooting and corrective actions

Incidents	Causes	Corrective actions
The pump is not running	• Incorrect motor power supply.	Check the power supply.
	• Temperature too low.	Reheat the pump and its oil.
	• Gumming of seals after prolonged storage.	1 - Disassemble the motor and try to turn the fan manually. 2 - Disassemble, clean the pump, replace seals, reassemble.
	• Oil contaminated after pumping.	Drain, flush and refill with clean oil.
	• Motor coupling damaged.	Replace by disassembling the motor.
	• Pump seized, due to a stopping after pumping in difficult conditions (no draining or flushing).	Disassemble, clean, hone the scratched metal parts (replace them if necessary) and reassemble.
The pump does not start	• Oil cold.	Warm pump.
	• Insufficient oil in the oil case.	Fill up to the level.
	• Oil contaminated.	Drain, flush and refill with clean oil.
	• Oil pump inlet partially blocked.	Drain, and clean the oil pump inlet duct.
	• Lubrication holes blocked.	Disassemble and clean.
	• Vane of oil pump damaged.	Replace it.
	• Incorrect anti-suckback system setting.	Repeat the assembly and the setting.
	Oil pressure sensor	
	✠ It indicates a too low or too high pressure	Clear the line or check the manometer/plug tightness.
	✠ It continues to indicate a too low or too high pressure	Disassemble, clean and reassemble using maintenance kit.
The vacuum pump does not produce a vacuum	**Ultimate pressure obtained: a few mbar/Torr**	
	• Direction of motor rotation incorrect.	Reverse 2 phases.
	• Insufficient motor power.	Check the power supply.
	• Intake filter blocked.	Clean it.
	• Insufficient oil in the oil case.	Add oil.
	• Oil cold, oil pump inlet blocked.	Warm, disassemble, clean.
	• Oil contaminated.	Drain, flush and start again with clean oil.

• All Series ✠ C1 ➧ C2 ♦ C1 and C2

Incidents	Causes	Corrective actions
The vacuum pump does not produce a vacuum (continued)	• Oil pump inlet partially blocked.	Drain and clean the oil pump inlet duct.
	• One of the LP safety valves is damaged.	Replace.
	• Part forgotten in reassembly.	Repeat the reassembly.
	Ultimate pressure obtained: a few 10^{-2} Torr (10^{-2} mbar)	
	• Gas ballast knob open (or supplied with dry nitrogen C1,C2 Series).	Close.
	• O-ring pinched.	Replace.
	• One of the seals is damaged.	Replace.
	• One of the HP safety valves is damaged.	Replace.
	• Lubrication holes blocked.	Disassemble and clean.
	• Incorrect anti-noise device setting.	Repeat the assembly and setting.
	• Part forgotten in reassembly.	Repeat the reassembly.
	✠ Filter cartridge clogged.	Replace.
	Accessories	
	• At the pump exhaust, the installation produces an exhaust pressure of 1.125 Torr (1.5 bar).	Check the installation.
	• Oil mist eliminator cartridge clogged.	Replace.
Noisy pump	• Oil level too high.	Drain and fill with a new oil.
	• Oil contaminated (presence of particles).	Drain, flush and refill with clean oil.
	• Pump not prepared for the oil used.	Check the pump configuration or the type of oil.
	• Incorrect motor power supply.	Check the power supply.
	• Motor bearings damaged.	Replace the motor after inspection.
	• Motor coupling incorrectly set or damaged.	Check the setting.
	• Incorrect fan assembly.	Check the assembly.
	• Incorrect anti-noise device setting.	Repeat the setting.
	• Vanes damaged or stuck.	Replace.
Pump too hot	• Ambient temperature too high.	
	• Pump placed in a poorly ventilated place or vents blocked.	Check the installation.
	• Operation at high pressure P > 22 Torr (30 mbar).	Check for system leaks.

• All Series	✠ C1	♦ C2	♦ C1 and C2

Maintenance

Incidents	Causes	Corrective actions
Pump too hot (continued)	• Excess pressure at exhaust.	Check the exhaust line.
	• Motor in over-voltage or Motor in short-circuit.	Check the voltage, replace the motor.
	• Oil contaminated.	Drain, flush and refill with clean oil.
	• Pump not prepared for the oil used or oil unsuitable.	Check pump configuration or type of oil.
Considerable oil losses	• Oil level too high.	Drain and fill with new oil.
	• Operation at high pressure.	Use an oil mist eliminator with oil recovery device.
	• Gas ballast open: 1 - accidentally, 2 - pumping of condensable vapours.	 1 - Close. 2 - Use a condensate collector.
	• Leak at oil case seal or at front seal.	Check the assembly and replace the seals if necessary.
	♦ Purges gas flow too important.	Readjust.
Poor pump tightness when switched off	• Gas ballast open.	Close.
	• Safety valve damaged.	Replace.
	• Incorrect anti-suckback assembly.	Repeat the assembly.
	• O-ring pinched.	Replace.
	• Seals damaged.	Replace.
	• Oil contaminated.	Drain, flush and refill with clean oil.
	◗ Using a plastic HP valve (not tight)	Check the installation or use a plastic valve with special o–ring.
Oil in base	• Oil case and frame cleaned poorly during reassembly.	Remove the base and clean.
	• Oil case seal pinched.	Disassemble the oil case, clean the faces and refit a new seal.
	• Front seal damaged or felt saturated.	Replace.

• All Series	✠ C1	◗ C2	♦ C1 and C2

Maintenance frequency

An incorrect ultimate vacuum or a reduction in pumping speed are signs that the oil has deteriorated.

The periodic inspection of the state of the oil is performed by comparison with a sample of new oil in order to check the level of contamination or deterioration of the lubricant.

The frequency at which oil is renewed is adapted to the type of operation:

- if the oil is cloudy, this indicates that condensables have been absorbed during pumping. The oil can be regenerated using the gas ballast (***see page 87***).
- a thickening of the oil, together with a blackish color and a "burnt" smell indicate that the oil has deteriorated.

Drain the pump and flush it.

When the lubricating oil is expensive (fluorocarbon synthetic oils), the use of an oil mist eliminator allows oil recovery after deposition.

Normally, **for a pump operating continuously at a pressure lower than 0.75 Torr (1 mbar) with a clean gas (dry air), the oil should be changed every 6 months. This value is given as a guide only**. It may be extended to 1 year if the ultimate vacuum required is sufficient (for primary vacuum pumps).

Similarly, **if the pump is stopped frequently for long periods, the oil should be changed at intervals of 6 months to a maximum of 1 year** (oil may become sticky).

Note: Every pumping operation is different. This oil must therefore be changed at intervals adapted to each specific application. The use of certain accessories (***see page 73***) can reduce the frequency of these maintenance operations.

Draining

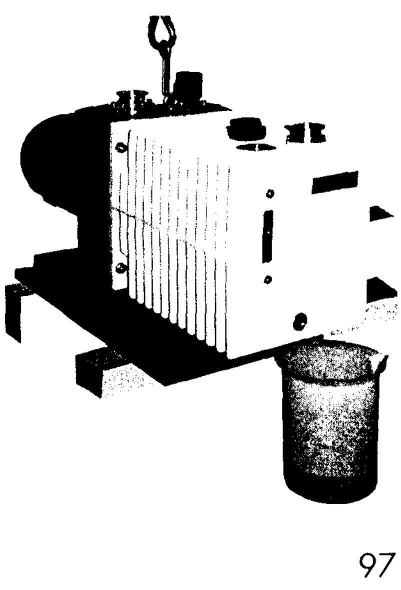
⚠ **The draining operation places the contaminated pumping circuit in communication with the outside atmosphere. Take all necessary steps to ensure personal safety.**

The pump must be drained when hot and after the oil case has been vented to atmospheric pressure. For this:

- switch off the pump;
- isolate the pump or disconnect from the installation;
- tilt the pump;
- unscrew the draining plug on the side of the oil case and the filling plug on the top of the oil case.

When all the oil has drained, replace the two plugs temporarily and run the pump for about 10 seconds leaving the intake open. Take care with the oil mist which may appear at the exhaust. This operation removes the oil from the functional block;

- drain this oil by removing the draining plug;



Draining (contd.)

- replace the draining plug and fill with fresh oil to the appropriate maximum level of the oil case oil sight glass through the filling orifice (***see page 78***).

Flushing

The draining operation can be followed by a flushing operation if the oil is particularly dirty. This operation requires a volume of oil equal to the capacity of the pump.

After draining the oil case (***see page 97***), replace the draining plug. Remove the intake filter, clean it and replace it. Run the pump at atmospheric pressure, pour the flushing oil **very slowly** through the inlet orifice. Take care with oil mist which may develop at the exhaust. Stop the pump and drain the flushing oil via the draining plug. Replace the plug and fill with fresh oil (***see page 78***).

Change of type of oil

ALCATEL 33 and 63 m^3/h series pumps are tested in the factory with ALCATEL 120 oil or 119 for the US (ALCATEL 113 for C2 series pumps) unless specified otherwise in the order. When the pump is delivered, a certain quantity of oil remains in the functional block
Thus, if you wish to use another type of oil, proceed as follows:

Compatible oils

Mineral oil can be replaced by another type of mineral oil. Simply flush the pump (**see above**) using the new oil and fill the pump (***see page 78***).
Mineral oils are also compatible with mineral-based synthetic oils (***see page 77***).

Incompatible oils

This is the case when, for example, a mineral oil is replaced by a synthetic oil (e.g. ALCATEL 120 by ALCATEL 113).
Synthetic oils are considered to be incompatible with each other for practical reasons: they are expensive. A mixture may cause slight cloudiness of the resulting mixture, which could be interpreted mistakenly as a sign of contamination or deterioration.
For the same reasons, clear synthetic and mineral oils (ALCATEL 300), which are also expensive, are treated as synthetic oils.

These remarks apply to ester or fluorocarbon type synthetic oils and the oils Alcatel 111, 113 and 300 (***see page 77***).

Proceed as follows:
- Disassemble the pump completely and clean it (***see page 100***).
- Reassemble it.
- Connect an oil mist eliminator to the pump exhaust.
- Fill the pump with the new oil (***see page 78***).

NOTE: to replace a synthetic oil by a mineral oil, proceed as for compatible oils.

Tools and consumable products

Special precautions

- Read the warning at the beginning of the maintenance chapter.
- Before disassembling the pump, drain it (***see page 97***).
- All the seals and faulty parts should be replaced, provide for a seal kit or a maintenance kit.

Spare parts

Minor kit

This contains all the seals on the pump which must be replaced at each complete disassembly.

Pump models	Part No.
1033/2033 SD	054285
1063/2063 SD	054485
1033/2033 C1	054286
1063/2063 C1	054488
2033 C2	065123
2063 C2	065552

Keep this kit in a dry place, away from heat and light (sunlight and ultraviolet light), in order to prevent any hardening of the elastomers (see AFNOR standards: "storage conditions for vulcanized elastomer based products" - FD T.46 022).

Major kit

In addition to the seal kit, this kit contains a set of spare parts to perform maintenance operations on the pump for a two year period, under normal operating conditions.

Pump models	Part No.
1033 SD	104416
1063 SD	104417
2033 SD	054288
2063 SD	054487
1033 C1	104418
1063 C1	104419
2033 C1	054289
2063 C1	054489
2033 C2	065124
2063 C2	065553

Screw kit

This kit contains all screws and washers for pump.

Pump models	Part No.
SD	105347
C1/C2	105348

Specific tools

This kit contains some tools to reassemble shaft seals and adjust the motor sleeve position.

Pump models	Part No.
All models	065192

Recommended tools

- Two flat screwdrivers n°3 and n°9
- Thin spanner: - All models: 12, 13, 16, 17 mm
  - C1 : 14, 16, 50 mm
  - C2 : 14, 16, 19 mm
- Allen wrenches: 2 - 4 - 5 - 6 and 8 mm
- Extraction screws M8
- Filter cartridge key (automobile equipment supplier) (C1 Series)

Disassembling the pump

⚠ Before any maintenance is performed, remember to provide protection against toxicity, corrosion, and radioactivity of pumped gases.

Depending on the individual situation, we recommend the following:

- flush system with dry nitrogen before maintenance is performed.
- wear gloves, goggles, and gas mask if necessary.
- make sure room is properly ventilated and disassemble pump under an exhaust hood.
- collect residues in appropriate containers.

Routine maintenance of ALCATEL serie SD, C1 and C2 requires only periodic oil changes.

In the event of heavy contamination or an operating breakdown (***see page 94 to 96***), the pump must be disassembled (***see page 101***).

Replace all seals whenever the pump is disassembled. The only tools needed are a few wrenches, found in any maintenance shop (***see page 99***).

Removing pump from system

The following steps are necessary to protect the pump as far as possible from the effects of corrosion.

Flush pump with a neutral gas to prevent toxic or corrosive gases from accumulating in the pump.

C2 Model > Disconnect the nitrogen lines to the pump.
If the sensors are connected, disconnect them.

Disconnect the pump from the system and seal off the inlet and exhaust ports. Bring the pump to the maintenance area immediately.

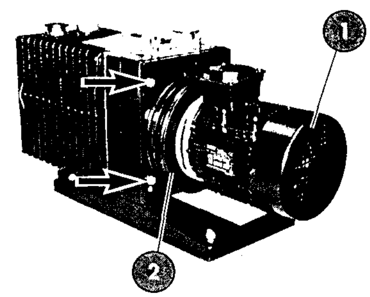
Drain pump (***see page 97***).

Do not store a pump in this condition for any length of time: once the neutral gas has dissipated, the inside of the oil case will be in contact with the ambient air laden with water vapor; this may react with the pumped gases to from acids that may corrode the pump even at room temperature.

The first phase of disassembly is to disassemble the motor; the second is to disassemble the pumping module.

Removing motor (see general drawing)

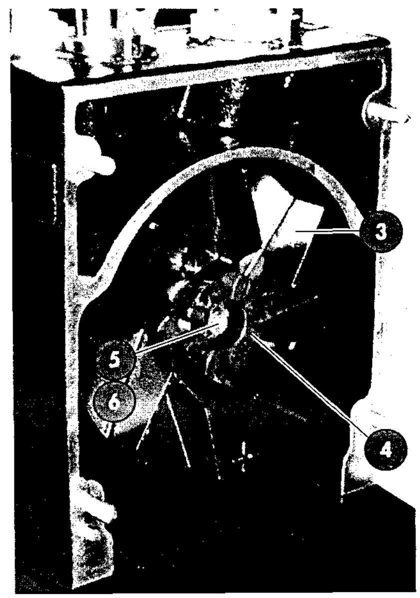
[12] Unscrew four nuts.
Remove motor assembly **(1)**, and motor mounting plate. The coupling separates into two halves, one on the motor side, the other on the pump side.



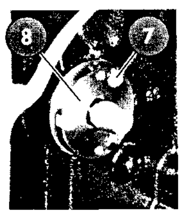
C2 Model ⇨ *In case of important pollution, roughly clean the pump with hot solvents under pressure.*

Prevent fan **(3)** from rotating by wedging a wooden chock against the side of the frame and two blades of the fan.
Remove elastomer coupling **(4)**.

[8] Unscrew self-locking screw **(5)** (not reusable) and remove washer **(6)**.
Using two 8 mm extraction screws, remove fan **(3)** and chock.

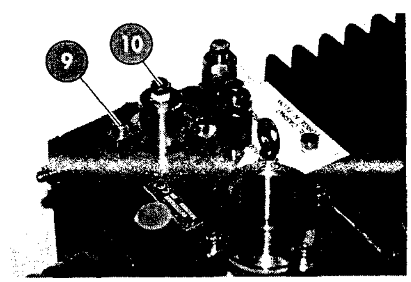


[5] Remove screws **(7)** and, using two 8 mm extraction screws, remove cover **(8)** with seal.



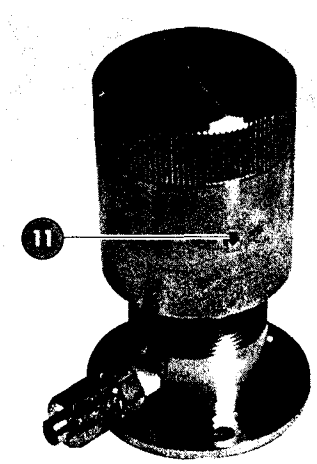
Dismantling gas ballast (C2 Model)

[12] *Remove three screws (9) and remove gas ballast assembly and o-ring.*
Valve and washer assembly cannot be disassembled.
Unscrew plug (10) (1/8" NPT).
Remove PTFE tape from plug thread and put new one when reassembling.



(C1 Model)

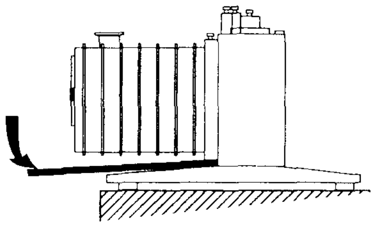
[2] *Removes the fastening screw (11). Unscrew completely the gas ballast knob and remove the 2 o-rings.*

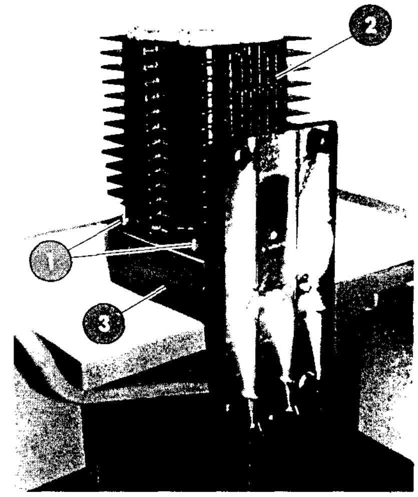


Removing oil casing

Install the pump vertically on a work bench using a hoist.

Remove four nuts **(1)** and remove the oil casing **(2)** and its gasket.





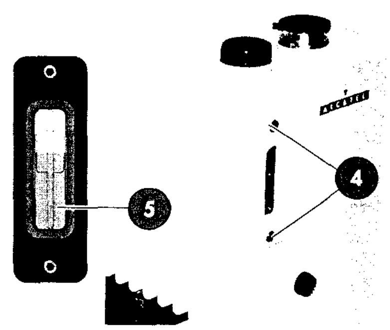
Gasket may cause case **(2)** and frame **(3)** to stick together due to aging: insert lever between base and bottom of case, and pry off case . Do not use a hammer or screwdriver, which could dammage the parts and sealing surfaces.

C1 and C2 Models

When the oil casing has been disassembled, leave the pump under a suction hood for fifteen to thirty minutes before disassembling it to make sure all the pumped gases have been evacuated.

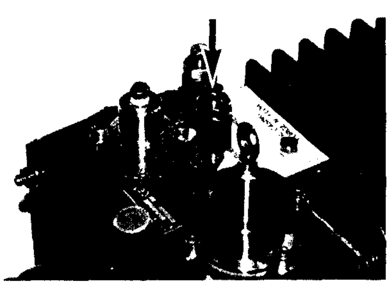
Removing oil sight (SD and C2 Models)

*Unscrew 2 screws **(4)** and remove them.*
*Remove body of oil sight **(5)**, the O-ring and flat gasket; replace them with new ones when reassembling sight.*



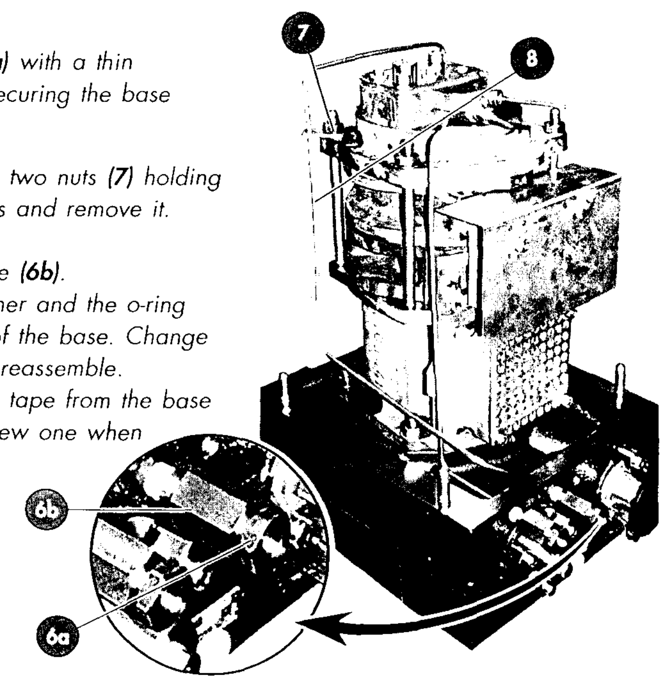
Removing accessories

Removing bubbler (C2 Model)



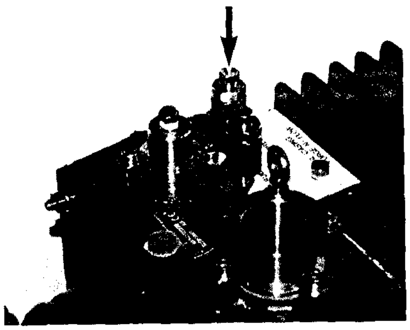
*Unscrew **(6a)** with a thin spanner, while securing the base **(6b)**.*

*Unscrew the two nuts **(7)** holding the tube fasteners and remove it.*
*Remove tube **(8)**.*
*Unscrew the base **(6b)**.*
Remove the washer and the o-ring from the inside of the base. Change the seal prior to reassemble.
*Remove the PTFE tape from the base **(6b)** and put a new one when reassembling.*



Removing accessories (contd.)

Removing oil pressure monitoring system (C2 Model)



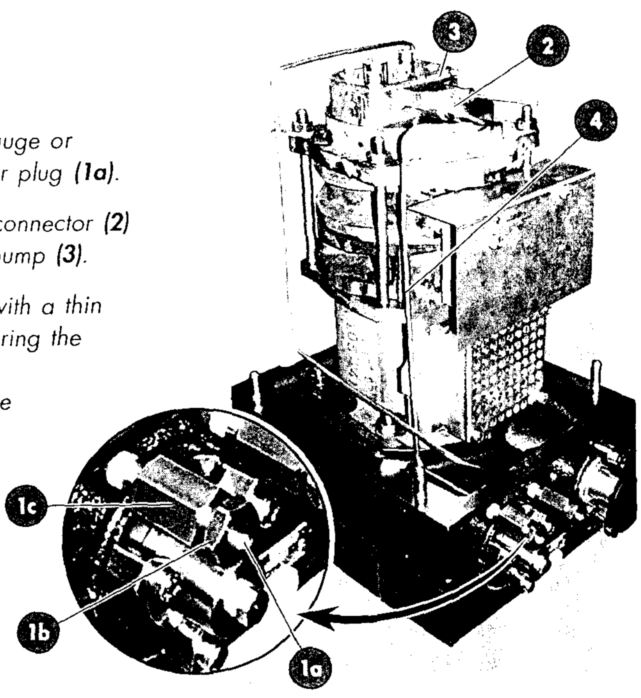
*Remove pressure gauge or monitoring device or plug **(1a)**.*

*Unscrew tube connector **(2)** located on the oil pump **(3)**.*

*Unscrew **(1b)** with a thin spanner, while securing the base **(1c)**.*

*Remove tube **(4)**, the washer and the o-ring from the inside of the base **(1c)**.*

*Remove PTFE tape from thread **(1b)** and **(2)**, and put a new one when reassembling.*



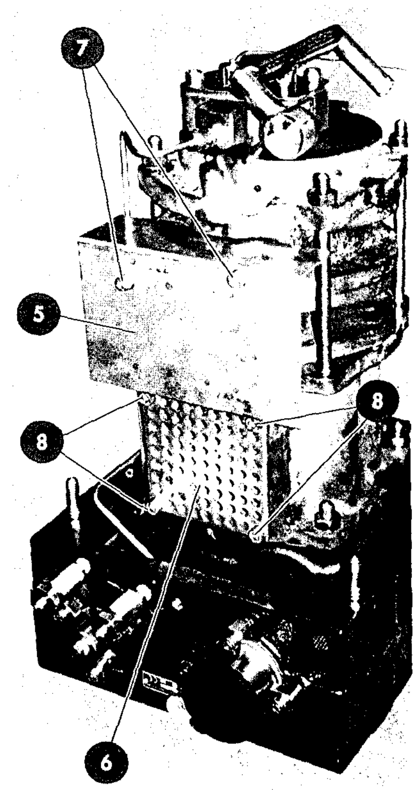
Removing the filter cartridge (C1 model)

Using the specific key (see page 99), remove the filter cartridge. In case of single stage vane pump, remove the two supports of case bushing, fitted on the oil pump.

Disassembling pumping module

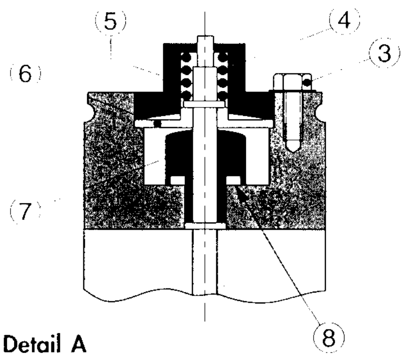
Removing valve cover

Remove valve covers **(5)** and **(6)** by loosening screws **(7)** and **(8)**. Remove valve spring, valve (or valves) and the HP valve (see details on the general drawing).



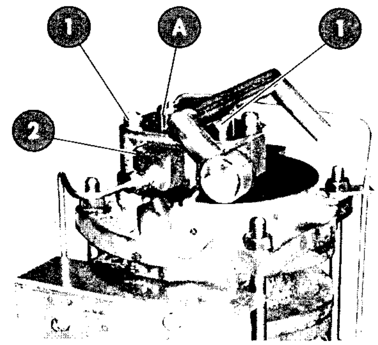
Disassembling pumping module (contd.)

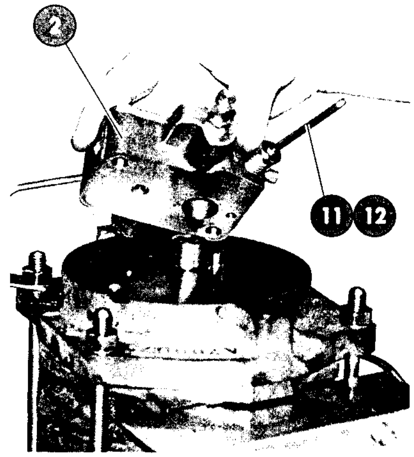
Removing oil pump



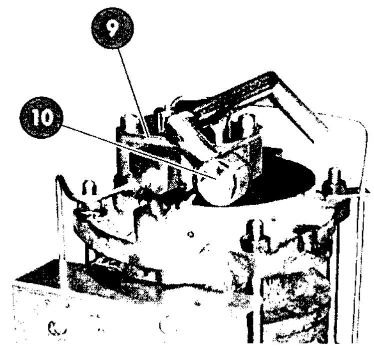
Detail A

Remove screws (1) and remove body (2).



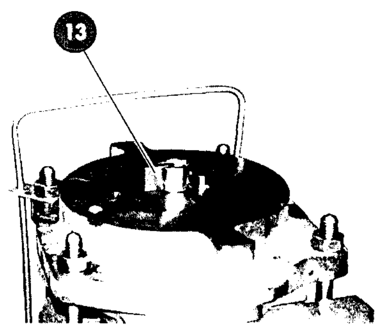


[4] Remove screws (3) and remove cylinder (4), spring (5) and diaphragm (6).
Remove seat (7) and O-ring (8).
Remove screw of oil inlet tube (9).
Remove oil inlet tube (10).
Unscrew air inlet tube (11) and remove spring (12).



If necessary, note setting of air inlet tube (11): number of turns until tube stops moving turning clockwise.

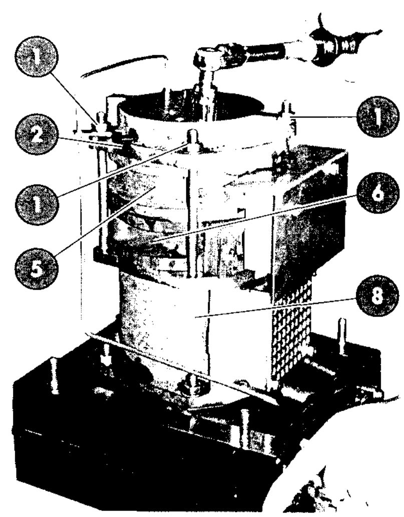
Remove vane (13).



Disassembling pumping module (contd.)

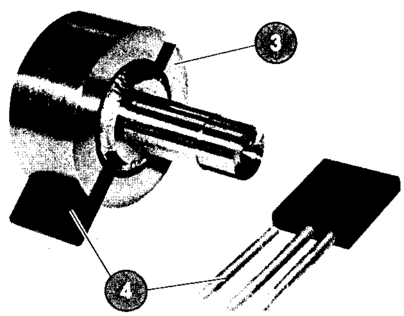
Removing rear plate

Unscrew four nuts (**1**).
Insert two screwdrivers into the two notches and twist to remove plate off pins.
Pull plate straight out, holding HP rotor (**2**) in place. Remove O-ring.



Removing HP rotor (3) (two-stage pumps)

Remove rotor (**3**) by sliding it out of stator.
Remove vanes (**4**) and their springs.



Removing HP stator (5)

Insert two screwdrivers into the two notches and twist to remove stator off pins.
Remove O-ring.

Removing central plate (6) (two-stage pumps)

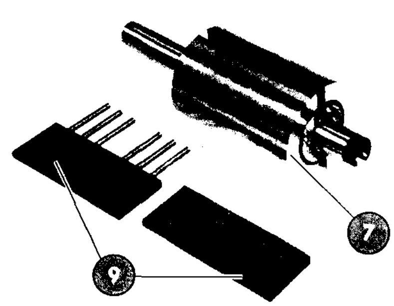
Insert two screwdrivers into the two notches and twist to remove central flate off pins.
Remove O-ring.

SD Model

Oil jet (item 78 on the general drawing page 125) lubricates the first stage. Do not remove it for cleaning. Where reassembling, spray with compressed air to remove any obstructions.

Removing LP rotor (7)

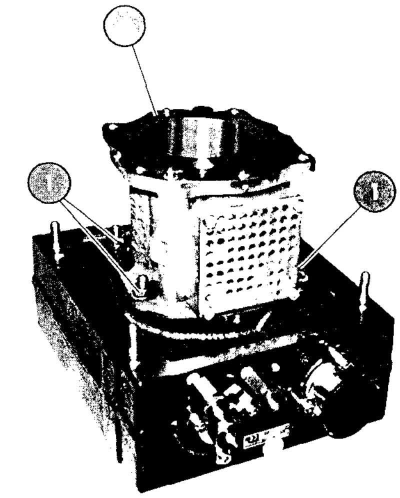
Remove rotor (**7**) by sliding it out of stator (**8**).
Remove vanes (**9**) and their springs.



Disassembling pumping module (contd.)

Removing LP stator

Unscrew four nuts **(1)**.
Insert two screwdrivers into the two notches and twist to remove it off the pins.
Remove O-ring.



Disassembling exhaust nipple

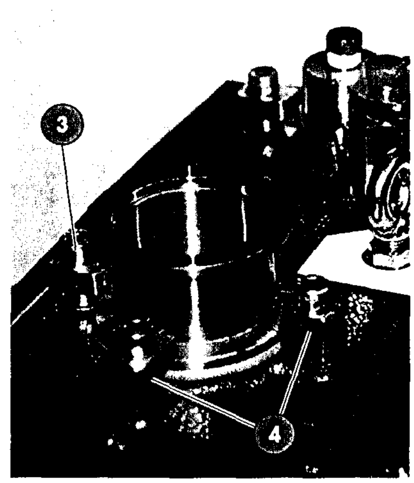
To remove exhaust nipple, the nipple must be connected to a line with an DN 40 centering ring with O-ring and quick connect clamp. Use the latter to unscrew nipple.

Remove O-ring.

SD Model ⇨ *Remove pin and filter, sleeve, shaft, valve and circlip.*

Desassembling inlet nipple

5 Remove four screws CHc **(3)** and remove clamps **(4)**.



Cleaning parts

Cleaning metal parts

Solvents are required to clean components.

Standard precautions should be taken in compliance with the manufacturer's instructions.

After use in mineral or synthetic oil, clean the metal components with a mineral products based solvent such as **AXAREL**(1), **CARECLEAN**(2), **PREMACLEAN**(3), **NAPHTEOL**(4). Proceed as follows:
- clean when cold or hot (max. 45°C) by dipping or using a cloth,
- vacuum dry in a ventilated oven,
- **the component must be cleaned a second time with alcohol.**

After use in (perfluorinate) synthetic oil, clean the metal components in a solvent such as **GALDEN S 90**™(5) and proceed as follows:
- clean when cold by dipping or using a cloth,
- dry the components in the air or with compressed air.

After use in (non-perfluorinate) synthetic or mineral oil, clean the metal components with a solvent such as alcohol and proceed as follows:
- clean when cold by dipping or using a cloth,
- dry the components in the air,
- industrial washing solutions can also be used. The cleaning operation should be followed by vacuum drying.

Oil sight glass cleaning

SD, C2 series pump

When cleaning the plastic sight flass, avoid contact with alcohol or alcohol based washing solutions. Clean the component with a solvent but do not dip it, and rinse it immediately.

C1 series pump

The sight glass of these pumps is made of glass.

Oil casing/frame surfaces cleaning

Replace the oil casing gasket each time the pump is disassembled. If necessary, clean the oil casing and central housing surfaces by scraping them with a piece of wood or plastic to avoid scratching them. When reassembling, oil the frame and case surfaces lightly.

(1) DUPONT DE NEMOURS registered trademark
(2) CASTROL registered trademark
(3) DOW registered trademark
(4) Nippon Chemical registered trademark
(5) MONTEDISON registered trademark

Replacement of shaft seals

Specific tools

- Specific assembly mandrel.*
- Protective sleeve.*

* *included in the tool kit (see page 99)*

Recommended tools

- A flat screwdriver.

Extracting a shaft seal from its housing

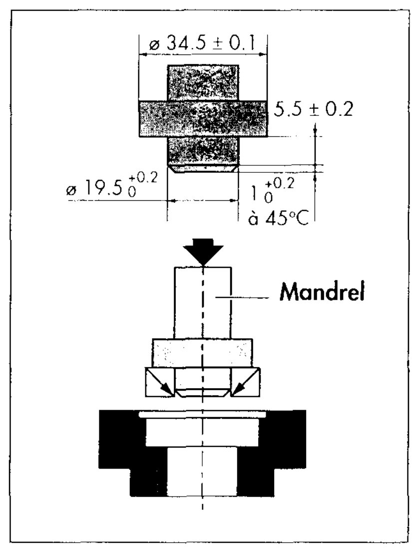
With the flange flat, the seal is extracted using a screwdriver, resting on the plate so as not to damage the seal housing.

Assembling the shaft seal

The seal housing and the seal lip are lubricated with the lubricant used in the pump.
The flange is resting on a flat surface.

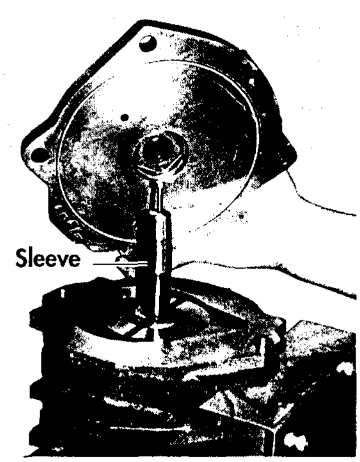
According to the direction of assembly specific to each pump, the seal is fitted on the assembly mandrel.

Using a press or a hammer, the seal is inserted in its housing.



Assembly the protective sleeve

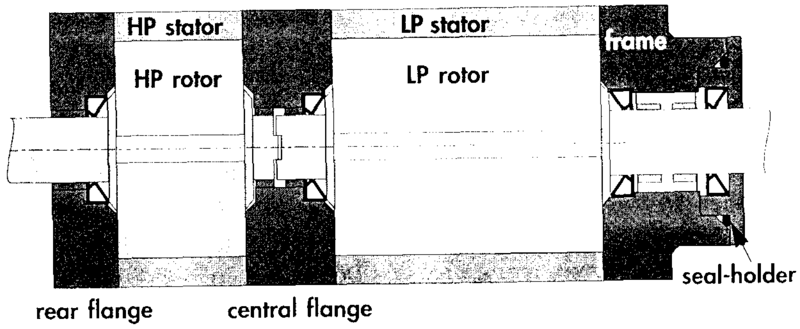
To install the plates, use protective sleeve and oil it before mounting plate (or wrap end of shaft with adhesive tape).



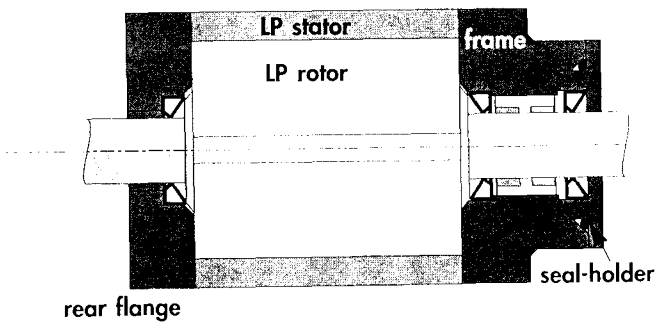
Direction of assembly of shaft seals

They are fitted using the assembly mandrel according to the direction of assembly below:

Two stage pump



Single stage pump



Maintenance

Reassembling the pump

Component preparation

• Rest the frame on a flat surface in order to raise the pump vertically.
• Oil used for lubricate pump parts must be the same as oil used for pump operation.

Before reassembly

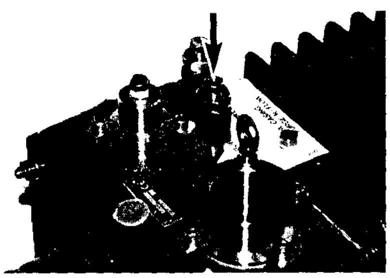
• **All parts must be dry** so that no solvent remains, particularly in blind holes.
• **Do not put too much oil** in the bottoms of the holes for the plate/stator alignments pins.
• **Coat all pump parts and lips of shaft seals** with clean oil. Make sure seals are correctly installed (see general drawing).
Fill lubrication holes of bearings and seal seats with oil.
• Tighten nuts without forcing (maximum torque see general drawing).
• **Apply PTFE tape** on sensor connector and connector for dry nitrogen line.

Assembling moving parts

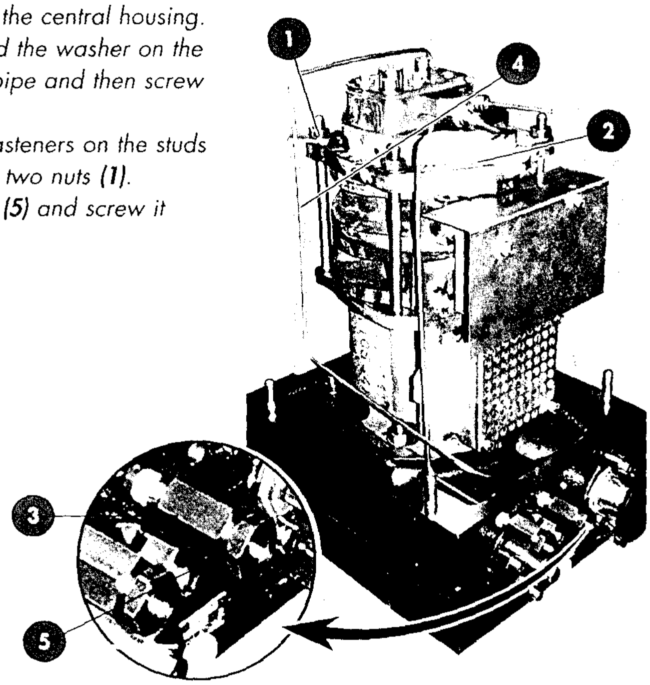
The bushings in the frame and plates can be replaced, but special machining is required whenever a bushing is changed. Consult ALCATEL for assistance.

• Reassemble moving parts in reverse order of disassembly.
• Before replacing valves, for a little oil into the stators through the valve holes.
• Before reassembling oil pump, assemble fan using a new self-locking screw to tighten it (Maintenance kit page 97).

Installing bubbler (C2 Model)

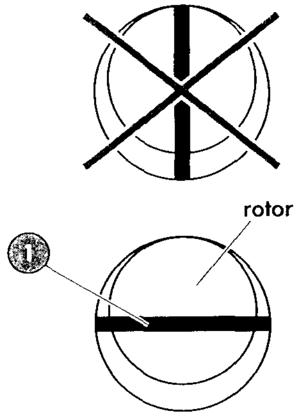


*Before tightening nuts **(1)** to fasten rear flange **(2)**, replace bubbler as follows:*
*Put a PTFE tape on base **(3)** and gas connection threads.*
*Set the pipe **(4)** in the central housing.*
*Put a new seal and the washer on the upper end of the pipe and then screw it in the base **(3)**.*
*Set the two tube fasteners on the studs ans screw it in the two nuts **(1)**.*
*Put a new seal on **(5)** and screw it on **(3)**.*

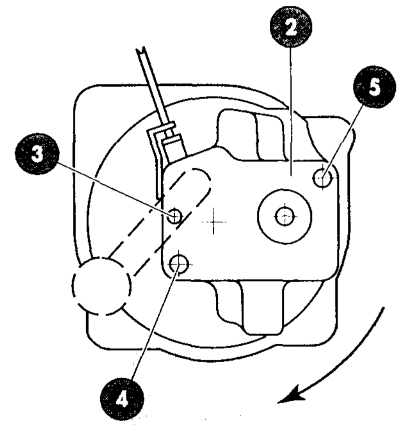


Assembling oil pump

Mount all necessary parts on oil pump body proceeding in reverse order as described page 104.



Place slot of oil pump rotor in horizontal position (parallel to pump base).
Fan can be used to turn rotor, **but never insert a screwdriver in the rotor slot as this may cause damage.**
Place vane **(1)** in its slot.
With pump horizontal, let pump body drop by gravity on to rotor.
With pump vertical, turn pump body **(2)** clockwise around alignment pin **(3)**, to bring it into contact with the rotor without forcing. **Never rest pump body on rotor; this will eliminate bearing play.**



Fit two screws **(4)** and **(5)**: must be tightened first **(4)**, and **(5)** second (maximum torque: 1mdaN).

Oil pump intake tube reassembly (C2 Model)

When positioning the oil tube, make sure that screw is properly centered in the centering hole, the collector located at the upper part of the tube must line up under the oil fill port in the oil casing.

Air inlet tube

Screw the air tube home and unscrew it of the number of turns given, when disassembling (usually 3 or 4 turns) (***see page 104***).

Installing the filter cartridge (C1 model)

Two-stage pump

Install the case bushing on the oil pump (the direction is defined by the centering pin). Than, screw the filter cartridge.

Single-stage pump

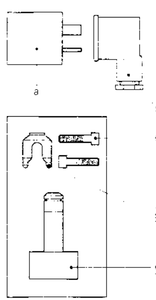
Install the two case bushing supports on the oil pump following the assembly diagram page 181 and secure them. Align the case bushing and screw the filter cartridge.

⚠ **Respect the centering to have a right oil circulation direction in the cartridge.**

Series
Baureihe
106 - 107
108 - 109 - 189

Mise en service
ELECTROVANNES TARAUDEES OU A APPLIQUE
Installation
SOLENOID VALVES, THREADED CONNECTION OR SUBBASE MOUNTING
Inbetriebnahme
MAGNETVENTILE GEWINDEANSCHLUSS ODER GRUNDPLATTEN - AUSFÜHRUNG

2/2 3/2



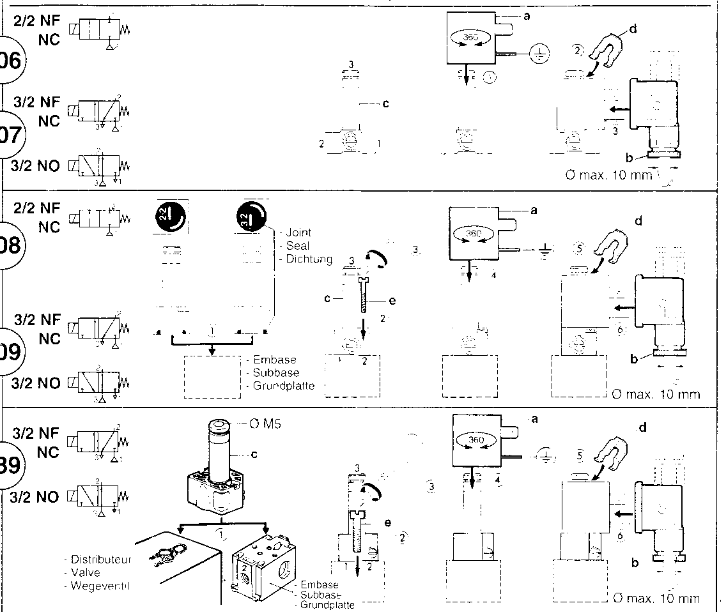
Conformément à la directive CEE 89/392 CEE Annexe II B une Déclaration d'incorporation peut être fournie sur demande. Veuillez nous indiquer le numéro d'accusé de réception (AR) et les références ou codes des produits concernés.
Ce produit est conforme aux exigences essentielles de la Directive 89/336 CEE sur la Compatibilité Electromagnétique et amendements et les directives Basse Tension 73/23 CEE - 93/68 CEE. Une déclaration de conformité peut être fournie sur simple demande.

A separate Declaration of Incorporation relating to EEC-Directive 89/392 EEC Annex II B is available on request. Please provide acknowledgement number and serial numbers of products concerned.
This product complies with the essential requirements of the EMC-Directive 89/336 EEC and amendments as well as the 73/23 EEC - 93/68 EEC Low Voltage Directives. A separate Declaration of Conformity is available on request.

Eine separate Herstellererklärung im Sinne der Richtlinie 89/392 EWG Anhang IIB ist auf Anfrage erhältlich. Geben Sie bitte für die Produkte die Nummer der Auftragsbestätigung und die Seriennummer an.
Das Produkt erfüllt die wesentlichen Anforderungen der EMV-Richtlinie 89/336 EWG und Ergänzungen sowie der Niederspannungsrichtlinien 73/23 EWG und 93/68 EWG.
Eine separate Konformitätserklärung ist auf Anfrage erhältlich.

a - Bobine b - Connecteur c - Corps d'électrovanne d - Clips pour maintien de la bobine e - EV 106 / 107 : néant EV 108 / 109 : 2 vis CM3 x 20 EV 189 : 2 vis CM4 x 20	a - Coil b - Plug c - Solenoid valve body d - Clip to hold the coil e - SV 106 / 107 : without SV 108 / 109 : 2 screws CM3 x 20 SV 189 : 2 screws CM4 x 20	a - Magnet b - Steckdose c - Magnetventil ohne Magnet d - Halteclips für Magnet e - MV 106 / 107 : ohne MV 108 / 109 : 2 Schrauben CM3 x 20 MV 189 : 2 Schrauben CM4 x 20

MONTAGE | MOUNTING | MONTAGE



MS-I-VT 2006/c (383 44 00)

■ MONTAGE
Les composants ASCO/JOUCOMATIC sont conçus pour les domaines de fonctionnement indiqués dans la documentation. Aucune modification ne peut être réalisée sur le matériel sans l'accord préalable du fabricant ou de son représentant. Avant de procéder au montage, dépressuriser les canalisations et effectuer un nettoyage interne.
Le produit peut être monté dans n'importe quelle position.
Le sens de circulation du fluide est indiqué par repères sur le corps et ou dans la documentation.
La dimension des tuyauteries doit correspondre au raccordement indiqué sur le corps, étiquette ou la notice.
Attention :
- Une restriction des tuyauteries peut entraîner des dysfonctionnements.
- Afin de protéger le matériel installer une crépine ou un filtre adéquat en amont, aussi près que possible du produit.
- En cas d'utilisation de ruban, pâte, aérosol ou autre lubrifiant lors du serrage, veiller à ce qu'aucun corps étranger ne pénètre dans le circuit.
- Utiliser un outillage approprié et placer les clés aussi près que possible du point de raccordement.
- Afin d'éviter toute détérioration, NE PAS TROP SERRER les raccords des tuyauteries.
- Ne pas se servir de la vanne ou de la tête magnétique comme d'un levier.
- Les tubes de raccordement ne devront exercer aucun effort, couple ou contrainte sur le produit.

■ RACCORDEMENT ÉLECTRIQUE
Le raccordement électrique doit être réalisé par un personnel qualifié et selon les normes et règlements locaux.
Attention :
- Avant toute intervention, couper l'alimentation électrique pour mettre hors tension les composants.
- Selon la tension, les composants électriques doivent être mis à la terre conformément aux normes et règlements locaux.
- Le raccordement s'effectue par connecteur débrochable 3 broches (2 + masse) avec CM 8 (Pg 9P) orientable à 180° et un degré de protection IP65 lorsque le raccordement est correctement effectué.
Avant mise sous tension, vérifier la concordance de tension entre bobine et réseau d'alimentation.

■ MISE EN SERVICE - ENTRETIEN
Avant de mettre le circuit sous pression, effectuer un essai électrique. Mettre la bobine sous tension plusieurs fois et écouter le "clic" métallique qui signale le fonctionnement de la tête magnétique.
L'électrovanne comporte un bobinage prévu pour mise sous tension permanente, dans les limites de température ambiante maximale (+60° C). Pour éviter toute brûlure, ne pas toucher la tête magnétique qui, en fonctionnement normal et en permanence sous tension, peut atteindre une température élevée.
Si l'électrovanne est facilement accessible, l'installateur doit prévoir une protection empêchant tout contact accidentel.
Chaque électrovanne est équipée d'une commande manuelle à position maintenue à commande par tournevis.
L'entretien nécessaire sur ces produits varie avec leurs conditions d'utilisation. Il est souhaitable de procéder à un nettoyage périodique dont l'intervalle varie suivant la nature du fluide, les conditions de fonctionnement et le milieu ambiant.

INSTALLATION
ASCO/JOUCOMATIC components are intended to be used only within the technical characteristics as specified on the nameplate. Changes to the equipment are only allowed after consulting the manufacturer or its representative. Before installation depressurize the piping system and clean internally.
The equipment may be mounted in any position.
The flow direction and pipe connection of valves are indicated on the body and or in the documentation.
The pipe connections have to be in accordance with the size indicated on the nameplate and fitted accordingly.
Caution:
- Reducing the connections may cause improper operation or malfunctioning.
- For the protection of the equipment install a strainer or filter suitable for the service involved in the inlet side as close to the product as possible.
- If tape, paste, spray or a similar lubricant is used when tightening, avoid particles entering the system.
- Use proper tools and locate wrenches as close as possible to the connection point.
- To avoid damage to the equipment, DO NOT OVERTIGHTEN pipe connections.
- Do not use valve or solenoid as a lever.
- The pipe connections should not apply any force, torque or strain to the product.

■ ELECTRICAL CONNECTION
Isolate from electrical supply, they are only to be made by trained personnel and have to be in accordance with the local regulations and standards.
Caution:
- Turn off electrical power supply and de-energize the electrical circuit and voltage carrying parts before starting work.
- Dependent upon the voltage electrical components must be provided with an earth connection and satisfy local regulations and standards.
- The electrical connection is by a plug with 3 pins (2 + earth) with CM 8 (Pg 9P) cable entry. The plug can be fitted in 2 positions x 180°
when correctly installed this connection provides IP-65 protection.
Before energising the coil ensure that the supply voltage is the same that indicated on the name plate of the coil.

■ PUTTING INTO SERVICE - MAINTENANCE
Before pressurizing the system, first carry-out an electrical test. Energize the coil a few times and notice a metal click signifying the solenoid operation.
The valve are equipped with coils suitable for continuous operation. The ambient temperature should not exceed +60° C to prevent. To prevent the possibility of personal or property damage do not touch the solenoid which can become hot under normal operation conditions.
If the solenoid valve is easily accessible, the installer must provide protection preventing accidental contact.
Every solenoid valve is fitted with a 2 position manual override which is operated using a screwdriver.
Maintenance on this products is dependent on service conditions. Periodic cleaning is recommended, the timing of which will depend on the media and service conditions.

■ EINBAU
Die ASCO/JOUCOMATIC Komponenten dürfen nur innerhalb der auf den Typenschildern angegebenen Daten eingesetzt werden. Veränderungen an den Produkten sind nur nach Rücksprache mit ASCO/JOUCOMATIC zulässig.
Vor dem Einbau der Ventile muß das Rohrleitungssystem drucklos geschaltet und innen gereinigt werden.
Die Einbaulage der Produkte ist generell beliebig.
Die Durchflußrichtung und der Eingang von Ventilen sind gekennzeichnet.
Die Rohranschlüsse sollten entsprechend den Größenangaben auf den Typenschildern mit handelsüblichen Verschraubungen durchgeführt werden.
Dabei ist folgendes zu beachten:
- Eine Reduzierung der Anschlüsse kann zu Leistungs- und Funktionsminderungen führen.
- Zum Schutz der Ventile sollten Schmutzfänger oder Filter so dicht wie möglich in den Ventileingang integriert werden.
- Bei Abdichtung am Gewinde ist darauf zu achten, daß kein Dichtungsmaterial in die Rohrleitung oder das Ventil gelangt.
- Zur Montage darf nur geeignetes Werkzeug verwendet werden.
- Konische Verschraubungen sind sorgfältig anzuziehen. Es ist darauf zu achten, daß beim Anziehen das Gehäuse nicht beschädigt wird.
- Magnet und Führungsrohr von Ventilen dürfen nicht als Gegenhalter benutzt werden.
- Die Rohrleitungsanschlüsse sollen fluchten und dürfen keine Spannungen auf das Ventil übertragen.

■ ELEKTRISCHER ANSCHLUß
Der elektrische Anschluß ist vom Fachpersonal entsprechend den geltenden VDE- und CEE-Richtlinien auszuführen.
Es ist besonders auf folgendes zu achten:
- Vor Beginn der Arbeiten ist sicherzustellen, daß alle elektrischen Leitungen und Netzteile spannungslos geschaltet sind.
- Je nach Spannungsbereich muß das Ventil nach den geltenden Regeln einen Schutzleiteranschluß erhalten.
- Der elektrische Anschluss erfolgt durch eine standardisierte Dreikontakt-Steckverbindung (2 Kontaktstifte + 1 Erde) mit CM8 (Pg 9P). 2 Positionen (jeweils 180° drehbar).
Bevor das Magnetventil eingeschaltet wird, prüfen, ob die Netzspannung mit der Spannung der Spule übereinstimmt.

■ INBETRIEBNAHME - WARTUNG
Vor Druckbeaufschlagung des Produktes sollte eine elektrische Funktionsprüfung erfolgen :
Den Magnet mehrmals ein- und ausschalten. **Es muß ein Klicken zu hören sein.**
Das Magnetventil ist für Dauerbetrieb bei einer maximalen Umgebungstemperatur von +60° C. Zur Vermeidung von Personen- und Sachschäden sollte jede Berührung mit dem Ventil vermieden werden, da der Magnet bei langerem Betrieb sehr heiß werden kann.
Bei leicht zugänglichem Magnetventil sollte vom Installateur ein Schutz vorgesehen werden, um jegliches versehentliches Berühren zu vermeiden.
Jedes Magnetventil ist mit einer Handnotbetätigung versehen. Verstellung über Schlitzachse mit Hilfe eines Schraubenziehers.
Die Wartung hängt von den Einsatzbedingungen ab. In entsprechenden Zeitabständen muß das Produkt geöffnet und gereinigt werden.

ASCO / JOUCOMATIC BP 312 · 92 506 Rueil cedex · France ☎ (33) 147 14 32 00 · Fax (33) 147 08 53 65

GB

GENERAL INSTALLATION AND MAINTENANCE INSTRUCTIONS

Note: These General Installation and Maintenance instructions must be read in conjunction with the instruction sheet for the specific product.

INSTALLATION

[illegible]

ELECTRICAL CONNECTION

[illegible]

PUTTING INTO SERVICE

[illegible]

SERVICE

[illegible]

SOUND EMISSION

[illegible]

MAINTENANCE

[illegible]

A separate Declaration of Incorporation relating to EEC-Directive 89/392/EEC Annex II B is available on request. Please provide acknowledgement number and serial numbers of products concerned.

FR

INSTRUCTIONS GÉNÉRALES D'INSTALLATION ET D'ENTRETIEN

Nota. Ces instructions generales d'installation et d'entretien completent la notice specifique du produit.

MONTAGE

Les composants ASCO/JOUCOMATIC sont conçus pour les domaines de fonctionnement indiqués sur la plaque signalétique [illegible]. Aucune modification ne peut être réalisée [illegible] du fabricant ou de son représentant. Avant le montage, [illegible] dépressuriser les canalisations et effectuer un nettoyage interne.

Sauf si une flèche ou la notice indique un sens de montage [illegible] de la tête magnétique, le produit peut être monté dans n'importe quelle position.

[illegible] indiqué par repères sur le [illegible].

[illegible]

Attention:

- [illegible] des dysfonctionnements.
- Afin de protéger le matériel, installer une crépine ou un filtre adéquat en amont, aussi près que possible du produit.
- [illegible]
- [illegible] possible du point de raccordement.
- Afin d'éviter toute détérioration, NE PAS TROP SERRER les [illegible].
- Ne pas se servir de la vanne ou de la tête magnétique comme [illegible].
- [illegible] ne doivent exercer aucun effet [illegible] sur le produit.

RACCORDEMENT ELECTRIQUE

Le raccordement électrique doit être réalisé par un personnel [illegible].

Attention:

- Avant toute intervention, couper l'alimentation électrique pour mettre hors tension les composants.
- Toutes les bornes à vis doivent être serrées correctement avant la mise en service.
- [illegible] doivent être mis à [illegible].

[illegible]

- Connecteur [illegible] DIN 46244 avec degré de protection IP65 lorsque le raccordement est correctement effectué.
- [illegible] sous boîtier métallique [illegible].
- [illegible] type AMP.
- [illegible] de la bobine.

MISE EN SERVICE

[illegible] la tête magnétique.

FONCTIONNEMENT

[illegible] peut atteindre une température élevée.

BRUIT DE FONCTIONNEMENT

[illegible]

ENTRETIEN

[illegible] produits ASCO/JOUCOMATIC [illegible] ou en cas de doute, veuillez contacter ASCO/JOUCOMATIC ou ses représentants officiels.

Conformement a la directive CEE 89/392/CEE Annexe II B, une Declaration d'incorporation peut être fournie sur demande. Veuillez nous indiquer le numéro d'accusé de réception (AR) et les références ou codes des produits concernés.

DE

ALLGEMEINE BETRIEBSANLEITUNG

ACHTUNG: Diese Allgemeine Betriebsanleitung gilt in Zusammenhang mit der jeweiligen Betriebsanleitung für die speziellen Produkte.

EINBAU

Die ASCO/JOUCOMATIC-Komponenten [illegible] der auf den Typenschildern angegeben Daten ein[illegible]. Veränderungen an den Produkten sind nur nach [illegible] mit ASCO/JOUCOMATIC zulässig.

Vor dem Einbau der Ventile muß das Rohrleitungssystem drucklos geschaltet und innen gereinigt werden.

Die Einbaulage der Produkte ist generell beliebig. **Ausnahme:** Die mit einem Pfeil gekennzeichneten Produkte müssen entsprechend der Pfeilrichtung montiert werden.

Die Durchflußrichtung und der Eingang von Ventilen sind gekennzeichnet.

Die Rohranschlüsse sollten entsprechend den Größenangaben auf den Typenschildern mit handelsüblichen Verschraubungen durchgeführt werden. **Dabei ist folgendes zu beachten.**

- Eine Reduzierung der Anschlüsse kann zu Leistungs- und Funktionsänderungen führen.
- Zum Schutz der Ventile sollten Schmutzfänger oder Filter so dicht wie möglich in den Ventileingang integriert werden.
- Bei Abdichtung am Gewinde ist darauf zu achten, daß kein Dichtungsmaterial in die Rohrleitung oder das Ventil gelangt.
- Zur Montage darf nur geeignetes Werkzeug verwendet werden.
- Konische Verschraubungen sind sorgfältig anzuziehen. Es ist darauf zu achten, daß beim Anziehen das Gehäuse nicht beschädigt wird.
- Spule und Führungsrohr von Ventilen dürfen nicht als Gegenhalter benutzt werden.
- Die Rohrleitungsanschlüsse sollen fluchten und dürfen keine Spannungen auf das Ventil übertragen.

ELEKTRISCHER ANSCHLUß

Der elektrische Anschluß ist von Fachpersonal entsprechend den geltenden VDE- und CEE-Richtlinien auszuführen. **Es ist besonders auf folgendes zu achten:**

- Vor Beginn der Arbeiten ist sicherzustellen, daß alle elektrischen Leitungen und Netzteile spannungslos geschaltet sind.
- Alle Anschlußklemmen sind nach Beendigung der Arbeiten vorschriftsmäßig entsprechend den geltenden Regeln anzuziehen.
- Je nach Spannungsbereich muß das Ventil nach den geltenden Regeln einen Schutzleiteranschluß erhalten.

Der Magnetantrieb kann je nach Bauart folgende Anschlüsse haben:

- Anschluß für Gerätesteckdose nach DIN 43650 Form A/ISO 4400 oder 3x DIN 46244 (durch ordnungsgemäße Montage der Gerätesteckdose wird Schutzklasse IP 65 erreicht).
- Anschlüsse innerhalb eines Blechgehäuses mittels Schraubklemmen. Kabeleinführung ins Gehäuse mit PG-Verschraubung.
- Offene Spulen mit Flachsteckern (AMP-Fabnen) oder mit eingegossenen Kabelenden.

INBETRIEBNAHME

Vor Druckbeaufschlagung des Produktes sollte eine elektrische Funktionsprüfung erfolgen.

Bei Ventilen Spannung an der Magnetspule mehrmals ein- und ausschalten. **Es muß ein Klicken zu hören sein.**

BETRIEB

Die meisten Ventile sind mit Spulen für [illegible] ausgerüstet. Zur Vermeidung von Personen- un[illegible] sollte jede Berührung mit dem Ventil vermieden [illegible]. Magnetspule bei längerem Betrieb sehr heiß wird.

GERAUSCHEMISSION

Diese hängt sehr stark vom Anwendungsfall, den Betriebsdaten und dem Medium, mit denen das Produkt beaufschlagt wird, ab. Eine Aussage über die Geräuschemission des Produktes muß deshalb von demjenigen getroffen werden, der das Produkt innerhalb einer Maschine in Betrieb nimmt.

WARTUNG

Die Wartung hängt von den Einsatzbedingungen ab. In entsprechenden Zeitabständen muß das Produkt geöffnet und gereinigt werden. Für die Überholung der ASCO/JOUCOMATIC Produkte können Ersatzteilsätze geliefert werden. Treten Schwierigkeiten bei Einbau, Betrieb oder Wartung auf, sowie bei Unklarheiten, ist mit ASCO/JOUCOMATIC Rücksprache zu halten.

(ASCO/JOUCOMATIC Produkte sind entsprechend der EG-Richtlinie 89/392/EWG gefertigt.

Eine separate Herstellereklarung im Sinne der Richtlinie 89/392/EWG Anhang IIB ist auf Anfrage erhältlich. Geben Sie bitte für die Produkte die Nummer der Auftragsbestätigung und die Seriennummer an.

ASCO JOUCOMATIC LTD [illegible]

ASCO JOUCOMATIC LTD
Wandl[illegible]
[illegible]

JOUCOMATIC S.A.
[illegible] MALMAISON CEDEX
France
Tel. [illegible]

ASCO JOUCOMATIC G.m.b.H.
[illegible] 5
D 40878 RATINGEN
Germany

ASCO JOUCOMATIC G.m.b.H.
[illegible]
[illegible] HEILBRONN [illegible]
Germany

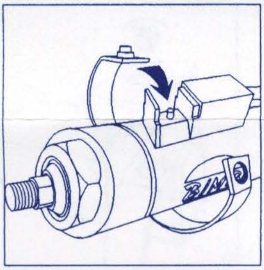
MRS® MAGNETIC REED SWITCH

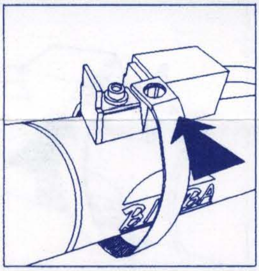
Pig Tail Lead Assembly Instructions

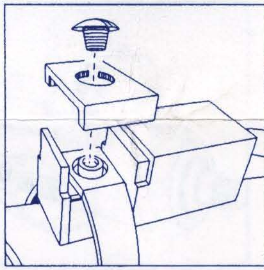
(see reverse side for Quick Connect Switches)

CONTENTS: 1 switch — 1 U-shaped bracket
1 band — 1 button head hex screw

SWITCH MOUNTING INSTRUCTIONS



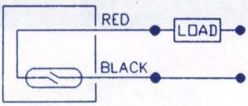




ELECTRICAL SPECIFICATIONS

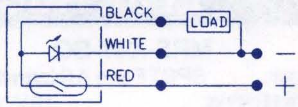
MRS-.087-B

Contacts .... SPST Form A (Normally Open)
Contact Rating .... 10 Watts max.
Switch Voltage .... 200 Volts max. AC/DC
Maximum Current ... 500 mA max. (Resistive)
Initial Contact Resistance ..... 0.10 ohms max.
Breakdown Voltage .... 400 Volts min.
Actuating Time Average .... 1.0 millisecond



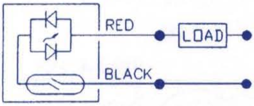
MRS-.087-BL

Contacts .... SPST Form A (Normally Open)
Contact Rating .... 9 Watts max.
Switch Voltage .... 6 to 24 Volts
Maximum Current ... 500 mA max. (Resistive)
Initial Contact Resistance ..... 0.10 ohms max.
Actuating Time Average .... 1.0 millisecond



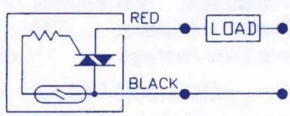
MRS-.087-PBL

Contacts .... SPST Form A (Normally Open)
Contact Rating .... 2.5 Watts max.
Switch Voltage .... 3 to 120 Volts AC or DC
Minimum Current .... 10 mA AC or DC
Maximum Current .... 20 mA AC or DC
Initial Contact Resistance ..... 0.10 ohms max.
Actuating Time Average .... 1.0 millisecond



MRS-.1.5-B

Contacts .... SPST Form A (Normally Open)
Voltage Rating ...... 12 to 230 Volts (AC only)
Minimum Current .... 0.1 amps
Maximum Current ... 1.5 amps @ 50ºF(10ºC)
0.5 amps @ 200ºF(93ºC)
Actuating Time Average ...... 2.0 milliseconds



Bimba Manufacturing Company
Monee, IL 60449
708/534-8544 FAX: 708/534-5767
Technical Assistance: 1-800-44-*BIMBA*

Bimba Limited
Cambridgeshire, United Kingdom
01733 391078 FAX: 01733 391080

Form MRS-398

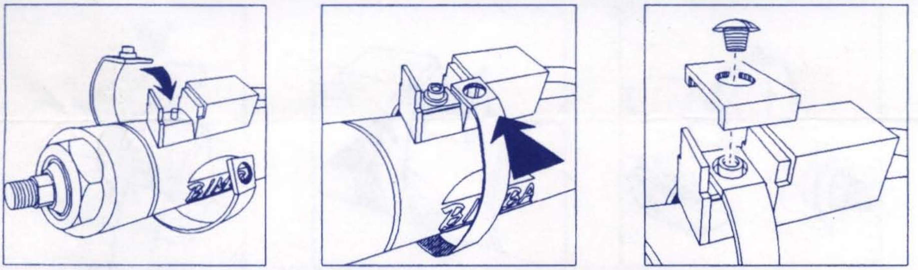
MRS® MAGNETIC REED SWITCH

Quick Connect
Assembly Instructions

(see reverse side for Pig Tail Lead Switches)

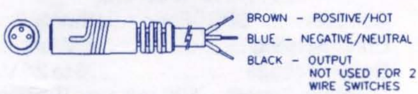
CONTENTS: 1 switch — 1 U-shaped bracket
1 band — 1 button head hex screw

SWITCH MOUNTING INSTRUCTIONS



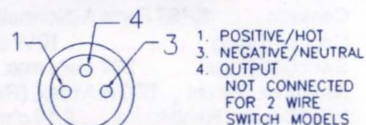
PIN AND WIRE ASSIGNMENTS

8mm Female Connector



Model "C" - 2m Cable
Model "CX" - 5m Cable

Face View of Male Connector



ELECTRICAL SPECIFICATIONS

MRS-.087-BQ

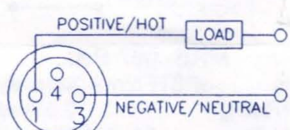
Contacts .... SPST Form A (Normally Open)
Contact Rating .... 10 Watts max.
Switch Voltage .... 120 Volts AC or DC
Maximum Current: .... 500 mA (Resistive)
Actuating Time Average .... 1.0 millisecond

MRS-.087-BLQ

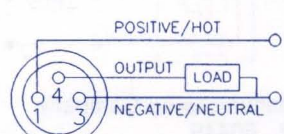
Contacts .... SPST Form A (Normally Open)
Contact Rating .... 9 Watts max.
Switch Voltage .... 6 to 24 Volts
Maximum Current: .. 500 mA max. (Resistive)
Initial Contact Resistance ..... 0.10 ohms max.
Actuating Time Average .... 1.0 millisecond

MRS-.087-PBLQ

Contacts .... SPST Form A (Normally Open)
Contact Rating .... 2.5 Watts max.
Switch Voltage .... 3 to 120 Volts AC or DC
Minimum Current .... 10mA AC or DC
Maximum Current .... 20 mA AC or DC
Initial Contact Resistance ..... 0.10 ohms max.
Actuating Time Average .... 1.0 millisecond



MRS-.087-BQ and
MRS-.087-PBLQ
8mm Male Connector



MRS-.087-BLQ
8mm Male Connector

Cryo-Torr® Pump Installation, Operation and Maintenance Instructions

Pub. No. 8040613, Rev. 105, 04/11/2005 ECO No. 16977 Printed in USA

HELIX TECHNOLOGY CORPORATION
http://www.helixtechnology.com

HELIX

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Section 5 - Maintenance Procedures

Appendix A - Customer Support Information

Index

  Pub. No. 8040613, Rev. 105, 04/11/2005 ECO No. 16977

Figures

Tables

Safety Conventions

Introduction

Follow all safety precautions during installation, normal operation, and when servicing CTI-Cryogenics products.

This chapter explains the safety conventions used throughout this manual. CTI-Cryogenics uses a specific format for cautions and warnings, which includes standard signal words and safety shapes.

See also the *Customer Support* appendix or call your local Customer Support Center for assistance.

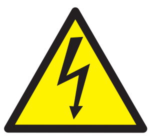
Signal Word Descriptions

All cautions and warnings contain signal words, which call attention to safety messages and designate the degree of hazard seriousness. The following table shows the signal words and their meanings that may be used in this document.

Term	Example	Definition
CAUTION	⚠ CAUTION	A signal word accompanied by a safety shape that indicates a potentially hazardous situation or unsafe practice. If not avoided, the action may result in **minor or moderate personal injury or equipment damage**. A CAUTION is highlighted in yellow.
CAUTION	CAUTION	A signal word that indicates a situation or unsafe practice, which if not avoided may result in **equipment damage**. A CAUTION is highlighted in yellow.
WARNING	⚠ WARNING	A signal word accompanied by a safety shape that indicates indicates a potentially hazardous situation. If not avoided, the action may result in **serious injury or death**. A WARNING is highlighted in orange.

Safety Shape Descriptions

All cautions and warnings contain safety shapes, which have specific safety meanings. The following table shows some of the safety shapes used in this document and their meanings.

Example	Term	Shape Definition
	General Warning	Indicates a general hazard. Details about this hazard appear in the safety notice explanation.
	High Voltage	Indicates a high voltage hazard.
	Hot Surface	Indicates a surface is hot enough to cause discomfort or a burn.

References

For more information about safety standards, see the following documents:

- ISO 7010: 2003(E), Graphic symbols - Safety colours and safety signs - Safety signs used in workplaces and public areas
- ISO 3864-1: 2002(E), Graphic symbols - Safety colours and safety signs - Part 1: Design principles for safety signs in workplaces and public areas

Section 1 - Cryo-Torr Cryopump Description

Introduction

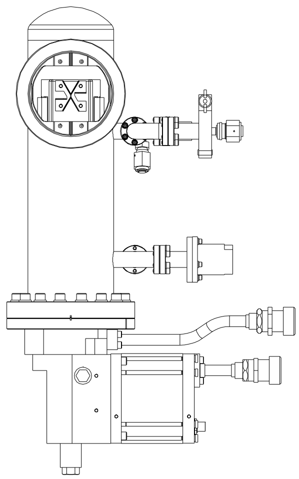
Cryo-Torr pumps, shown in Figure 1-1 and Figure 1-2, are one of the two major components that make up the Cryo-Torr Pumping System. The second component is the Compressor. Instructions for the compressor are contained in each compressor manual.

The Cryo-Torr Pump provides fast, clean pumping of all gases in the 10^{-3} to 10^{-9} Torr range. The cryopump operates on the principle that gases can be condensed and held at extremely low vapor pressures, achieving high speeds and throughputs, as described in Table 1-1 - Table 1-11.

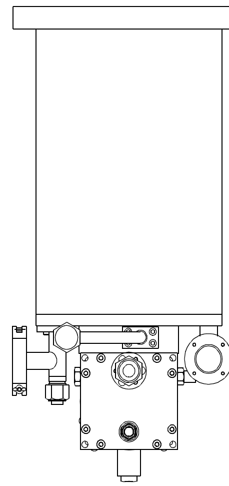
Your Cryo-Torr Pump is a highly-reliable and rugged unit that requires a minimum of servicing. Since the cryopump exposes no moving parts, operating fluids, or backing pumps to the vacuum, the possibility of system or process contamination from the cryopump itself is eliminated.

Installation, Operation, and Service Instructions

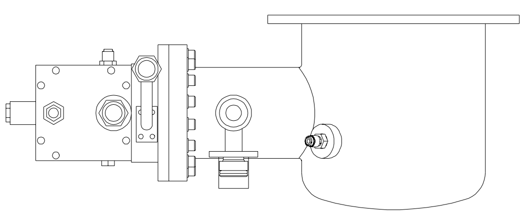
Installation, Operation and Maintenance Instructions for your Cryo-Torr vacuum pump provides easily accessible information. All personnel with installation, operation, and servicing responsibilities should become familiar with the contents of these instructions to ensure safe, reliable cryopump performance.



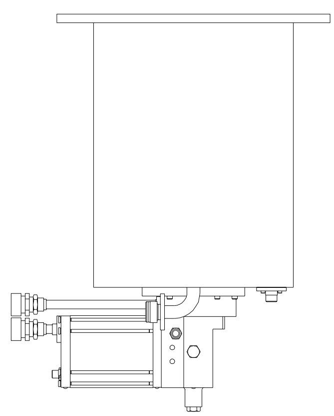
CRYO-TORR 4F



CRYO-TORR 8

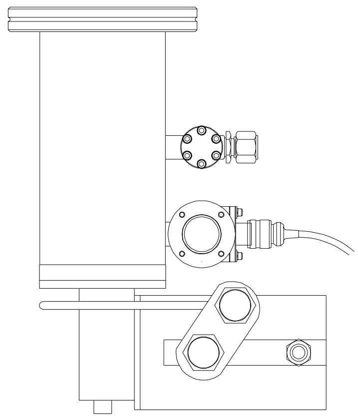


CRYO-TORR 8F

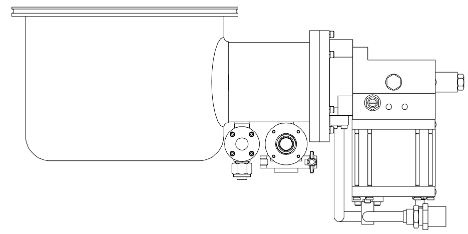


CRYO-TORR 10

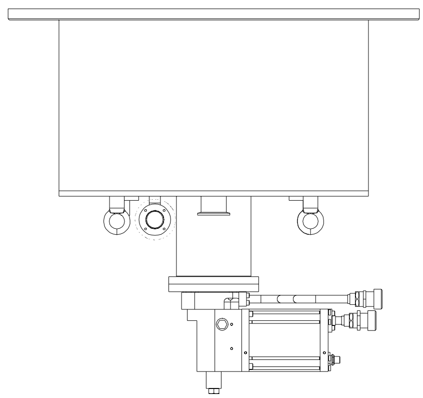
Figure 1-1: Cryo-Torr Pumps



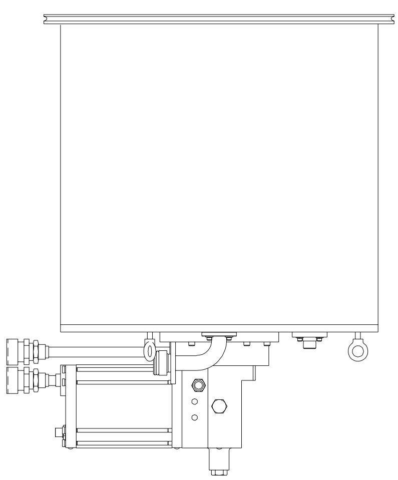
CRYO-TORR 100



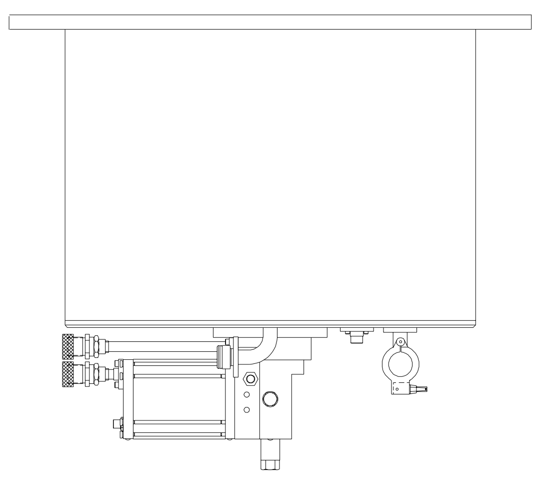
CRYO-TORR 250F



CRYO-TORR 20HP



CRYO-TORR 400



CRYO-TORR 500

Figure 1-2: Cryo-Torr Pumps

Specifications

Table 1-1: Cryo-Torr 4F Cryopump Specifications

Parameter	Specifications
Rough Pump Connection	NW 25 ISO KF
Integrated Hardware	Second Stage Diode
Pumping Speeds: Water Air Hydrogen Argon	 1100 liters/sec 370 liters/sec 370 liters/sec 310 liters/sec
Argon Throughput	700 scc/min. (9 Torr liters/second)
Capacity: Argon Hydrogen	 210 std. liters 3 std. liters @ 5 x 10^{-6} Torr
Crossover	100 Torr-liters
Cooldown Time 60 Hz 50 Hz	 75 min. 90 min.
Dimensions	Refer to Installation/Interface drawing
Weight	37 lbs. (17 kg)

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Table 1-2: Cryo-Torr 8 Cryopump Specifications

Parameter	Specifications
Rough Pump Connection	NW 25 ISO KF
Integrated Hardware	Second Stage Diode
Pumping Speeds: Water Air Hydrogen Argon	 4000 liters/sec 1500 liters/sec 2500 liters/sec 1200 liters/sec
Argon Throughput	700 scc/min. (9 Torr liters/second)
Capacity: Argon Hydrogen	 1000 std. liters 17 std. liters @ 5 x 10^{-6} Torr
Crossover	150 Torr-liters
Cooldown Time 60 Hz 50 Hz	 90 min. 110 min.
Dimensions	Refer to Installation/Interface drawing
Weight	45 lbs. (20 kg)

Table 1-3: Cryo-Torr 8F Cryopump Specifications

Parameter	Specifications
Rough Pump Connection	NW 25 ISO KF
Integrated Hardware	Second Stage Diode
Pumping Speeds: Water Air Hydrogen Argon	 4000 liters/sec 1500 liters/sec 2200 liters/sec 1200 liters/sec
Argon Throughput	700 scc/min. (8.9 Torr liters/second)
Capacity: Argon Hydrogen	 1000 std. liters 8 std. liters @ 5 x 10^{-6} Torr
Crossover	150 Torr-liters
Cooldown Time 60 Hz 50 Hz	 90 min. 110 min.
Dimensions	Refer to Installation/Interface drawing
Weight	42 lbs. (19 kg)

Table 1-4: Cryo-Torr 10 Cryopump Specifications

Parameter	Specifications
Rough Pump Connection	NW 25 ISO KF
Integrated Hardware	Second Stage Diode
Pumping Speeds: Water Air Hydrogen Argon	 9000 liters/sec 3000 liters/sec 5000 liters/sec 2500 liters/sec
Argon Throughput	1500 scc/min. (19 Torr liters/second)
Capacity: Argon Hydrogen	 2000 std. liters 24 std. liters @ 5 x 10^{-6} Torr
Crossover	300 Torr-liters
Cooldown Time 60 Hz 50 Hz	 100 min. 120 min.
Dimensions	Refer to Installation/Interface drawing
Weight	85 lbs. (39 kg)

Table 1-5: Cryo-Torr 10F Cryopump Specifications

Parameter	Specifications
Rough Pump Connection	NW 25 ISO KF
Integrated Hardware	Second Stage Diode
Pumping Speeds: Water Air Hydrogen Argon	 9500 liters/sec 3600 liters/sec 6000 liters/sec 3000 liters/sec
Argon Throughput	1500 scc/min. (19 Torr liters/second)
Capacity: Argon Hydrogen	 2000 std. liters 24 std. liters @ 5 x 10^{-6} Torr
Crossover	300 Torr-liters
Cooldown Time 60 Hz 50 Hz	 100 min. 120 min.
Dimensions	Refer to Installation/Interface drawing
Weight	90 lbs. (41 kg)

Table 1-6: Cryo-Torr 250F Standard Cryopump Specifications

Parameter	Specifications
Rough Pump Connection	NW 25 ISO KF
Integrated Hardware	Second Stage Diode
Pumping Speeds: Water Air Hydrogen Argon	 6500 liters/sec 2200 liters/sec 3200 liters/sec 1800 liters/sec
Argon Throughput	700 scc/min.
Capacity: Argon Hydrogen	 1000 std. 16 std. liters @ 5 x 10^{-6} Torr
Crossover	150 Torr-liters
Cooldown Time 60 Hz 50 Hz	 100 min. 120 min.
Dimensions	Refer to Installation/Interface drawing
Weight	48 lbs. (22 kg)

Table 1-7: Cryo-Torr 250FH High Capacity Cryopump Specifications

Parameter	Specifications
Rough Pump Connection	NW 25 ISO KF
Integrated Hardware	Second Stage Diode
Pumping Speeds: Water Air Hydrogen Argon	 6500 liters/sec 2200 liters/sec 4500 liters/sec 1800 liters/sec
Argon Throughput	700 scc/min.
Capacity: Argon Hydrogen	 1000 std. 24 std. liters @ 5 x 10^{-6} Torr
Crossover	150 Torr-liters
Cooldown Time 60 Hz 50 Hz	 100 min. 120 min.
Dimensions	Refer to Installation/Interface drawing
Weight	48 lbs. (22 kg)

Table 1-8: Cryo-Torr 400 Standard Capacity Cryopump Specifications

Parameter	Specifications
Rough Pump Connection	NW 25 ISO KF
Integrated Hardware	Second Stage Diode
Pumping Speeds: Water Air Hydrogen Argon	 16,000 liters/sec 6000 liters/sec 5000 liters/sec 5000 liters/sec
Argon Throughput	500 scc/min. (6 Torr liters/second)
Capacity: Argon Hydrogen	 2500 std. 15 std. liters @ 5 x 10^{-6} Torr
Crossover	300 Torr-liters
Cooldown Time 60 Hz 50 Hz	 150 min. 180 min.
Dimensions	Refer to Installation/Interface drawing
Weight	160 lbs. (73 kg)

Table 1-9: Cryo-Torr 400 High Capacity Cryopump Specifications

Parameter	Specifications
Rough Pump Connection	NW 25 ISO KF
Integrated Hardware	Second Stage Diode
Pumping Speeds: Water Air Hydrogen Argon	 16,000 liters/sec 6000 liters/sec 12,000 liters/sec 5000 liters/sec
Argon Throughput	500 scc/min. (6 Torr liters/second)
Capacity: Argon Hydrogen	 2500 std. 42 std. liters @ 5 x 10^{-6} Torr
Crossover	300 Torr-liters
Cooldown Time 60 Hz 50 Hz	 150 min. 180 min.
Dimensions	Refer to Installation/Interface drawing
Weight	160 lbs. (73 kg)

Table 1-10: Cryo-Torr 500 Cryopump Specifications

Parameter	Specifications
Rough Pump Connection	NW 25 ISO KF
Integrated Hardware	Second Stage Diode
Pumping Speeds: Water Air Hydrogen Argon	 30,000 liters/sec 10,000 liters/sec 10,000 liters/sec 8400 liters/sec
Argon Throughput	500 scc/min. (6 Torr liters/second)
Capacity: Argon Hydrogen	 3000 std. liters 16 std. liters @ 5 x 10^{-6} Torr
Crossover	500 Torr-liters
Cooldown Time 60 Hz 50 Hz	 180 min. 220 min.
Dimensions	Refer to Installation/Interface drawing
Weight	205 lbs. (93 kg)

Table 1-11: Cryo-Torr 20HP Cryopump Specifications

Parameter	Specifications
Rough Pump Connection	NW 25 ISO KF
Integrated Hardware	Second Stage Diode
Pumping Speeds: Water Air Hydrogen Argon	 31,500 liters/sec 10,000 liters/sec 15,000 liters/sec 8,400 liters/sec
Argon Throughput	1500 scc/min. (19 Torr liters/second)
Capacity: Argon Hydrogen	 5700 std. liters 46 std. liters @ 5 x 10^{-6} Torr
Crossover	300 Torr-liters
Cooldown Time	150 min.
Dimensions	Refer to Installation/Interface drawing
Weight	152 lbs. (69 kg)

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Theory of Operation

Your Cryo-Torr Cryopump consists of a cold head and a vacuum vessel. An 80K condensing array, a 15K array, cold head station heaters, and an 80K radiation shield are located in the vacuum vessel. The cold station heaters and 15K array are secured to the cold head, which is welded to the vacuum vessel. The cold head provides cooling to the three arrays. Gases are removed from your vacuum chamber, thereby creating a vacuum when they are condensed or adsorbed on the cryogenically-cooled arrays.

Cold Head

The cold head consists of a two-stage cold head cylinder (part of the vacuum vessel) and drive unit displacer assembly, that together produce closed-cycle refrigeration at temperatures that range from 60 to 120K for the first-stage cold station to 10 to 20K for the second-stage cold station, depending on operating conditions. Within the drive unit displacer assembly, the drive unit actuates the displacer-regenerator assembly located in the cold head cylinder and thereby controls the flow of helium into the cold head. Within the drive unit are located the crankcase and drive motor, which is a direct-drive constant-speed motor, operating at 72 rpm on 60Hz power and 60 rpm on 50 Hz power.

During operation, high pressure helium from the compressor enters the cold head at the helium supply connector, and flows through the displacer-regenerator assembly, crankcase, and motor housing before exiting through the helium gas return connector and returning to the compressor. Helium expansion in the displacer-regenerator assembly provides cooling at the first and second stage cold stations.

Vacuum Vessel and Arrays

The 80K condensing array, as shown in Figure 1-3, condenses water and hydrocarbon vapors. The 15K array condenses nitrogen, oxygen, and argon while the specially processed charcoal of this array traps helium, hydrogen, and neon.

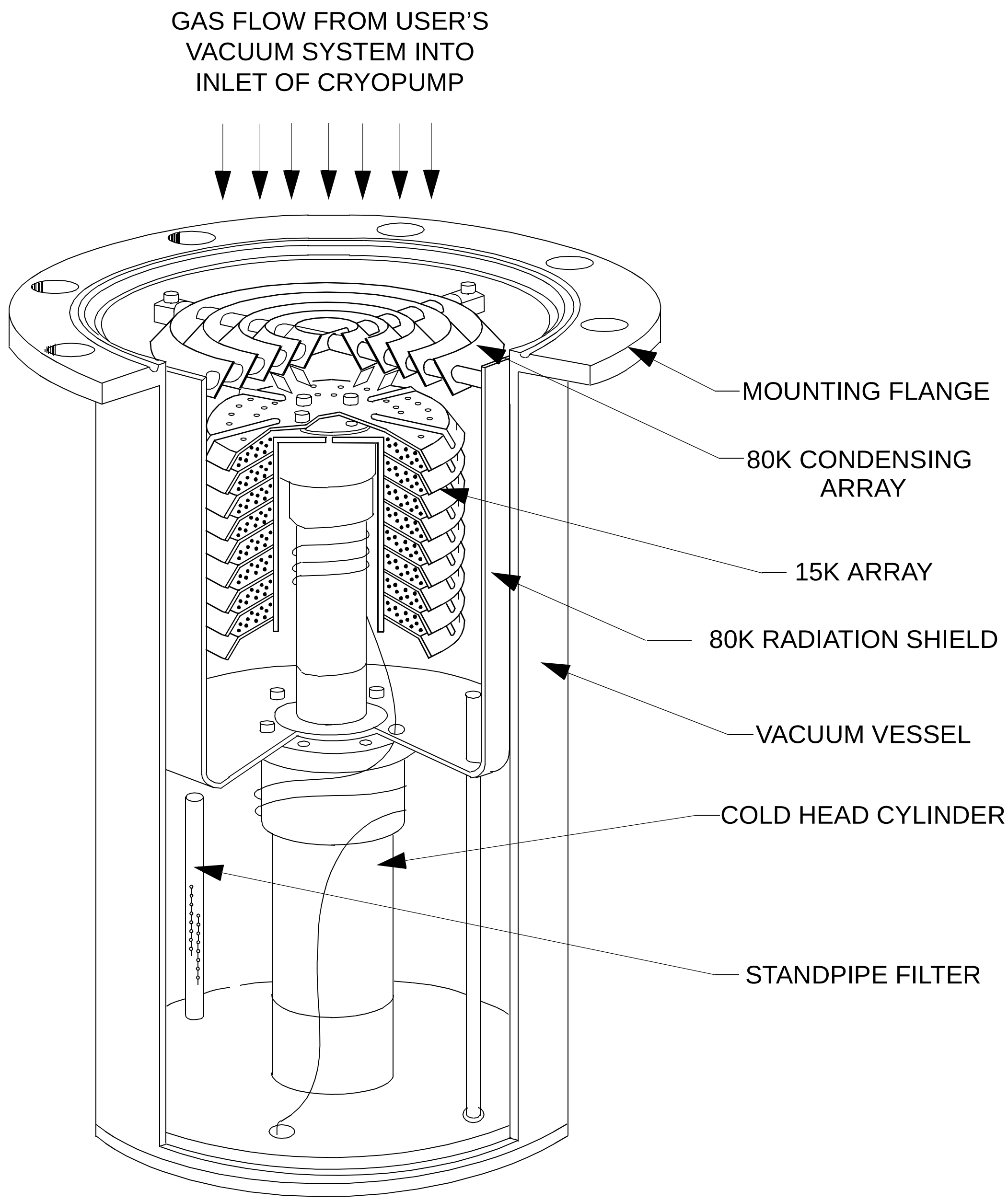


Figure 1-3: Cutaway View of a Typical Cryo-Torr Pump

Compressor Gas and Oil Flows

Helium returning from the cryopump cold head enters the compressor, and a small quantity of oil is injected into the gas stream, thereby overcoming helium's low specific heat and inability to carry heat produced during compression. Helium is then compressed and passed through a heat exchanger for removal of compression-caused heat.

The helium continues its flow through an oil-mist separator and a charcoal filter adsorber (cartridge), within the compressor, where oil and contaminants are removed. A differential pressure relief valve in the compressor limits the operating pressure differential between the helium supply and return lines, thereby allowing compressor operation without cold head operation. When cold head operation reaches a steady-stage condition, further pressure regulation is unnecessary.

Cryo-Torr Interface

The Cryo-Torr Interface, shown in Figure 1-3, is required when; connecting more than one Cryo-Torr Cryopump to a variety of CTI-CRYOGENICS Compressors, or when connecting a single Cryo-Torr Cryopump to the 9000 AND 8510 Series of compressors.

The Cryo-Torr Interface accepts input cryopump power from the compressor and distributes it to a maximum of three Cryo-Torr Cryopumps. The Cryo-Torr Interface also supports a Compressor Remote feature which can be used to turn the Cryo-Torr Cryopumps off when the compressor is turned off.

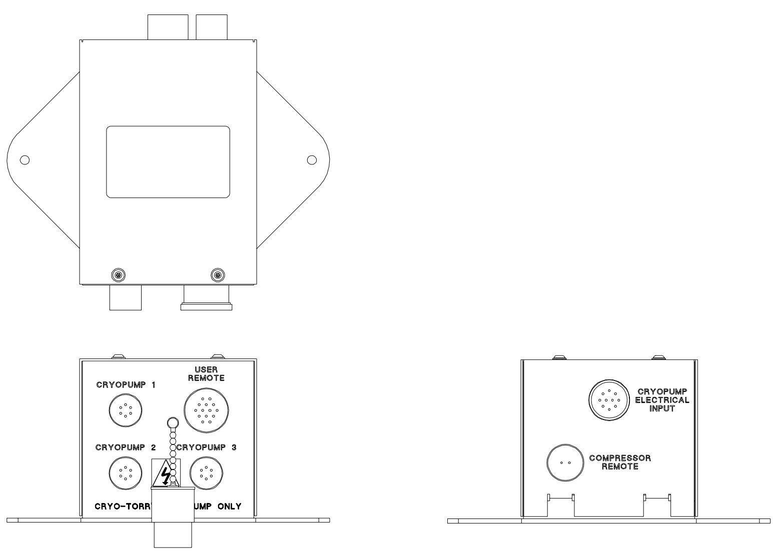


Figure 1-4: Cryo-Torr Interface

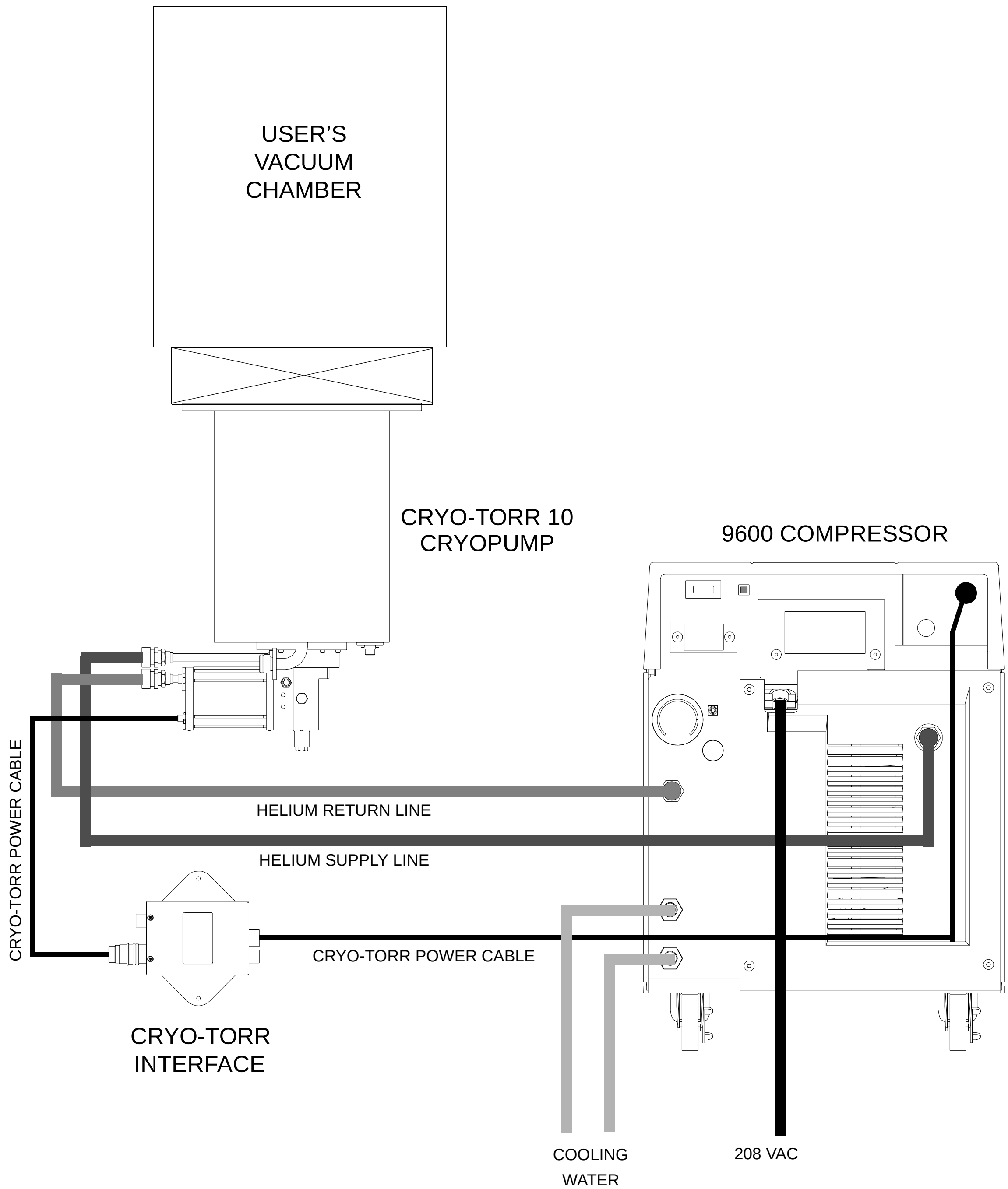


Figure 1-5: Typical Cryo-Torr System with 9000 Series Compressor

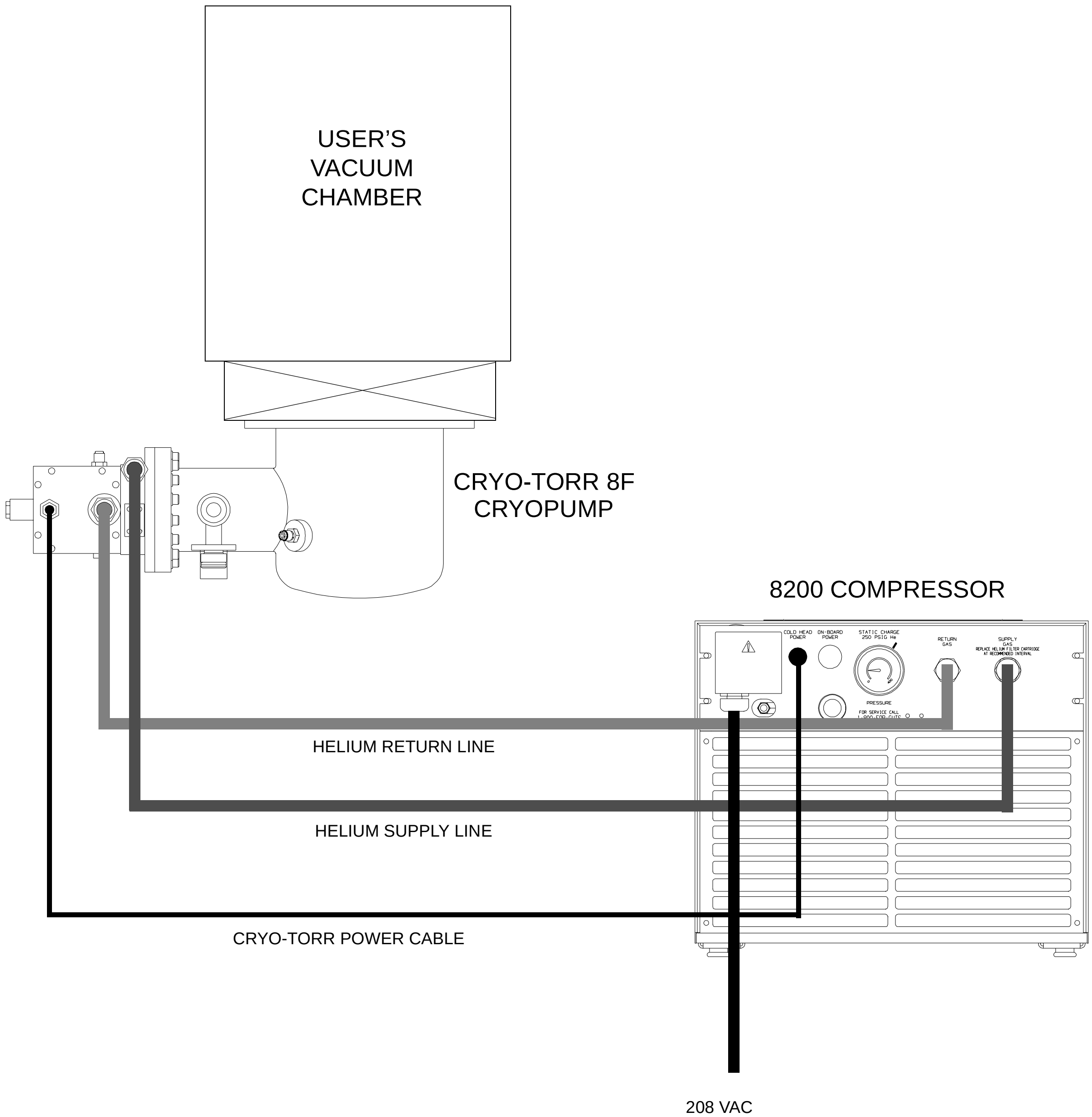


Figure 1-6: Typical Cryo-Torr System with 8200 Compressor

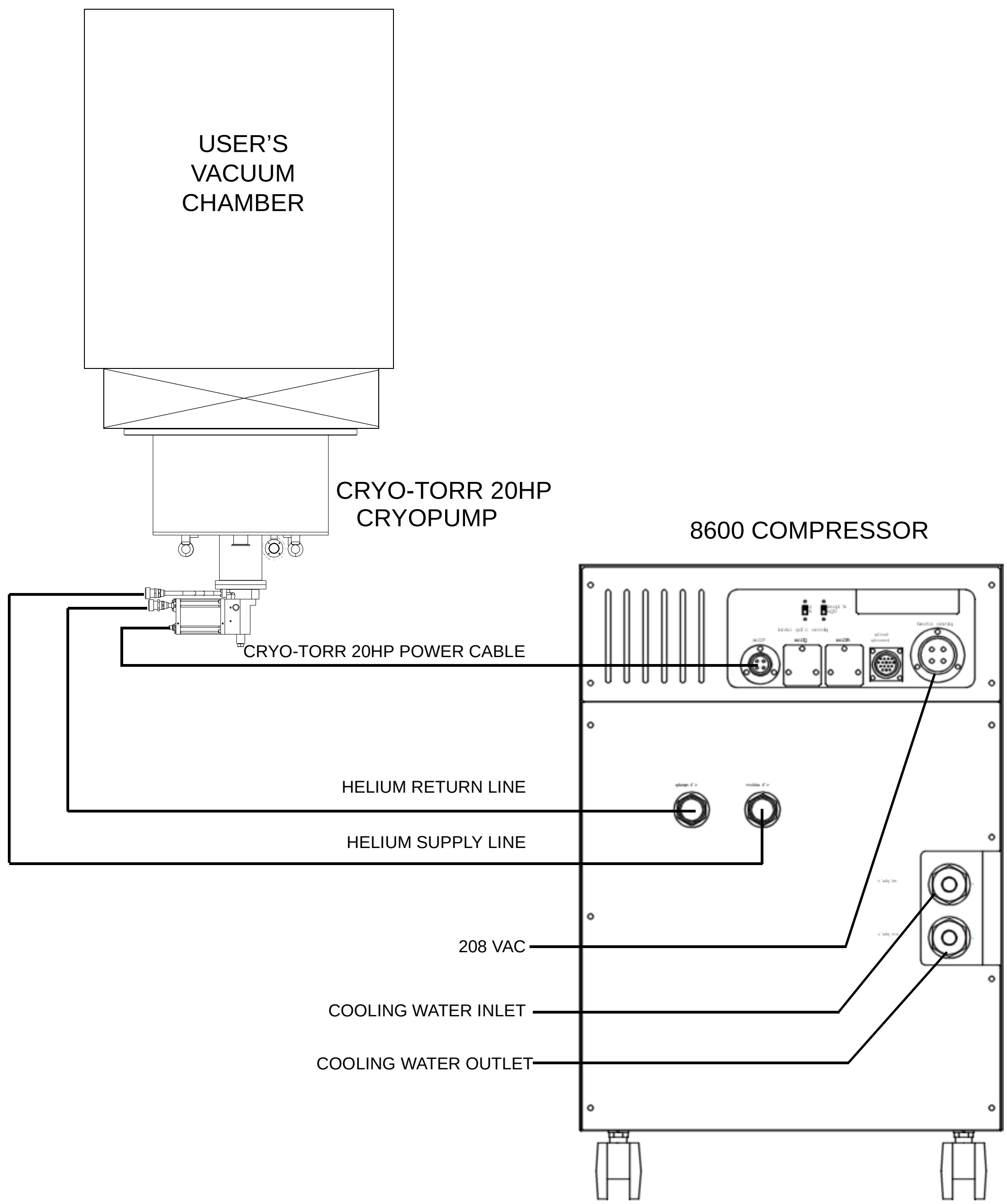


Figure 1-7: Typical Cryo-Torr System with 8600 Compressor

Section 2 - Installation

Introduction

Installation information is presented for experienced and non-experienced Cryo-Torr Cryopump system technicians. The flowchart in Figure 2-1 highlights the major tasks for installation of Cryo-Torr Cryopumps. Refer to Figure 2-1 and the appropriate installation procedure within this section for the type of cryopump being installed.

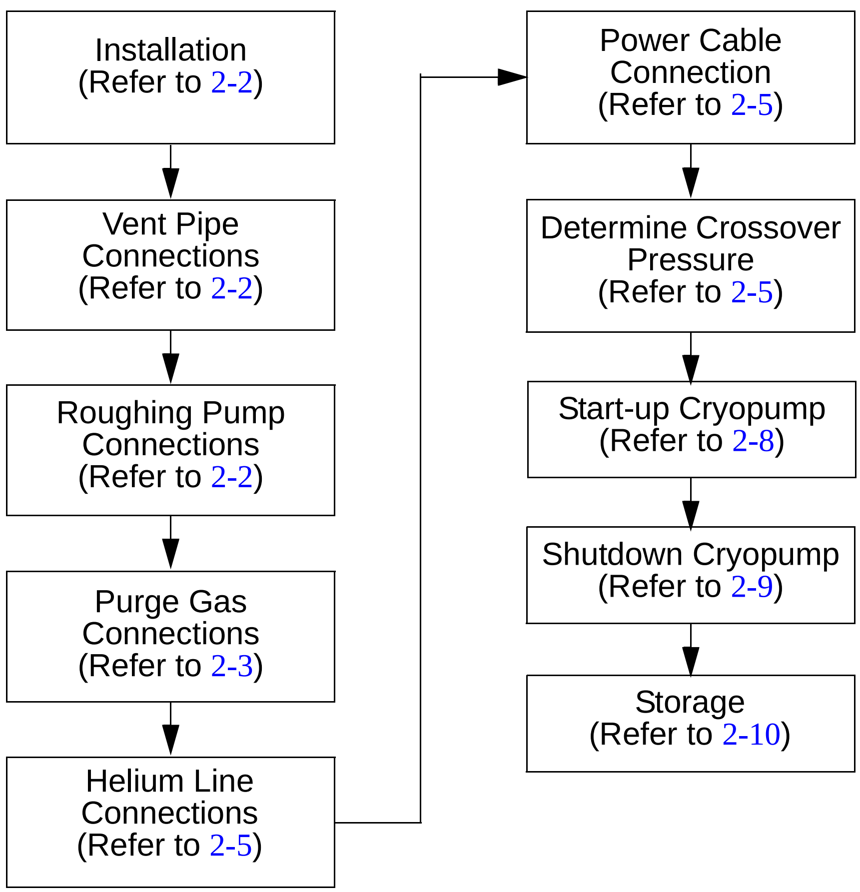


Figure 2-1: Block Diagram for Cryo-Torr System Installation

Installation

The cryopump may be installed in any orientation without affecting its performance.

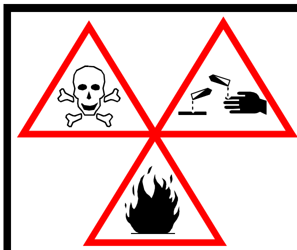
Before mounting the cryopump to the vacuum system, a high-vacuum isolation valve (Hi-Vac valve) should be installed between the cryopump and vacuum chamber to isolate the cryopump from the chamber during rough pumping, cooldown, and regeneration.

Install the cryopump to the vacuum system as follows:

1. Remove the protective cover from the main flange of the cryopump.
2. Clean all sealing surfaces and install the O-ring or metal seal gasket as appropriate.
3. Mount the cryopump to the Hi-Vac valve or vacuum chamber mounting flange. Follow the mating flange manufacturer's recommendations for the required hardware and securing procedures. Use all of the required mounting hardware.

Vent Pipe Connection

The cryopump pressure relief valve can be vented directly into the room or can be connected to an exhaust system.



WARNING

If toxic, corrosive, or flammable gases are pumped, a vent pipe must be connected to the cryopump relief valve and directed to a safe location.

When connecting a vent pipe to your cryopump, the 1.30-inch diameter x 1.38-inch long volume around the relief valve must remain open for proper relief valve operation.

Vent pipe adapters are available from CTI-CRYOGENICS (P/N 8080250K008).

Roughing Pump Connection

Connect your Cryo-Torr Cryopump to a roughing pump system using a roughing line with the largest inside diameter possible to minimize the roughing time required during start-up procedures prior to normal operation. The roughing pump should have a blank-off pressure of less than 20 microns. The roughing pump connects to the Cryo-Torr Cryopump roughing valve. The valve will accept an ISO NW-25 flange.

A molecular sieve roughing trap to minimize oil backstreaming from your roughing pump system is recommended and should be installed in the roughing pump line near the roughing pump. The trap must be properly maintained. Connect the roughing valve to the roughing pump as follows:

1. Install the roughing pump line to the cryopump roughing valve port using the clamp provided. Tighten the clamp securely.

Purge Gas Connection

Connect your purge gas supply line to the purge valve 1/8 NPTF fitting. Adjust the supply pressure to achieve 1-2 cfm.

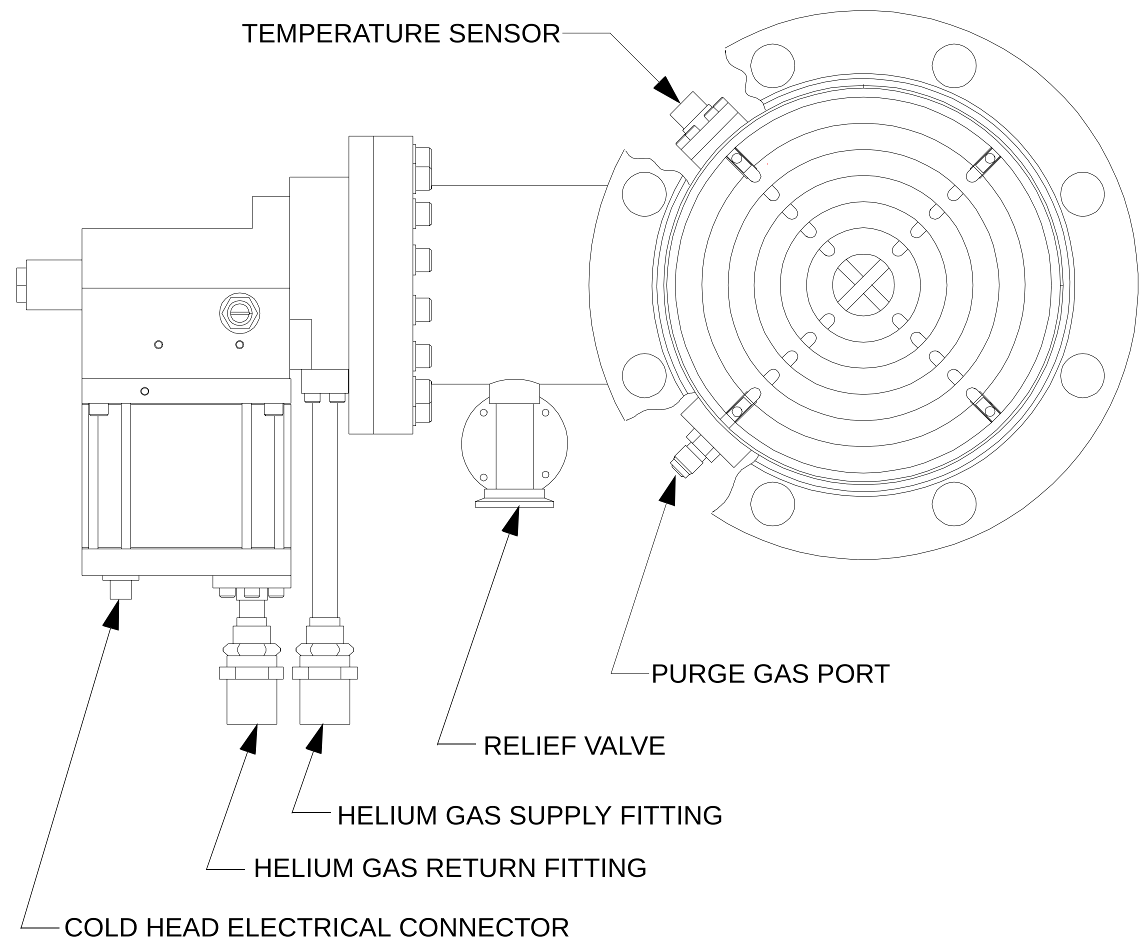


Figure 2-2: Gas/Electrical Components on a Typical Cryo-Torr Cryopump

Helium Return and Supply Line Connections

Make the connections between the cryopump and compressor. Refer to Figure 2-2, while making the component interconnections.

1. Remove all dust plugs and caps from the supply and return lines, compressor, and cryopump. Check all fittings.
2. Connect the helium-return line from the gas-return connector on the rear of the compressor to the gas-return connector on the Cryo-Torr Cryopump.
3. Connect the helium supply line from the supply connector on the cartridge to the gas-supply connector on the Cryo-Torr Cryopump.
4. Attach the supply and return line identification decals (CTI-CRYOGENICS supplied) to their respective connecting piping ends.

NOTE: Verify proper helium supply static pressure as described in the Installation Section of the appropriate Compressor Manual.

Power Cable Connection

CAUTION

The system power circuit breaker switch at the back of the compressor must be in the OFF position before making any and all electrical connections.

Do not connect the compressor to its power source until all connections have been made between the components of the Cryo-Torr system.

1. Connect the Cryo-Torr power cable from the cold head connector on the compressor to the Cryo-Torr Cryopump power connector.

Crossover Pressure Calculations

Crossover is that point in time when the pumping of a vacuum chamber is switched from *rough* pumping to *high-vacuum* pumping. Rough pumping brings the vacuum chamber pressure from one atmosphere (760 Torr) down to a pressure of approximately 0.5 Torr. At crossover, the roughing valve is closed and the high vacuum valve is opened bringing the vacuum chamber down to a pressure typically less than 10^{-6} Torr. This momentary pulse of gas and water molecules is cryo-condensed on the arrays of the Cryo-Torr Cryopump.

To determine the maximum permissible crossover pressure (CP), perform the following calculation using the crossover values (CV) for your model Cryo-Torr Cryopump shown in Table 2-1 and the actual volume of your vacuum chamber (VC).

Table 2-1: Crossover Values

Cryo-Torr Pump	Torr-Liters
4	100
8	150
8F	150
10	300
100	40
250F	300
400	300
20HP	300
500	500

Where VC = 100 liters:

$$CP = \frac{\text{CROSSOVER VALUE}}{\text{VACUUM CHAMBER VOLUME}} = \frac{CV}{VC}$$

$$CP = \frac{\text{300 TORR-LITERS}}{\text{100 LITERS}} = \text{3 TORR}$$

Optimizing Crossover Pressure

The calculated crossover pressure may not be optimized for your system. To help prevent any backstreaming during the roughing of the vacuum chamber, you should stop roughing at as high a pressure as possible. The optimum crossover pressure for a vacuum chamber should cause a very slight rise in temperature with a rapid recovery. Increase the roughing pressure in small increments (15-20%) until the rise in temperature is noted; then drop the value by a small amount (10%). This will be the optimum pressure for that vacuum chamber.

Cryo-Torr Cryopump Capacity Calculations

Cryopump capacity is defined as the total standard liters of gas that can be accommodated within a cryopump prior to regeneration. The number of hours between regeneration cycles can be easily calculated in the case of a continuous gas flow of a known gas species:

$$A = \frac{16.6 \times C}{B}$$

Where:

A = Duration of operation with a continuous gas flow (hours)

B = Gas flow (scc/min.)

C = Cryo-Torr capacity for the particular gas species being flowed (std. liters) as shown in Table 2-2.

Table 2-2: Condensable Gases Capacity (Argon, Nitrogen, Oxygen, etc.)

Parameter	Value
Cryopump	Cryo-Torr 10F
Standard Liters	2000
Torr-Liters	1,500,000

Example:

For a sputtering application of continuously flowing argon gas at 70 scc/min, the duration of continuous operation with this gas flow (between regeneration) would be:

$$A = \frac{16.6 \text{ x } 2000 \text{ (std liters)}}{70 \text{ (scc/min)}} = 474 \text{ hours}$$

Crossover Cycle Calculations

The number of crossover cycles between regeneration cycles can also be easily calculated when the crossover pressure and vacuum chamber volume are known:

$$N = \frac{760{,}000 \text{ Torr-liters}}{P \text{ x } V}$$

Where:

N = Number of crossover cycles

V = Volume of vacuum chamber (liters)

P = Pressure of vacuum chamber prior to crossover (Torr)
(roughing pressure)

Example:

For a vacuum chamber of 100 liters and a roughing pressure of 1.5 Torr, the number of crossover cycles between regeneration cycles would be:

$$N = \frac{760{,}000 \text{ Torr-liters}}{1.5 \text{ (Torr) x } 100 \text{ (liters)}} = 5{,}060 \text{ cycles}$$

Cryopump Start-up Procedure

1. Close the Hi-Vac valve to isolate the Cryo-Torr Cryopump.
2. Initiate a Nitrogen purge of the Cryo-Torr Cryopump for one hour.

3. Open the roughing valve and rough the Cryo-Torr Cryopump to 50 microns. Close the roughing valve.

NOTE: If step 4 cannot be achieved, repeat step 3.

4. Check the rate-of-rise. The rate-of-rise should be 10 microns/ minute.

NOTE: Cryo-Torr Cryopump power is turned ON/OFF when compressor power is turned ON/OFF.

5. Turn compressor power ON.
6. Wait for the second stage temperature (T2) to be less than 17 K.
7. Open the Hi-Vac valve.

Cryopump Shutdown Procedure

Typically, a cryopump can be left in operation continuously if you are not processing or not using the vacuum chamber, by simply closing the Hi-Vac value to isolate the cryopump from your vacuum chamber. You are now able to load, unload, repair or replace components in the chamber and the cryopump will be available for restarting the process as necessary.

1. Close the Hi-Vac valve to isolate the cryopump.
2. Shut off the cryopump by removing the input power cable to the cryopump motor.
3. Initiate Nitrogen gas purge.
4. Continue Nitrogen gas purge until ambient temperature is reached.
5. Shut off the Nitrogen gas purge.

Cryopump Storage

WARNING

If the cryopump has been used to pump toxic or dangerous materials, you must take adequate precautions to safeguard personnel. If such a cryopump is shipped to a Product Service Department, clearly mark on all storage cartons the identity of the toxic or dangerous materials to which the cryopump has been subjected. All shipped equipment that contains hazardous/toxic materials must conform to DOT regulations.

If the cryopump is stored while attached to your vacuum system, the cryopump vacuum vessel should be kept at a slight positive atmospheric pressure with dry nitrogen or argon.

If the cryopump is removed from your vacuum system, install the protective cover on the mounting flange of the cryopump vacuum vessel inlet before storage.

The remaining components of your Cyro-Torr high vacuum pump system are fully protected during storage if kept under positive helium pressure and all component connections left connected. Periodically, check the helium supply pressure gauge on the compressor and refer to the compressor manual for the proper static charge pressure.

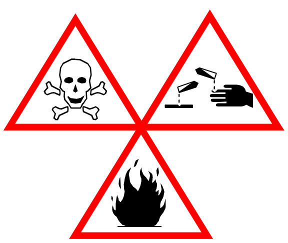
Section 3 - Regeneration

Introduction

A Cryo-Torr cryopump periodically requires a regeneration cycle to return it to its original operating capabilities.

Gases captured from a vacuum chamber and trapped in the cryopump through condensation and cryo-adsorption are held primarily in an ice-like form. A regeneration cycle removes trapped gases through a process similar to defrosting a refrigerator freezer compartment.

During a regeneration cycle, the cryopump is warmed to room temperature or higher, allowing trapped gases to change from a solid state to a gaseous state and thereby released from the cryopump through the pressure relief valve to the atmosphere.



WARNING

If toxic, corrosive, or flammable gases are pumped, a vent pipe must be connected to the cryopump relief valve and directed to a safe location.

When to Regenerate

The need to regenerate the Cryo-Torr pump as a result of saturation is a function of the cryopump capacity and the process gas throughput.

If the cryopump becomes incapable of maintaining a high-vacuum (typically an increase in your vacuum chamber base pressure by a factor of 10, even though the cold head and compressor unit are operating satisfactorily), the cryopump requires regeneration.

It is recommended that your cryopump be regenerated on a regular schedule coinciding with system maintenance, weekend system shutdown, etc. A suitable time interval between regeneration cycles can be determined from experience.

Extended loss of electrical power (10 minutes or longer), system vacuum failure, such as venting with a partially open vacuum isolation valve, and operator error may necessitate cryopump regeneration.

NOTE: *Short term electrical outages of up to 10 minutes should not result in the need to regenerate your cryopump.*

Assisted Regeneration

A regeneration cycle incorporating the use of a heated dry inert purge gas (nitrogen/argon) is the preferred method of regeneration and will overcome unassisted regeneration technical difficulties by:

- Minimizing the required time to bring the condensing and cryo-adsorbing arrays to room temperature
- Reducing the time required to rough the cryopump because the dry inert purge gas will minimize the amount of residual water vapor in the 15K array
- Diluting hazardous gases and ensuring their removal from the cryopump housing

Table 3-1: Required Accessories for Assisted Regeneration

Part Number	Description
8080250K020	Purge Gas Heater, 110 V
8080250K023	Purge Gas Solenoid Valve, 110V

NOTE: *Call 1-800-FOR GUTS to obtain the accessories listed in Table 3-1:.*

1. Close the Hi-Vac isolation valve.
2. Shut off the cryopump by setting the System Power switch on the compressor to the OFF position.
3. Immediately introduce heated dry purge gas through the vacuum vessel purge fitting at approximately 150º F (66º C) and at a flow rate of 1 -2 cfm. Allow the purge gas to vent through the relief valve.
4. Halt the gas purge when the condensing arrays reach 80º F (26º C) (300K).

5. When the condensing arrays reach ambient temperature, rough the cryopump to an initial starting pressure, usually between 50 and 100 microns.

NOTE: *After roughing, perform a rate-of-rise (ROR) test to ensure that your cryopump regeneration has been thorough and that no air-to-vacuum leaks are present.*

6. Perform the rate-of-rise test as follows:
   a. Once the roughing cycle has roughed the cryopump starting pressure to between 50 - 100 microns, close the roughing valve.
   b. Observe the rate of pressure rise (ROR) over a five minute period.

NOTE: *The ROR should be less than 10 microns/minute over a five minute period (50 microns total).*

   c. If the ROR is greater than 50 microns, repurge the cryopump, check for leaks, and repeat steps 5 and 6.
7. Close the cryopump roughing valve and start the cryopump.
8. The cryopump is ready for use when the second stage array reaches a temperature of 20K or lower.

Section 4 - Troubleshooting

Troubleshooting the Cryopump

The primary indication of trouble in a vacuum pumping system is a rise in base pressure in your vacuum chamber. A rise in the base pressure may be caused by a leak in the vacuum system or by a fault in the cryopump or saturation of the 15K cryo-adsorbing charcoal array (regeneration may be necessary). If the cryopump temperature is below 20K it must pump at rated capacity; a high base pressure is usually caused by an air-to-vacuum leak in the system.

If you suspect a leak in your vacuum system, isolate the cryopump by closing the Hi-Vac valve and leak check your vacuum chamber. If no leaks are found, a leak may be present below the Hi-Vac valve (cryopump). Leak checking below the Hi-Vac valve should be performed with the cryopump shut OFF and at room temperature. Leak checking while the cryopump is operating may mask leaks that are present (due to the ability of the cryopump to pump helium). If no leak is found, refer to the cryopump troubleshooting procedures summarized in Table 4-1.

The problems presented in Table 4-1 are followed by possible causes and corrective actions. The causes and corresponding actions are listed in their order of probability of occurrence.

Maintaining a log of certain parameters during normal operation can be a valuable tool in troubleshooting the cryopump. The log may contain many parameters, however, the following minimum parameters should be included: the cooldown time to 20K, the roughing time to 50μ, the time to base pressure at crossover, the time between regeneration cycles, and the compressor pressure reading.

Technical Inquiries

Please refer to **Appendix A** of this manual for a complete list of the CTI-CRYOGENICS' world wide customer support centers.

Table 4-1: Troubleshooting Procedures

Problem	Possible Cause	Corrective Action
High base pressure of vacuum system, and a cryopump temperature *below* 20K.	Air-to-vacuum leak in vacuum system or in cryopump.	Check cryopump relief valve for proper seating. Check cryopump for leaks. Check vacuum chamber and Hi-Vac valve for leaks.
	High partial pressure of non-condensables (helium, hydrogen, or neon) within the cryopump because the 15K array has reached full capacity.	Regenerate the cryopump as described in Section 3 - Regeneration.
	One of the arrays is loose, which is preventing good thermal contact with the cold station.	Warm the cryopump to ambient temperature and retighten the array mounting screws to 15 - 20 in. lbs.
High base pressure of vacuum system, and a cryopump temperature *above* 20K.	Decrease in cryopump cold head performance.	If the helium return pressure gauge reads below the normal-operating return pressure 60-85 psig (415-590 kPa), add gas as described in the appropriate Compressor manual.
	High partial pressure of non-condensables (helium, hydrogen, or neon) within the cryopump because the 15K array has reached full capacity.	Regenerate the cryopump as described in Section 3 - Regeneration.
	Excessive thermal load on frontal array.	Reduce the thermal radiation load by 1) shielding the cryopump or 2) lowering the temperature of the radiating surface.

  Pub. No. 8040613, Rev. 105, 04/11/2005 ECO No. 16977

Table 4-1: Troubleshooting Procedures (Continued)

Problem	Possible Cause	Corrective Action
Cryopump fails to cool down to the required operating temperature or takes too long to reach that temperature (20K).	Low helium supply pressure.	Add gas as described in the appropriate Compressor manual.
	Compressor problems.	Refer to Troubleshooting section of the appropriate Compressor manual.
	Vacuum leak in vacuum system or cryopump.	Check the cryopump relief valve for proper seating. Check cryopump for leaks. Check vacuum system for leaks.
	Incomplete regeneration may not have fully cleaned the adsorbing array. Partial pressures of non-condensables (hydrogen, neon or helium) may remain.	Regenerate the cryopump as described in Section 3 - Regeneration.

Section 5 - Maintenance Procedures

Helium Circuit Decontamination

Contamination of the helium-gas circuit is indicated by sluggish or intermittent operation (ratchetting) of the cold head drive mechanism. With severe contamination the cold head drive may seize and fail to operate. One of the major sources of contamination is using helium gas of less than the required purity. When performing the decontamination process, use only 99.999% pure-helium gas, and the regulator and charging line must be properly connected and purged.

This decontamination procedure will remove contaminants from the cold head and/or compressor, thereby restoring system performance. The cold-trapping of contaminants inside the cold head during this procedure will also decontaminate the compressor if the contamination of the system is not severe. Separate decontamination of the compressor is required whenever the compressor has been opened to atmosphere, or the pressure dropped to zero.

Cryo-Torr Cryopump Decontamination Procedures

NOTE: Refer also to the appropriate Compressor Manual.

1. Cool down the cryopump and operate it for one to three hours. If the system will not cool down, proceed to step 2. Operating the cryopump will isolate the contaminants by "freezing" them in the cold head. The contaminants in the helium-gas circuit of the cryopump tend to become frozen inside the cold head. The longer the cryopump is operated beyond the one-hour period, the greater is the amount of contamination that becomes isolated inside the cold head.
2. Shut down the cryopump as described in Section 2 - Installation.
3. *Immediately* disconnect the helium supply and return lines from the gas-supply and gas-return connectors at the rear of the compressor. Leave them attached to the cold head.
4. Attach the maintenance manifold to the disconnected ends of the return and supply lines.

5. Reduce the pressure in the cold head to a level of 30 psig by using the maintenance manifold. Reducing the pressure in the cold head to below 30 psig (200 kPa) may introduce more contaminants into the helium circuit.

   If you only have the manual regeneration option, turn the cryopump OFF and open the purge valve until the second stage temperature reaches 290K.

6. Attach a two-stage regulator (0-3000/0-400 psig) and charging line to a helium bottle (99.999% pure). DO NOT OPEN THE BOTTLE VALVE AT THIS TIME. Purge the regulator and charging line as introduced in steps a through d below. Do *not* use helium gas that is *less than 99.999% pure.*

   a. Open the regulator a small amount by turning the adjusting knob clockwise until it contacts the diaphragm; then, turn approximately 1/8 to 1/4 turn more, so that the regulator is barely open.

   b. Slowly open the bottle valve, and purge the regulator and line for 10 to 15 seconds. Turn the regulator knob counter-clockwise until the helium stops flowing.

   c. Loosely connect the charge line to the 1/8-inch Hoke valve on the maintenance manifold.

   d. Purge the charge line again, as in step a, for 30 seconds, and tighten the charge line flare fitting onto the Hoke valve while the helium is flowing.

This procedure is required to ensure that both the regulator and the charging line will be purged of air and that the air trapped in the regulator will not diffuse back into the helium bottle. For best results, CTI-CRYOGENICS suggests a dedicated helium bottle, regulator, and line, which are never separated, for adding helium.

7. Perform in sequence:

   a. Backfill the cold head with helium to a static charge pressure of 195-205 psig (1345-1415 kPa) by adjusting the regulator to the required pressure, and opening the Hoke valve on the manifold. Close the Hoke valve when the pressure is correct.

   b. Depressurize the cold head to 30 and 50 psig 200 and 330 kPa) by slowly opening the ball valve and allowing the helium to bleed out slowly. Do *not* reduce the pressure to *less than* 30 psig or the cold head may be further contaminated.

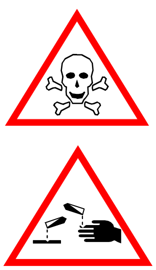
c. Perform the flushing steps a and b four more times.

d. Pressurize the cold head to a static charge pressure of 195-205 psig (1345-1415 kPa) and run the cold head drive motor for 10 to 30 seconds.

e. Perform steps b through d four more times for a total of 25 flushes and 5 drive-motor runs.

8. Verify that the cold head is pressurized to the static charge pressure of 195-205 psig (1345-1415 kPa).
9. Disconnect the maintenance manifold from the helium return and supply lines.
10. Reconnect the helium return and supply lines to the return and supply connectors at the rear of the compressor. The cryopump is now ready for operation.

Cleaning the Cryo-Torr Cryopump



WARNING

If the cryopump has been used to pump toxic or dangerous materials, you must take adequate precautions to safeguard personnel.

Cleaning the arrays or other interior surfaces of the cryopump vacuum vessel is seldom required because dust build-up does not affect performance, and the special alloy copper cryo-condensing arrays are nickel plated for corrosion resistance.

If you wish to clean the arrays and other interior surfaces, follow the procedures below.

1. Confirm that an adequate supply of indium gasket material, P/N 3543738P001, is available to replace gaskets inadvertently damaged during disassembly.
2. Carefully disassemble the components in the vacuum vessel, including the arrays and radiation shield, to avoid damage to the indium gaskets.
3. Clean the interior surface of the vacuum vessel, the 80K condensing array, and the 80K radiation shield as follows:

a. Wash each item in strong soap or detergent solution and hot water.

b. Rinse the item in *clean hot water.*

c. Air or oven dry all items at 150°F (66°C) maximum before reinstalling into the cryopump.

CAUTION

Do not clean the 15K cryo-adsorbing array, because you may severely contaminate the adsorbent in the cleaning process.

4. Wearing lint-free gloves, reassemble the cryopump. Replace any indium gasket damaged during disassembly with a gasket cut from indium gasket material.
5. Torque all screws that compress indium gaskets for a minimum of 5 seconds to allow proper gasket seating:

Table 5-1: Indium Gasket Screw Torque Specifications

Screw Thread	Torque (Inch-Pounds)
No. 4-40	11
No. 6-32	20

Appendix A - Customer Support Information

Customer Support Center Locations

To locate a Customer Support Center near you, please visit our website ***www.helixtechnology.com*** on the world wide web and select *CONTACT* on the home page.

Guaranteed Up-Time Support (GUTS)

For 24 hour, 7 day per week Guaranteed Up-Time Support (GUTS) dial:

800-367-4887 - Inside the United States of America

508-337-5599 - Outside the United States of America

Product Information

Please have the following information available when calling so that we may assist you:

- Product Part Number
- Product Serial Number
- Product Application
- Specific Problem Area
- Hours of Operation
- Equipment Type
- Vacuum System Brand/Model/Date of Manufacture

E-mail

For your convenience, you may also e-mail us at:

techsupport@helixtechnology.com

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CRYO-TORR®
TEMPERATURE INDICATOR

Overview

These instructions describe the installation and operation of the Cryo-Torr Temperature Indicator.

Upgrade Contents

Introduction

The Cryo-Torr Vacuum-Pump Temperature Indicator, part number 8043459G001 shown in Figure 1 on the following page, is used with Cryo-Torr high-vacuum pumps, to monitor cryopump operating temperatures. In cryopumps provided with a silicon diode sensor, the indicator is easily connected to the cryopump with an electrical cable. The digital readout is in Kelvin (K), with a system range from 9K to 320K. The indicator has two set points that are adjustable over this range. When the vacuum pump temperature reaches either setpoint, electrical contacts in the in-line 6-pin male connector on the rear panel can be used to activate indicators or to operate solenoid valves for controlling temperature-related functions. A pair of switches on the front panel permits momentary display of the two setpoints.

The Temperature Indicator can be used on a desktop or installed in an electronics rack using customer-supplied mounting hardware.

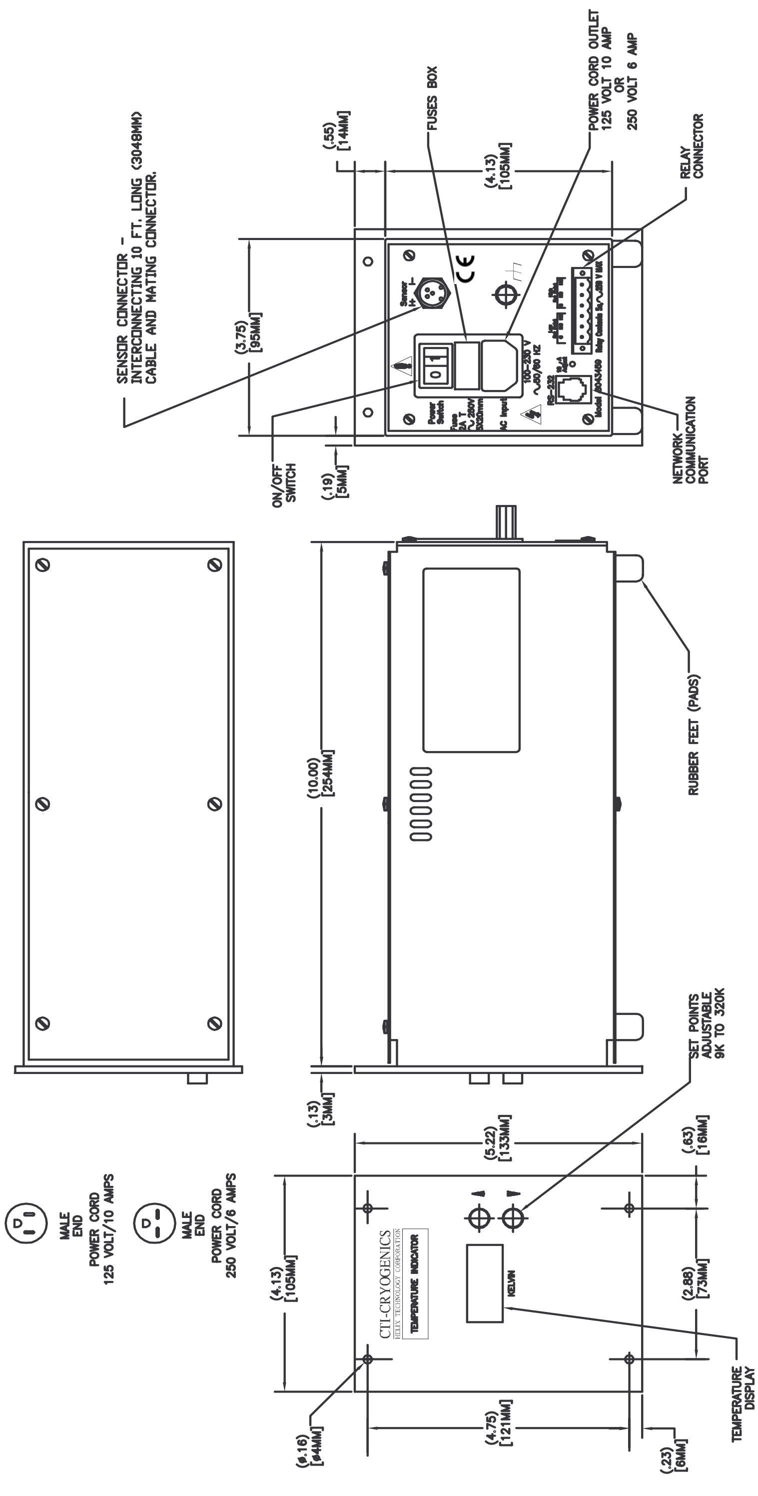

Figure 1: Cryo-Torr Temperature Indicator and Dimensions

Each Temperature Indicator is packaged with:

- 115VAC power cord - 7 ft. (2.13 m)
- 230VAC power cord - 7 ft. (2.13 m)
- Sensor cable (pump-to-temperature-indicator) - 10 ft. (3 m)
- Fuses (2)
- I/O communication cable (DB9 TO RJ11) - 7 ft. (2.13 m)
- Snap-on ferrite beads (2)
- Relay connector (In-line 6-pin female)
- Temperature indicator
- Copy of these instructions

Specifications

Electrical

100 - 230V, single phase (1ϕ), 50/60Hz (Nominal)

Two (2) 2A 250VAC fuses in the **POWER INPUT MODULE** on rear panel

Constant Current Output to Diode

10.0 - microampere (µA)

System Accuracy

10 - 27K: ± 2.5K

27 - 80K: ± 3.5K

80 - 90K: ± 4.5K

90 - 100K: ± 5.5K

100 - 320K: ± 2.5K

Readout Meter

Digital panel meter with temperature scale in Kelvin (K), range 9K to 320K, 100 microampere (µA) full scale.

Analog temperature readout is:

$$T_{C\ KELVIN} = 0.1125 \times V(mVDC)$$

Resolution

0.1K from 9 to 99.9K

1.0K from 100 to 450K

Alarm

Setpoints – Two (2) setpoints adjustable over 9K to 320K range, via front panel switches.

Output – Two relays - SPDT with 5.0A / 250V (max) (C, NO, NC) contacts.

RS-232 Interface

Output of temperature

External setting of alarm setpoints

Shipping Weight

5 pounds (11 Kg)

Input/Output Connections

- Sensor Connector (5-pin round female connector)

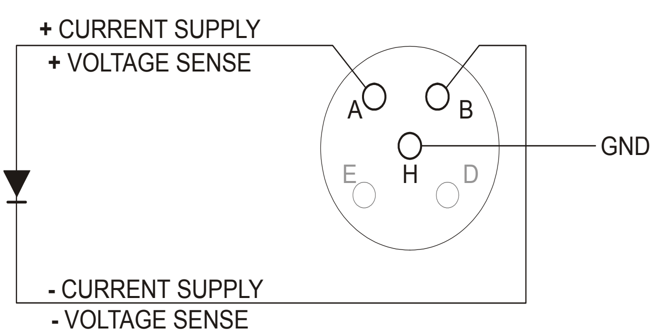

Figure 2: Sensor Connection Pinout

- RS-232 Communication Connector (RJ-11 connector)

Table 1: RS-232 Connections

BLK - Ground	GRN - Receive (In)
RED - Transmit (out)	YEL - (No Connection)

- Relay Alarm Output Connector (inline 6-pin male connector)

Table 2: Relay Connector Pin Assignments

Pin Number	Low Setpoint Relay 1	Pin Number	High Setpoint Relay 2
1	Common	4	Common
2	Normally Open (NO)	5	Normally Open (NO)
3	Normally Closed (NC)	6	Normally Closed (NC)

Installation

See Figure 3 for reference.

To install the electronics rack, do the following:

1. Remove the four pads from the bottom of the Temperature Indicator using a Phillips screwdriver.

2. Install the Temperature Indicator into the electronics rack using customer-supplied mounting hardware.

To install and connect the Temperature Indicator, do the following:

1. Connect the cryopump to the Temperature Indicator's SENSOR connector using the 10 ft. (3 m) interconnecting cord supplied with the indicator. If the supplied cord is too short, contact CTI-Cryogenics to order a longer cord.

2. Connect the Temperature Indicator to an appropriate power receptacle, using the correct power cord.

   Both 115V and 230V power cords are supplied with the unit, in the box. The unit has a universal power supply capable of operation from 85 to 264VAC, 50/60Hz, 5Watts. No switching is required to change the power cord.

3. Connect the ground stud on the Temperature Indicator to a suitable connection.

NOTE: *Perform Step 3 only when the power cord is connected to an ungrounded power supply.*

4. Wire the inline 6-pin female connector, supplied in the box, as shown in Step 3 of Input/Output Connections, to either the indicators or the solenoid valves as required.

5. Insert the inline 6-pin female connector into the male connector at the rear of the Temperature Indicator.

To use a remote connection:

- Connect an RS-232 cable (I/O communication cable) between the RS-232 connector on the Temperature Indicator and the host computer, using the cable supplied. See Figure 4 a picture of the cable. See Table 3 for the cable connection point.

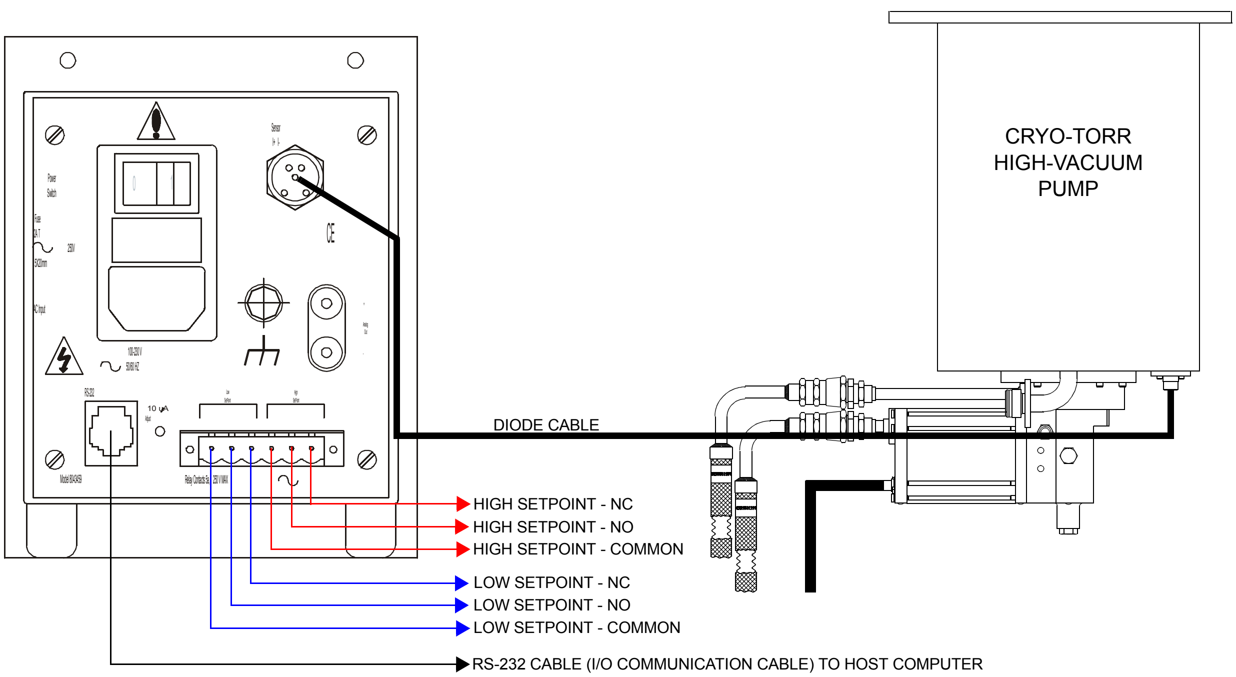

Figure 3: Temperature Indicator Installation

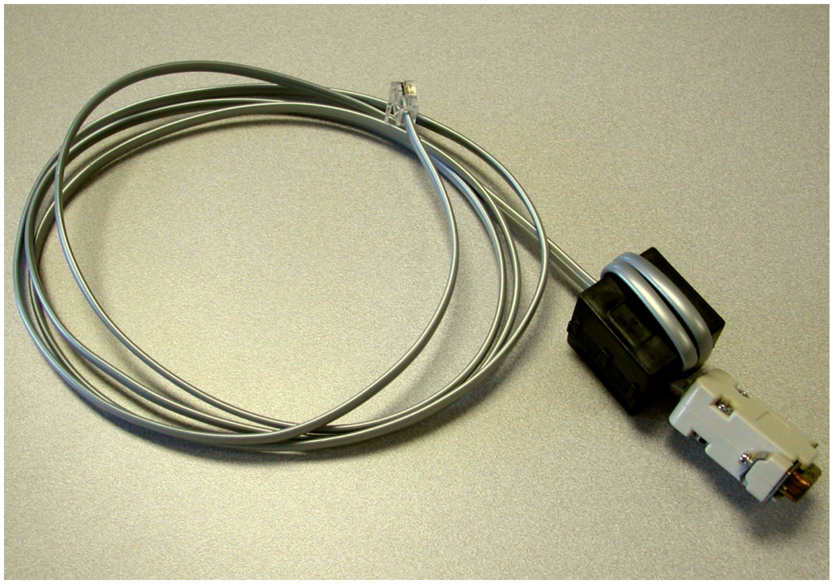

Figure 4: I/O Communication Cable for Remote Connections

Operation

To turn the power on:

- Set the main power rocker switch of the power module on the rear panel to (I) ON. The panel meter will display temperature in Kelvin.

Establishing Temperature Setpoints

Temperature setpoints control the operation of the relays within the Temperature Indicator. When the sensing diode inside the Cryo-Torr High-Vacuum Pump senses the temperature falls below the LOW setpoint temperature, power will be applied to the LOW SETPOINT RELAY. If the temperature is at or above the HIGH setpoint, power will be applied to the HIGH SETPOINT RELAY.

To set the temperature setpoints:

1. Press and release the UP arrow button to display the HIGH setpoint or press the DOWN arrow button to display the LOW setpoint.

2. Press and hold both UP and DOWN arrow buttons. The digital display flashes.

NOTE: *Pressing and holding the UP or DOWN arrow button causes the digital display value to change rapidly.*

3. Press the UP or DOWN arrow buttons to increase/decrease the temperature setpoint.
4. Release the arrow button after displaying the setpoint temperature.
5. Three seconds after you set the new setpoint, the setpoint is stored and displayed for two additional seconds. After the setpoint appears, the normal Cryo-Torr High-Vacuum Pump temperature appears.

To check the setpoint readout:

1. Operate the push button switches located on the right side of the front panel.
2. Press the bottom switch to display the LO setpoint reading on the meter.

   Or press the top switch to display the HI setpoint reading on the meter.

NOTE: *A display of **00.0** indicates an open sensor, and a display of 55.5 indicates a shorted sensor. Contact Helix Technology Corporation with the information in Appendix A - Customer Support Information.*

About the Relay Function

The NC (normally closed) relay contacts of the LO setpoint relay remain closed until the temperature of the sensor drops below the LO setpoint.

The NC contacts of the HI setpoint relay remain closed until the temperature of the sensor rises above the HI setpoint. Refer to Table 3.

Table 3: Relay Contact Truth Table

Temperature	HI-NC	HI-NO	LO-NC	LO-NO
Above HI Setpoint	Open	Closed	Closed	Open
Between Setpoints	Closed	Open	Closed	Open
Below LO Setpoint	Closed	Open	Open	Closed

Using the RS-232 Function

1. Insert the cable assembly receptacle into the RS-232 port located at the extreme left-hand side of the rear panel.

2. Set the computer to a baud rate of 9600, no parity, 8 data bits and 1 stop bit. Hardware flow control is not needed.

3. Communicating data to/from the Temperature Indicator:

Temperature Data

The Temperature Indicator transmits the current temperature reading to the host computer when a 'T' and carriage return <CR> are received.

The instrument responds to both upper-case and lower-case keystrokes.

Transmitting Setpoint Data

The Temperature Indicator accepts a new alarm setpoint value for the selected relay when the host computer transmits the following code:

S1N <CR>

in which:

- **S1** indicates that the setpoint is for relay #1 (use S2 for relay #2)

Table 4: Setpoint Designations

S1	High Setpoint
S2	Low Setpoint

- **N** is the temperature setpoint in Kelvin (to tenths-of-a-degree resolution), with the least significant digit being the tenth's digit.
- **<CR>** is a carriage return.

Example: A setpoint value of 12.3K for relay #2 is transmitted to the Temperature Indicator as:

S2123 <CR>

Since the maximum range of the system is 300K, the largest alarm setpoint value that will be correctly interpreted is 3000.

Table 5: Default Setpoints

Low	20K
High	290K

Querying Setpoint Data

The Temperature Indicator transmits the current setpoint value for the selected relay when the host computer transmits the following query code:

S1 <CR> or **S2 <CR>**

as applicable.

To access the diagnostic subroutine:

1. Before applying power, PRESS AND HOLD the **DOWN** switch. Apply power and release the **DOWN** switch. The instrument will now enter the diagnostic subroutine and all eight segments of all readout decades will be displayed.

2. Press the **DOWN** switch again. The instrument will display the version of software in the instrument.

3. Press the **DOWN** switch once more to return the instrument to its normal display of temperature.

Troubleshooting

CAUTION

Equipment Damage

When checking diode or connections to diode, do not use a multimeter which could subject the diode to more than five milliamperes forward current, or more than 200 volts reverse bias. Excess current or voltage will permanently damage the diode.

Table 6: Troubleshooting

Fault	Possible Cause	Corrective Action
Panel meter fails to indicate a reading.	Power switch is off.	Turn switch on.
	Power cord not plugged in.	Plug in power cord
	Fuse blown on rear panel of indicator.	Replace the fuse.
	No power coming from power source.	Check the service fuses, circuit breakers, and wiring associated with power source and repair as needed.
	Defective interconnecting cable.	Check continuity and replace, if needed.
	Connections to the diode sensor are loose or disconnected.	Check the continuity at the cryopump connections pins 3 and 4. Repairs must only be made by a qualified technician.
	Polarity of diode is incorrect.	Check the polarity.
Solenoid valves or indicator are not operating at proper temperature in accordance with Table 3.	Defective relays or electronics.	Check to see if the proper signal is being provided by the electronics. Repair as required by a qualified technician.
Panel Meter displays a reading of 555.	Temperature diode in cryopump is shorted.	Check diode circuit, replace the diode, and/or replace the cryopump.

Table 6: Troubleshooting

Fault	Possible Cause	Corrective Action
Panel Meter displays a reading of 000.	Temperature diode in cryopump is open.	Check diode circuit, replace the diode, and/or replace the cryopump.

Appendix A - Customer Support Information

Customer Support Center Locations

To locate a Customer Support Center near you, please visit our website ***www.brooks.com*** on the world wide web and select *CONTACT* on the home page.

Guaranteed Up-Time Support (GUTS)

You can reach Brooks Global Customer Support Teams around the world. For 24 hour, 7 day per week Guaranteed Up-Time Support (GUTS) dial the appropriate number listed in Table 1.

Table 1: Global Customer Support Numbers

North America	1 800-FOR-GUTS (800-367-4887)
Germany France UK	+49 1804-CALL-GUTS (1804-2255-4887)
Japan Helix Technology K.K. Yaskawa Brooks Automation, Inc.	+81-3-5767-3412 +81-45-478-7373
China	+86-21-5131-7066
Taiwan	+886-3-5525225
Korea	+82-31-288-2500
Singapore	+65-6464-1481

Product Information

Please have the following information available when calling so that we may assist you:

- Product Part Number
- Product Serial Number
- Product Application
- Specific Problem Area

- Hours of Operation
- Equipment Type
- Vacuum System Brand/Model/Date of Manufacture

E-mail

For your convenience, you may also e-mail us at:

tscallcenter@brooks.com

DATA-LINC GROUP

User's Guide

DLM4000

Dial-Up/Leased Line Modem

Table of Contents

DATA-LINC GROUP

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DLM4000 Operation Instructions

The DLM4000 does have some requirements, which need to be met for proper operation and communication.

1. The standard DLM4000 modem requires 9 VAC and the 24V version requires 24 VDC.

2. The minimal current requirement for the modem is 300mA.

3. This modem uses a 10 bit word format only. Below is a table to reference to understand the data formats supported.

Start Bit	Data Bits	Parity	Stop Bit	Total Bits
1	8	None	1	10
1	7	None	2	10
1	7	Even, Odd	1	10

4. When using the DLM4000 on a leased line, there are some specifications to note. The leased line must be an analog voice grade line or unshielded twisted pair. The DLM4000 will not work on a digital line. This leased line must be two wire.

5. The DLM4000 is an asynchronous modem and therefore will not operate directly with synchronous protocols.

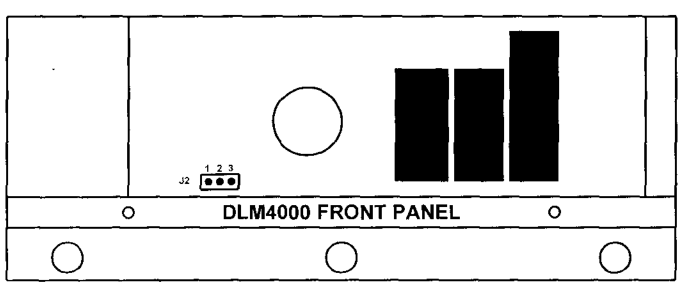
6. Handshaking lines such as DTR and RTS are not required for this modem and are ignored per the standard configuration.

7. Error correction and compression are disabled in the standard configuration. Enabling these options may make connection with a PLC impossible.

8. Data-Linc Group highly recommends the use of lightning and surge protection devices for the DLM4000.

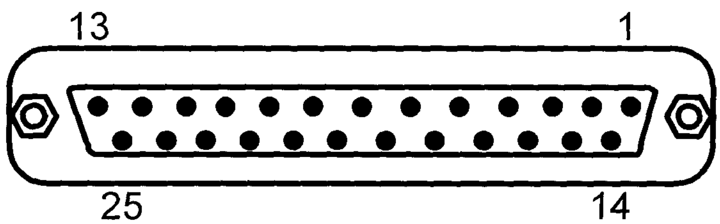
9. To enable AT command configuration of the DLM4000 the modem must be in command mode, which is the default mode for dial-up operation. To enable command mode, remove the modem cover and place J2 in positions 1-2. Positions 2-3 is leased line mode. See diagram 1.

Diagram 1



Connecting the DLM4000

The DLM4000 provides an RS232 port for the connection to other devices. Below is a diagram of the serial port configuration. It is important to use the proper cable when connecting equipment to the DLM4000. An off the shelf serial cable will not always provide the proper configuration.



Pin Identification for the RS232 Port

Pin 1	Protective Ground
Pin 2	Data into the Modem from the PLC
Pin 3	Data out of the Modem into the PLC
Pin 4	Request to send prom PLC to Modem, ignored by default
Pin 5	Clear to send from Modem to PLC, flow control is disabled
Pin 6	Data set ready from Modem to PLC
Pin 7	Signal Ground
Pin 8	Carrier detect
Pin 9	Data terminal ready from PLC to Modem, ignored by default

DATA-LINC GROUP

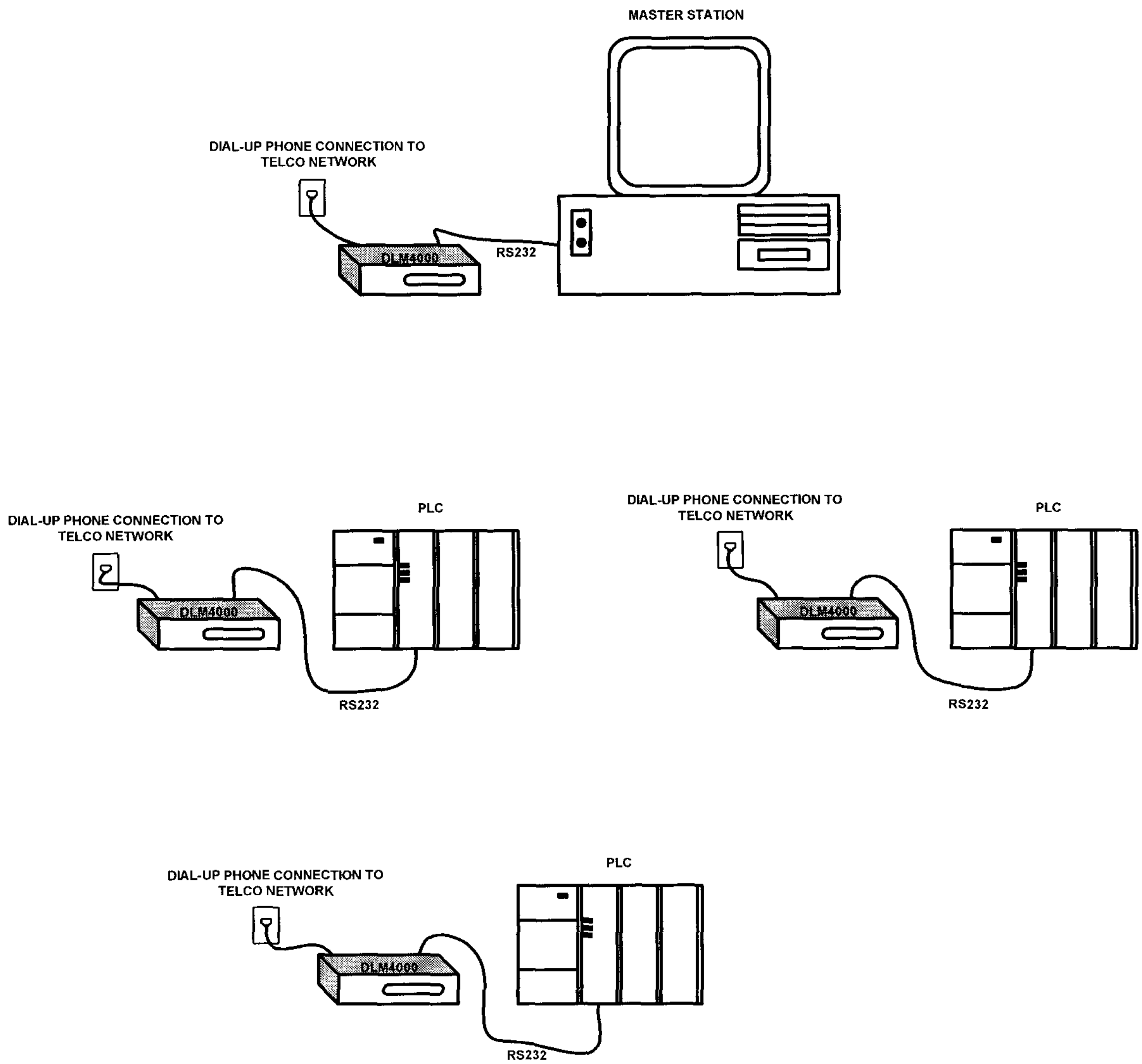
DLM4000 Communications

The DLM4000 operates with many asynchronous protocols, some of which are listed below. The DLM4000 also provides different options for connecting PLC's and other equipment. Some examples are provided on the following pages.

Dial-Up System Example

Diagram 2

DLM4000 multipoint full duplex system using a PC master and PLC remotes. The system may involve Dial-Up polling or periodic retrieval of data from remote locations.

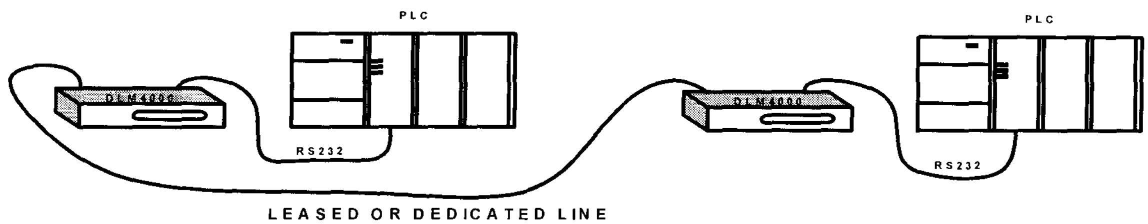


DATA-LINC GROUP

Leased Line System Example

Diagram 3

Leased or dedicated wire application. Multipoint operation is not an option. Only a point to point link is possible in Leased Line Mode.

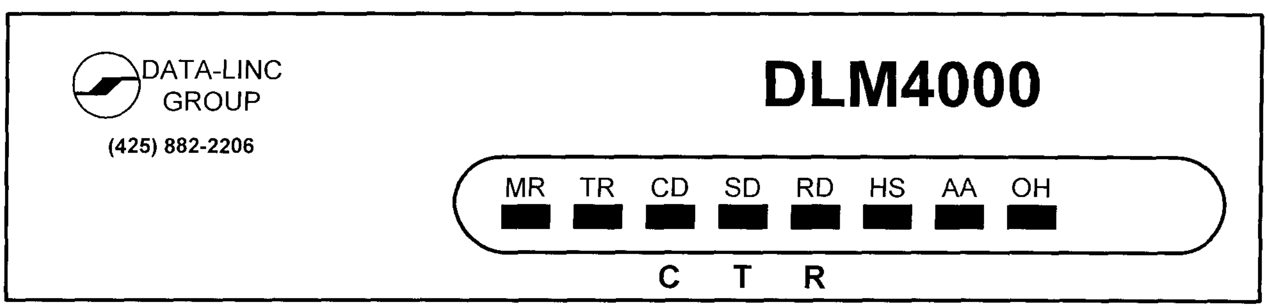


Communications Description

Communication with the DLM4000 is possible in a multipoint configuration, but only through dial-up configuration. Per the diagram 1 it is possible to setup a dial-up polling operation. The link is a full duplex link, which can be set up to 19200 bps.

Leased line mode is another option that can be used when dial-up lines are not available or desired, See diagram 3. This link is strictly a point to point full duplex link. On unloaded lines this link may be up to 20 miles. When the DLM4000 modems are being used on a loaded telephone company leased line the distance is unlimited. No ATDT commands are required to connect. When the DLM4000 modems are set for leased line operation and powered up they will connect and achieve carrier. The communications rate may be set up to 19,200 bps.

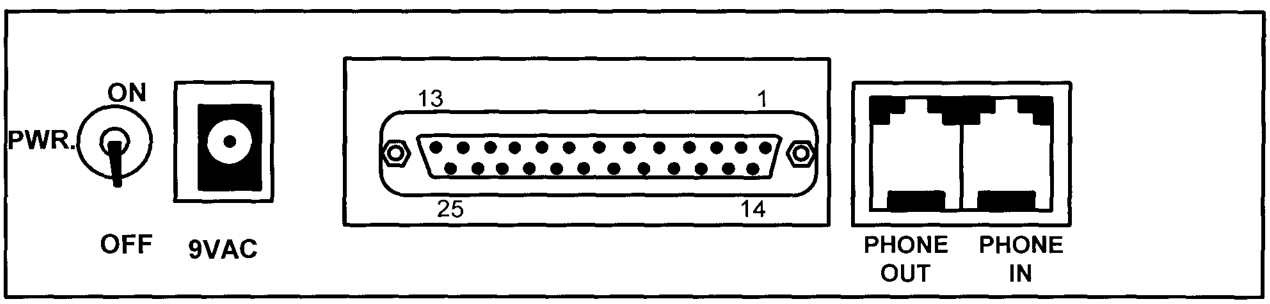
DLM4000 Led Descriptions



DATA-LINC GROUP

(MR) Modem Ready	Lit when the modem is turned on.
(TR) Data Terminal Ready	Denoted as DTR. Flashes when DTR signal is detected. The Data-Linc default is ignore DTR.
(CD) Carrier Detect	Lit when the remote modem's carrier is detected.
(SD) Send Data or TXD	Flashes when the modem is sending data to the remote modem or when receiving data from the local DTE equipment.
(RD) Receive Data or RXD	Flashes when the modem is receiving data from the local DTE equipment.
(HS) High Speed	Lights up when line speed is 2400 bps or above. Off when low speed.
(AA) Auto-Answer	Lights up when the modem is set for auto-answer. Flashes when incoming ring is detected.
(OH) Off-Hook	Lights up when modem is using the telephone line (off-hook). Off when the modem is not using the line (on-hook).

DLM4000 Connection Points



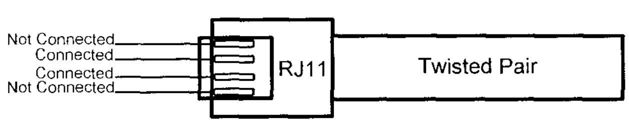
(PWR) The DLM4000 utilizes a toggle switch for powering the modem on and off.

(9VAC) The power connection is made with a barrel connector which comes on the supplied power supply.

(RS232) The connection for the RS232 port on the modem is a DB25 female connection. Keep in mind that this device is considered a DCE.

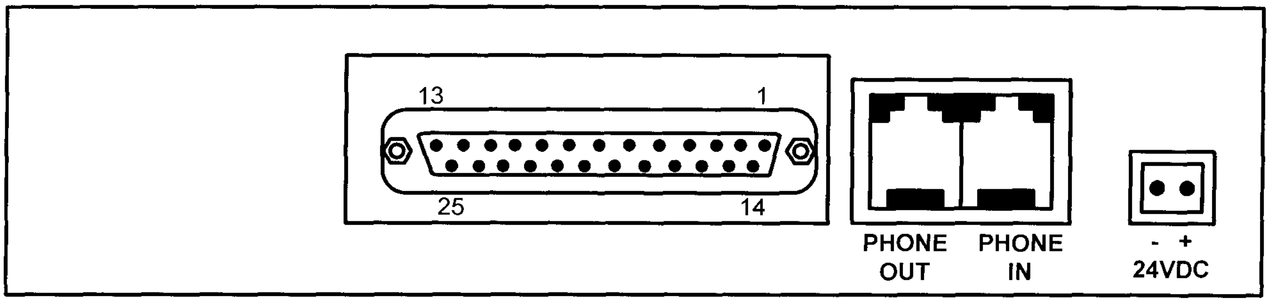
(PHONE OUT) For most applications a phone is not required. Data-Linc supplies the modem with an RJ11 plug in this jack. This may be removed if connection of a phone to the modem is required.

(PHONE IN) Connection of the modem to the telephone company dial-up is done via this RJ11 jack. A dedicated for leased line may also be used at this jack. Note that this unit is a two wire device and only the two center connection points of the RJ11 jack are used.



DATA-LINC GROUP

DLM4000 24V Connection Points

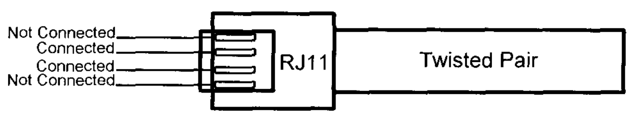


(24VDC) The power connection to the DLM4000/24V is a terminal block. The connection points are designated in the above diagram. There is no on or off switch on this version.

(RS232) The connection for the RS232 port on the modem is a DB25 female connection. Keep in mind that this device is considered a DCE.

(PHONE OUT) For most applications a phone is not required. Data-Linc supplies the modem with an RJ11 plug in this jack. This may be removed if connection of a phone to the modem is required.

(PHONE IN) Connection of the modem to the telephone company dial-up is done via this RJ11 jack. A dedicated for leased line may also be used at this jack. Note that this unit is a two wire device and only the two center connection points of the RJ11 jack are used.



Verifying Operation of the DLM4000 Leased Line and Dial-Up Modem

Components Required for Dial-Up Verification:

1. A desktop or laptop computer.
2. Two DLM4000 modems configured for dial-up operation.
3. A serial cable for connection to the computer. Refer to diagram below.
4. A paperclip or jumper wire for the serial port of the DLM4000.
5. A phone line simulator or preferably two direct dial-up lines.

Components Required for Leased Line Verification

1. A desktop or laptop computer.
2. Two DLM4000 modems configured for leased line operation.
3. A serial cable for connection to the computer. Refer to diagram below.
4. A paperclip or jumper wire for the serial port of the DLM4000.
5. A phone cord or pair of wires with RJ11 connectors for the modems.

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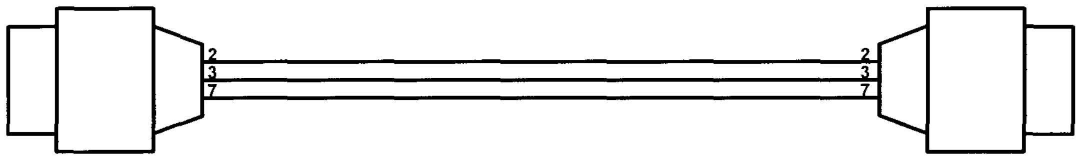
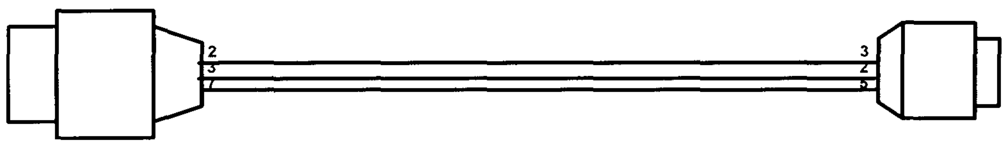
Cable Requirements for Connection of the DLM4000

DLM4000 D B25 Male **Computer D B25 Female**

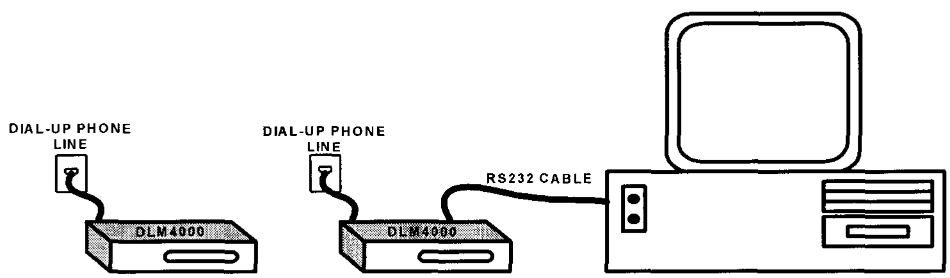


DLM4000 D B25 Male **Computer D B9 Female**

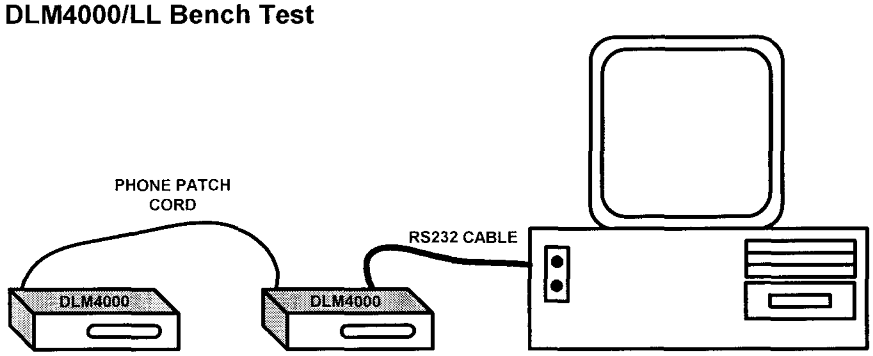


Setting up the Equipment for Bench Test Verification

DLM4000/DL Bench Test



DLM4000/LL Bench Test



After connecting the equipment in either of the above configurations it is required that HyperTerminal be launched. If the computer being used for this test does not have HyperTerminal another terminal emulation program may be used. The following setup of HyperTerminal may be referenced if another program is being used. Follow these instructions step by step to achieve the proper configuration for bench testing. The following HyperTerminal example was launched from Windows 98.

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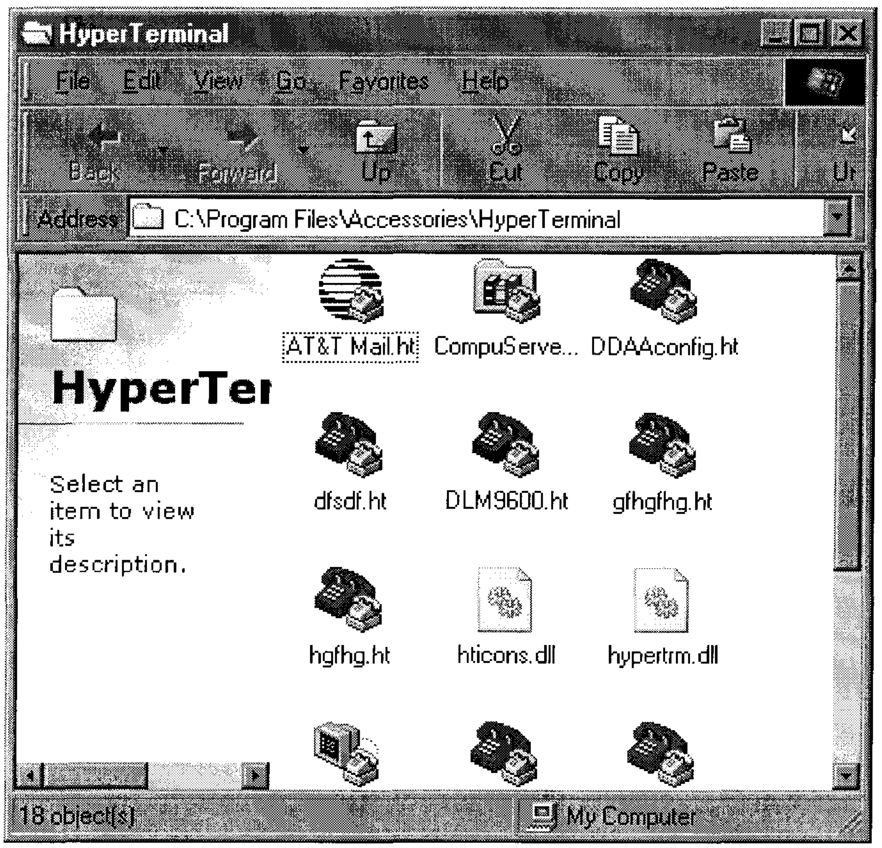
Setting Up and Using HyperTerminal for Testing

Note that HyperTerminal is required for connecting the dial-up DLM4000 modems to each other. Leased Line versions only need to be powered up and they will establish carrier between each other.

The following steps will walk through launching and configuring HyperTerminal to talk to the DLM4000 modem.

1. Launching HyperTerminal

Click on Start at the bottom of the computer desktop and a column of options should be displayed. Next select Programs, Accessories, Communications and then select HyperTerminal. A screen similar to the one below should be displayed.

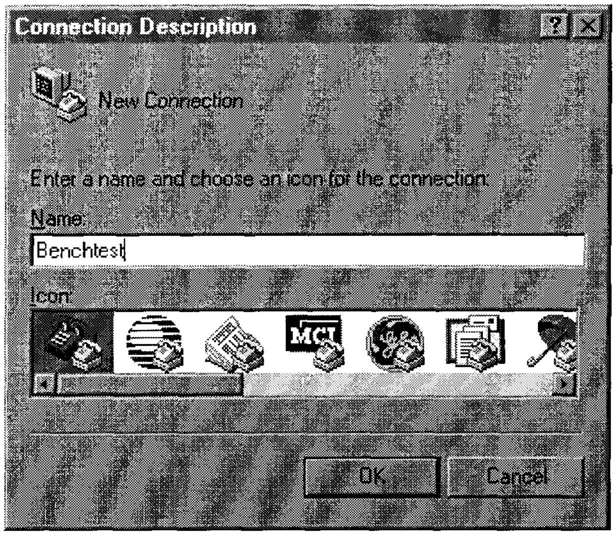


Now select the icon labeled "Hypertrm.exe." Selecting this icon will launch HyperTerminal.

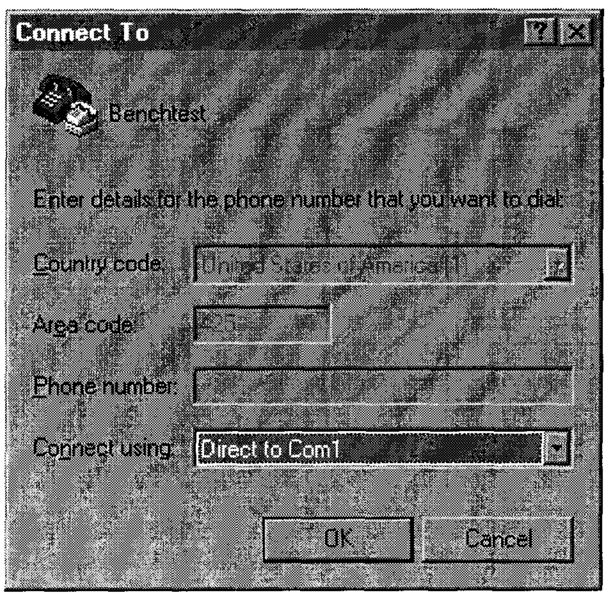
DATA-LINC GROUP

2. Configuring HyperTerminal

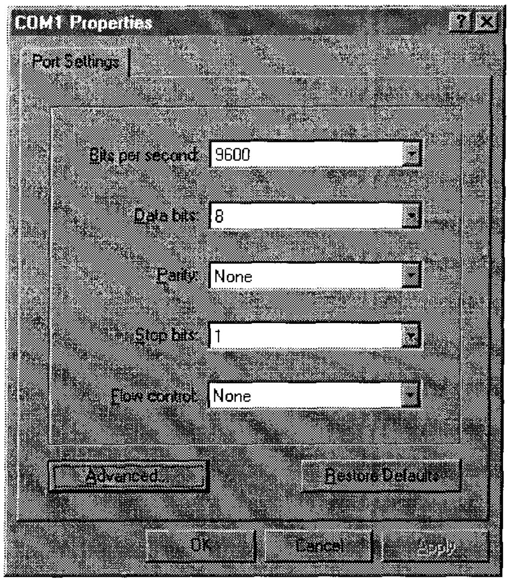
After launching HyperTerminal the following setup option will be displayed.



Type in an appropriate name for your connection. After you have typed a name in select OK. Another window is displayed requiring the entry of additional information about the configuration.

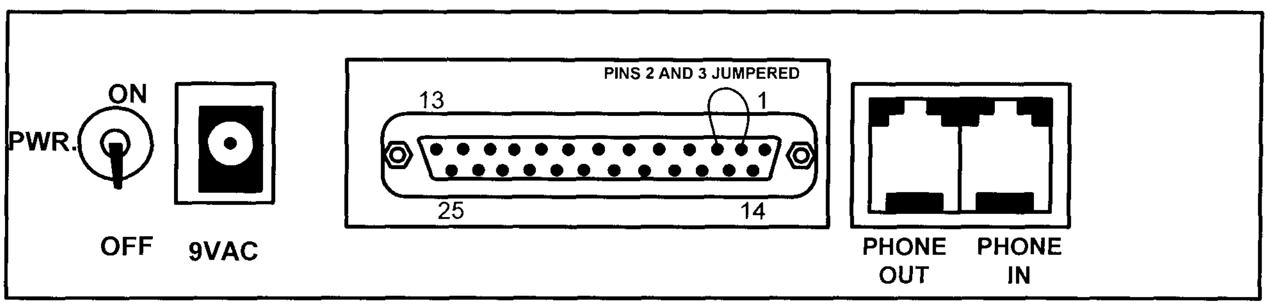


In this next window the entry of a phone number is ignored. At the bottom of the window is an option to "Connect using:" and there is an arrow. Select the arrow and more options will be displayed. Select the computer COM port the DLM4000 is connected to. Now select OK. Another menu is displayed:



3. Transferring a Text File

The above settings are the standard for setting up the DLM4000. The DLM4000 modems purchased may have been setup for another data rate. Make sure that the data rates are the same. Now select OK after making the above changes. The HyperTerminal connection window will now be displayed. At this time it is necessary to place a paperclip or jumper wire in the serial port of the receiving modem. The following diagram illustrates how to accomplish this.



The jumper on the serial port of the receiving modem will allow data that is being sent to the modem to be sent back to the transmitting DLM4000. The text file that is being sent will be displayed on the screen of the computer. It is now time to transfer a text file.

Select "Transfer" at the top of the window. Some additional options will be displayed. Select text file transfer. A new window appears prompting for a text file to transfer. Any text file may be transferred, but a large file size is preferred. If Windows is being used a good file to select is located in the Windows folder. Once the Windows folder is selected the file Network.txt can be located by scrolling to the end of the folder directory. Select this file and the text file transfer will begin. The information being displayed on the computer screen should be readable with no missing characters.

If problems arise, see troubleshooting section of this manual.

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DLM4000 Command Descriptions

AT: The attention command clears the command buffer must proceed all command lines except A/ and +++.

A/: This command re-executes the last command in the command buffer.

+++: This is the escape sequence to take the modem from data mode to command mode.

B: The B command defines the communications protocol as follows.
- **B0:** Selects CCITT protocol, which is used in Europe and most countries in the world.
- **B1:** Selects Bell protocol, which is mainly used in the U.S. and Canada.

E: This command is used to enable or disable the echo of command characters and is only effective in command mode.
- **E0:** Disables the echo of command characters.
- **E1:** Enables the modem to echo command characters so they can be Viewed and verified on the screen.

H: This command instructs the modem to go on or off hook. On hook means hang-up where off- hook means to use the telephone line.
- **H0:** Modem goes on-hook.
- **H1:** Modem goes off-hook.

L: This command adjusts the volume of the modem speaker for call progress monitoring.
- **L0:** Selects low speaker volume.
- **L1:** Selects low speaker volume.
- **L2:** Selects medium speaker volume.
- **L3:** Selects high speaker volume.

M: This is the speaker on-off control.
- **M0:** Turns the speaker off at all times.
- **M1:** Turns the speaker on until a connection is established.
- **M2:** Turns the speaker on at all times.
- **M3:** Turns the speaker on until carrier is detected, is turned off when dialing.

N: Sets the number of times the modems will redial if busy. The redial times counter is cleared to 0 after a connection is made.

String: N=n	Range: n=0-15	Unit: Time	Default: 0

N5: Sets the interval between redials.

String: N5=n	Range: 0-255	Unit: 2 seconds	Default: 0

N?: Displays the current settings of the DLM4000s redial times.

N5?: Displays the interval time between redials.

P: Instructs the modem to use pulse dialing to dial a number.
ATDT P 882-2206

Q: Enables or disables the sending of response codes after a command line is executed.
- **Q0:** Enable the sending of response codes.
- **Q1:** Disable the sending of response codes.

S=n: Instructs the modem to dial a stored number previously saved with the &Z command. For example, ATDTS=2. This would dial a number stored in memory location 2.

Sr?: Displays the contents of a particular S register. For example, ATS8?. This would display the value stored in register S8.

Sr=n: Changes the value in a particular register. For example, ATS8=1. This could change the value in register S8 to 1.

V: This command instructs the DLM4000 to send response codes in a word for or digital form.
- **V0:** Sends response codes in digital form.
- **V1:** Sends response codes in word form such as OK or CONNECT.

Xn: This command determines which response codes shall be enabled and disabled.
- **X0:** This command enables the response codes OK, CONNECT, RING, NO CARRIER and ERROR.
- **X1:** This command enables the response codes OK, CONNECT, RING, NO CARRIER, ERROR and CONNECT 1200.
- **X2:** This command enables the response codes OK, CONNECT, RING, NO CARRIER, ERROR, CONNECT 1200, NO DIAL TONE and NO ANSWER.
- **X3:** This command enables the response codes OK, CONNECT, RING, NO CARRIER, ERROR, CONNECT 1200, BUSY and NO ANSWER.
- **X4:** This command enables the response codes OK, CONNECT, RING, NO CARRIER, ERROR, CONNECT 1200, NO DIAL TONE, BUSY and NO ANSWER.

Z: This command resets the modem.
- **Z1:** Resets the modem with SCP1(stored configuration profile 1).
- **Z2:** Resets the modem with SCP2(stored configuration profile 2).

&C: This command determines how the DLM4000 reacts to carrier detect.
- **&C0:** Carrier detect is always forced on.
- **&C1:** The modem tracks the data carrier from the remote one and initializes carrier detect accordingly.
- **&C2:** Carrier detect is forced on during command state, but is tracked on connection.

&D: This command determines how the DLM4000 reacts to DTR.
- **&D0:** Instructs the modem to ignore DTR.
- **&D1:** Instructs the modem to assume command state upon detection of DTR, but maintain and active line connection.
- **&D2:** Instructs the modem to go on-hook, assume command state, and disable auto-answer upon the detection of a DTR on-to-off transition.
- **&D3:** Instructs the modem to re-initialize itself when it detects a DTR. The ACA(active configuration profile) will be overwritten by the SCP(stored configuration profile).
- **&D4:** Instructs the modem to deliver all buffered data before disconnecting to on-off transition.

&L: Leased or dial-up line selection.
- **&L0:** Sets the modem for dial-up line operation.
- **&L1:** Sets the modem for leased-line operation dedicated between two destinations.

&R: Determines how the DLM4000 will react to CTS/RTS signals.
- **&R0:** CTS tracks the condition of RTS.
- **&R1:** RTS is ignored and the CTS is forced on.

&V: Displays configuration profiles.
- **&V0:** Displays the ACA, SCP and current modem operational status.
- **&V1:** Displays the STN.

&W: Writes the configuration profile.
- **&W0:** Writes ACP(active configuration profile) to SCP0.
- **&W1:** Writes ACP to the SCP1(stored configuration profile 1).

&Y: Selects a stored profile.
- **&Y0:** Sets SCP0 as the major SCP.
- **&Y1:** Sets SCP1 as the major SCP.

&Zn=: Stores telephone number. For example AT&Z0=882-2206.
Range: n = 0 to 9 which are memory locations

,: The comma allows a pause to be inserted into a dialing string. The time of the pause is set in register S8 which defaults to 2 seconds. For example ATDT,8822206.

\J: This command controls serial port baud rate adjustment.
- **\J0:** Turns off port adjustment. The port speed is fixed regardless of the line speed. This is used when the DLM4000 is in normal or reliable mode.
- **\J1:** Turns on the port adjustment. The modem automatically adjusts it's port speed to match the on-line speed.

\N: This selects the ECDC operation mode.
- **\N0:** Selects normal mode. Error-correction is disabled, but the data buffer is activated.
- **\N1:** Selects direct mode. Both error-correction and the data buffer are deactivated.
- **\N2:** Selects ECDC reliable mode. Both error-correction and the data buffer are activated.
- **\N3:** Selects auto-reliable mode. The DLM4000 will establish a reliable link or normal link depending on the remote modem.

\Q: This option determines which flow control method the DLM4000 uses.
- **\Q0:** Disables serial port flow control.
- **\Q1:** Uses bi-directional XON/XOFF hardware flow control.
- **\Q2:** Uses uni-directional CTS flow control. Data transmission from the local device stops if the DLM4000 turns CTS off, and resumes when CTS is turned on.

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\Q3: Uses bi-directional CTS/RTS flow control. The data transmission from the local device to the DLM4000 stops when CTS is off, and resumes when CTS is on. Data transmitted from the DLM4000 to connected device stops when RTS is off, and resumes when RTS is on. This assumes connected device uses handshaking.
\Q4: The serial port does not respond to XON/XOFF flow control.
\Q5: Uses uni-directional flow control as \Q2, but keeps CTS off until a connection is established.
\Q6: Uses bi-directional hardware flow control just as \Q3 does, but keeps CTS off until a connection is established.

\Tn: Inactivity timer. Determines how many minutes the modem hangs up in, if no data is send or received during a normal or reliable link. These link types must be used for this option to work.
Range: 0 to 255 Unit: Minutes Default: 0

%Bn: Sets the maximum port baud rate.
n= 300, 1200, 2400, 4800, 7200, 9600, 19200

%C: This command controls data compression.
%C0: Data compression is disabled.
%C1: Enables V.42bis and MNP Class 5 data compression.

%E: This command determines if the DLM4000 will automatically retrain when telephone line quality is poor.
%E0: Disables automatic retrain capability.
%E1: Enables auto-retrain. When the line quality is poor, the DLM4000 makes three attempts to re-establish the connection, for a total of 6 seconds, before it hangs up. This command is valid at speeds of 2400 bps or higher.

DLM4000 Registers

Sn?: This will allow viewing of the register value. Here is an example of how to read register S7. ATS7?.

Sn=: This will allow modification of the register value. Here is an example of how to change register S7. ATS7=130.

S0: This register determines the number of rings before the modem will answer a call. When S0 is set to 0 the modem will not auto-answer calls.
Range: 0-255 Unit: Ring

S1: This register counts the number of rings on the line when a modem is set to auto-answer. The register is cleared 8 seconds after the last ring.

S2: This register stores the decimal ASCII value of the escape character. The default value is 43 which is a +.
Range: 0-127 Unit: ASCII Default: 43

S3: Stores the decimal ASCII value of the carriage return character, which terminates both the command line and the response code.
Range: 0-127 Unit: ASCII Default: 13

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S4: This register stores the decimal ASCII value of the line feed character, which follows a carriage return after a response code is sent.
Range: 0-127 Unit: ASCII Default: 10

S5: This register stores the decimal ASCII value of the backspace character, which is used as the backspace key for editing and as the character echoed to move the cursor backwards on the screen.
Range: 0-32 Unit: ASCII Default: 8

S6: Determines how long the modem waits after of-hook before it proceeds to dial. This delay allows the central office to detect the off-hook status of the line and apply a dial tone. If this is set too short this may not allow a call to go through. This register is valid only when X0, X1, or X3 is in effect. If X2 or X4 is in effect, the dial tone detection is enabled and the modem will not blind-dial.
Range: 2-255 Unit: Second Default: 2

S7: Determines how long the modem will wait for a remote carrier signal after it dials or answers.
Range: 1-255 Unit: Second Default: 30

S8: Determines pause time for a comma.
Range: 0-255 Unit: Second Default: 2

S9: Determines how long a carrier signal must continuously exist before it is recognized as a valid signal by the DLM4000. A longer time gives DLM4000 time to distinguish the carrier signal from noise.
Range: 1-255 Unit: .1 Seconds Default: 6

S10: Determines how long the DLM4000 will wait before hanging up after it detects a loss of carrier. This delay permits the carrier to momentarily disappear without causing the modem to disconnect. If this register is set to 255, the modem ignores carrier status as though a carrier was always present. S10 should be set to a value larger than S9.
Range: 1-255 Unit .1 Seconds Default: 14

DLM4000 Troubleshooting

When connecting modem to terminal emulation program modem does not respond:

1. Make sure the modem is connected to correct com port the terminal emulation program is using.
2. Make sure the com port is free and no other devices are using it such as an internal modem.
3. Make sure the cable connecting the modem to the PC is the correct cable. Refer to cable requirements section of the manual.
4. Try re-starting the terminal emulation program.
5. Make sure the proper power supply is being used. The DLM4000 requires a 9VAC power supply for proper operation.

When sending a text file with the modems, the received text has missing characters.

1. Ensure that the communications program's baud rate matches that of the DLM4000.
2. Make sure the word length is set to a 10 bit word and not an 11 bit word. Refer to DLM4000 requirements section of manual.

A programmed phone number is stored in the modem, but when carrier is lost the modem does not redial.

1. The DLM4000 modem is capable of dialing a stored phone number when the modem is powered up only and will not redial upon loss of carrier.
2. If the modem has Auto Answer Dial Back board installed, most likely there is no stored phone number or the configuration is incorrect. Refer to Auto Answer Dial Back section of the manual.

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I am trying to connect to the DLM4000 modem with my PC modem, but it does not work.
Data-Linc Group does not recommend or support the use of another modem. It is recommended a second DLM4000 be purchased for connection.

The leased line DLM4000 modems are powered up, but they do not try to connect.
1. The modems are most likely not configured for leased line operation.
2. Refer to the DLM4000 requirements for the proper jumper setting in the modem.

The DLM4000 modems have carrier, but my PLCs are not communicating.
1. Make sure that the PLC is setup to use a 10 bit word and that the baud rate matches that of the modem.
2. Verify that the modem cabling is correct. If the cable is supplied by Data-Linc verify the cable pinout per the supplied cable diagram. If no cable diagram was present contact Data-Linc Group.
3. Ensure that the PLCs are setup and the addressing is correct. The DLM4000 modem does not require handshaking and this should not be enabled in the PLC.
4. If a problem is suspected of the DLM4000 a loopback test should be ran if possible. Refer to the section on Setting Up And Using HyperTerminal For Testing.

When in leased line mode the DLM4000 modems are constantly trying to establish communications with each other.
1. Verify that the communications line being used is an analog voice grade line and not a digital line.
2. Confirm that the leased line connection at both DLM4000 locations is connected properly. The two center pins of the jack are the correct pins.
3. Make sure that the leased line is a 2 wire leased line and not a four wire. The DLM4000 will not operate on a four wire leased line.
4. Verify proper modem operation with a bench test and a phone patch cord.
5. Is there a possible source of electrical noise near the modem such as a variable frequency drive?
6. If the lines are telephone company provided, check with them to verify line integrity.

When communicating between two PLCs I have a flashing T LED on the master and a flashing R LED on the remote. I never have a flashing R on the master and T on the remote.
1. The poll is getting to the remote PLC, but it is not answering back. Verify the PLC addressing is correct.
2. If possible, try connecting the PLCs together with a null cable directly. If they do not work most likely a PLC programming or processor issue exists.
3. Make sure that no handshaking is used in the PLC.
4. Check and verify that the word length is 10bits and the baud rates match. Verify this on both PLC locations.
5. Make sure the protocol is asynchronous and not synchronous.
6. Verify that the cabling is correct.

After a storm the DLM4000 modem is not longer operating.
1. Verify that surge protection is not damaged.
2. Re-initialize modem configurations.
3. Verify DLM4000 operation with a bench test.
3. Verify that DLM4000 power supplies are still operating properly.

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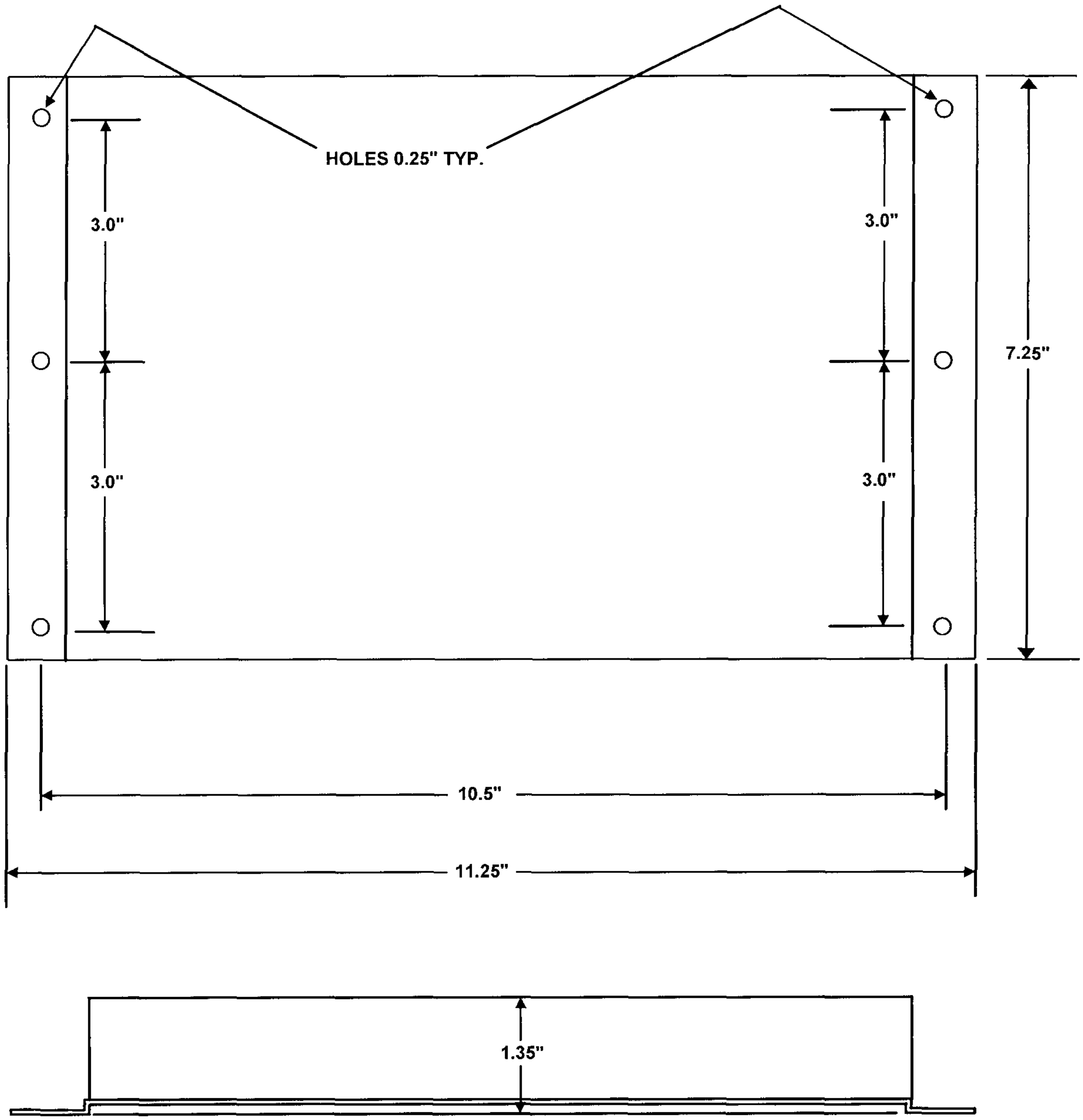
DLM4000 Enclosure Dimensions



Installation Dimensions

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DLM4000 Technical Specifications

Data Communication Standards
CCITT V.32bis, V.32, V.22bis, V.22, V.23, V.21, Bell 103, Bell 212A

Data Compression & Error Correction
CCITT V.42bis, V.42, MNP Class 2-5

Protocol
Asynchronous **(10 bit word format)**

Connection Speed
Up to 19200bps uncompressed.

Receiver Sensitivity
-43 dBm

Transmit Level
0 to –15 dBm

Command Buffer
40 Characters

Built in non-volatile memory
2 stored configuration profiles
2 factory default profiles
10 stored telephone numbers with 36 characters each in a total of 100 bytes

RS-232 Interface
DB25 Female connection

Telephone Interface
2 wire RJ-11 connection

Transmission Distance
Up to 20 miles on an unloaded line. Unlimited on a Telco loaded line.

Optional Interfaces
RS422 four wire and RS485 two wire interface
AADB interface to have modem redial when carrier is lost

Power Requirements
9VAC at 300mA with 3 watt maximum power consumption

Temperature Tolerance
0 to 60 degrees Celsius

Humidity Tolerance
Up to 90% non-condensing

Dimensions in inches
H x W x D: 1.4 x 7.5 x 11.3

DATA-LINC GROUP

Technical Support

Data-Linc Group maintains a fully trained staff of service personnel who are capable of providing complete product assistance. They can provide you with technical, application and troubleshooting, spare parts and warranty assistance. Our technical staff are based in Redmond, Washington USA and may be reached at 425-882-2206 or email support@data-linc.com.

Product Warranty

Data-Linc Group warrants equipment of its own manufacture to be free from defects in material and workmanship for one year from date of shipment to original user. Data-Linc Group will replace or repair, at our option, any part found to be defective. Buyer must return any part claimed defective to Data-Linc Group, transportation prepaid.

Return Material Authorization

If a part needs to be sent to the factory for repair, contact Data-Linc Group's corporate office and request a Return Material Authorization (RMA) number. The RMA number identifies the part and the owner and must be included with the part when shipped to the factory.

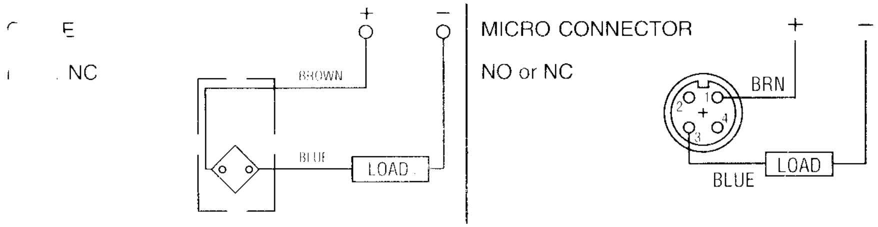
Contact Information

Corporate Office	**Data-Linc Group** 2635 151st Place Northeast Redmond, Washington 98052 USA Telephone: 425.882.2206 Fax: 425.867.0865 Email: info@data-linc.com Web site: www.data-linc.com
Eastern Regional Office	**Data-Linc Group** P.O. Box 404 Lawrence, Pennsylvania 15055 Telephone: 724.942.4524 Fax: 724.942.3875
Southern Regional Office	**Data-Linc Group** 4301 Cavern Springs Road Austin, Texas 78727 Telephone/Fax: 512.431.7806

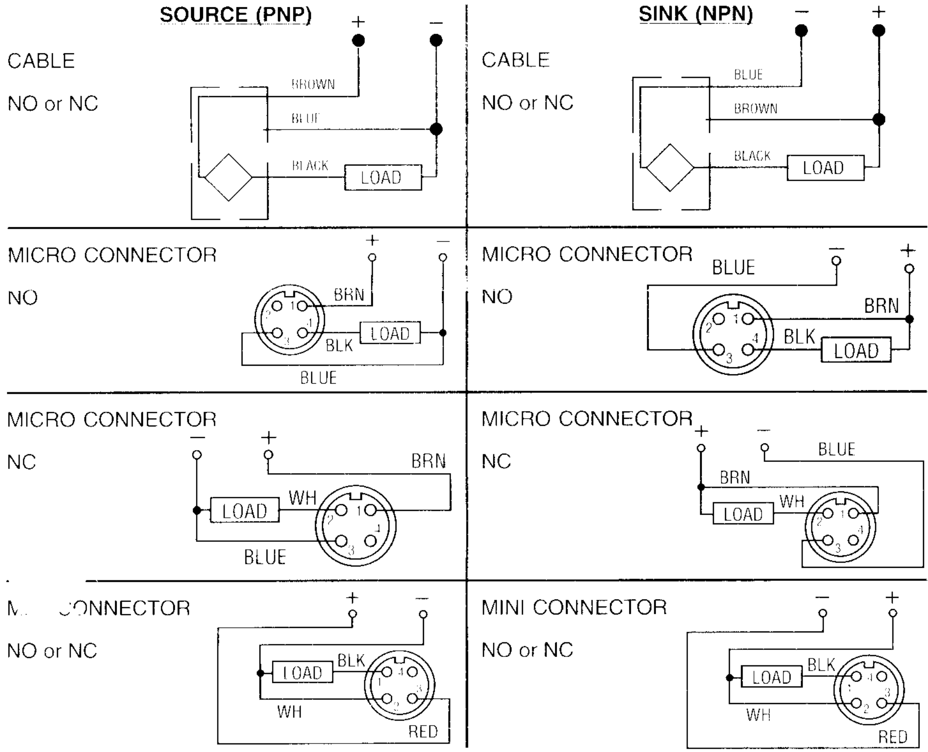
E57 WIRING DIAGRAM – DC PROXIMITY SWITCHES

View From Connector End

2 WIRE



3 WIRE



NOTE: Enclosure-type ratings:

Switches with integral cable: 1, 2, 4, 4X, 6, 6P, 12, and 13

Switches with Pin-connector: 1, 2, 4, 4X, 6, 6P, 12, and 13 (indoor use only). User must use recognized component plug and cord set, manufactured by Daniel Woodhead, Series 409 or 411 for devices with mini-connector and manufactured by Molex, Series 08071M04, 08001M04, 08441M24 or 08451M24 for devices with micro-connectors and molded with cable marked SJTO or STO.

The installation and use of Cutler-Hammer products should be in accordance with the provisions of the U.S. National Electrical Code and/or other local codes or industry standards that are pertinent to the particular end use. Installation or use not in accordance with these codes and standards could be hazardous to personnel and/or equipment.

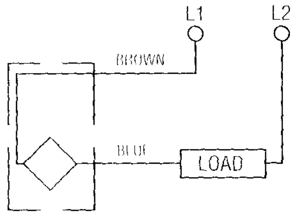
E57 WIRING DIAGRAM – AC PROXIMITY SWITCHES

View From Connector End

2 WIRE AC

CABLE

NO or NC

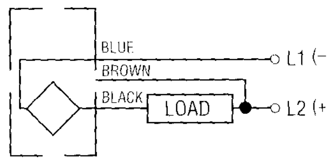


3 WIRE AC/DC

CABLE

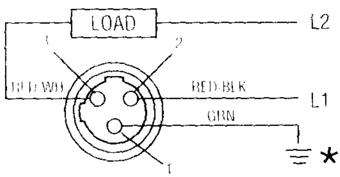
SINK (NPN)

NO or NC

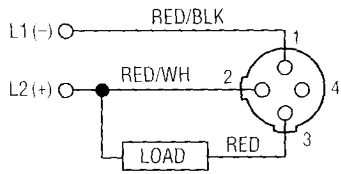


MICRO CONNECTOR
(SEE NOTE ON PAGE 1)

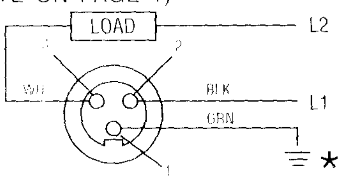
NO or NC



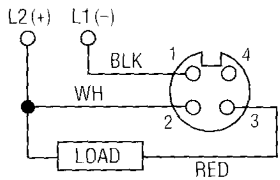
MICRO PIN CONNECTOR



MINI CONNECTOR
(SEE NOTE ON PAGE 1)



MINI PIN CONNECTOR



***12 mm Devices:** Connect cordset grounding conductor.
***18 mm & 30 mm Devices:** Double insulated, cordset grounding conductor is not connected to proximity switch enclosure. Equipment grounding conductor is not required.

MAXIMUM TORQUE LIMITS FOR METAL AND PLASTIC TUBES

Do not exceed these torque limits when tightening the hex nuts.

	METAL TUBES	PLASTIC TUBES
Sensor Dia. mm	Torque Lb. Ft. (Nm)	Torque Lb. Ft. (Nm)
8	4 (5.5)	(–)
12	4 (5.5)	2 (2.7)
18	15 (20)	4 (5.4)
30	30 (41)	6 (8.1)
NOTE: For high vibration installation use a thread locking compound or lockwasher.		

For service or more information, call:
National 1-800-833-3927

1L16855

Introduction

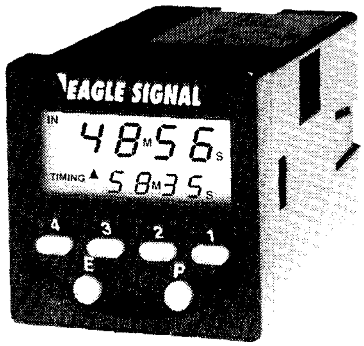
An excellent value in its class, the B856 features a compact 1/16 DIN package, the precision of digital setting, versatile functionality, and a straightforward button-per-digit interface.

It can be easily programmed to perform any standard timing operation: On-Delay, Off-Delay, Interval, or Repeat Cycle. A unique On-Delay /Interval Mode can in many cases perform the function of two separate timers. Output is via DPDT relay contacts.

Five selectable time ranges, and a programmable decimal point provide preset times ranging from .01 seconds to 9999 hours.

An available model's output features separate timed and instantaneous SPDT contacts.

Simplicity of operation is maintained while still providing a high level of functionality. All programming is done through the front panel, with an intuitive button-per-digit keypad that makes entry of preset times quick and easy. A crisp dual line LCD display lets the operator readily view elapsed or remaining cycle time as well as the preset value. Prominent annunciators indicate information such as the time range and the status of the input and outputs.



Reliability is a key feature of the B856. IEC Level 4 noise immunity ensures flawless operation in harsh electrical environments, while its IEC IP65 enclosure rating allows use in washdown conditions.

Wiring via an industry standard 11 pin socket and a power supply that can accept 24 - 240 VAC or 24 VDC easily simplify setup.

Technical Manual 702070-0001

Eagle Signal brand Series B856 Multifunction LCD Timer

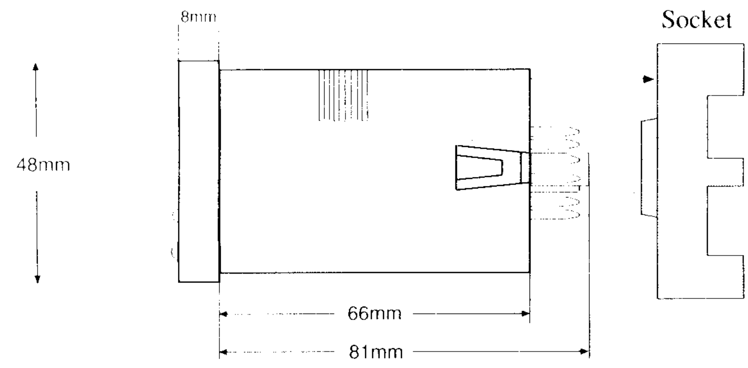
Features

- Field programmable choice of 5 operating modes
- 5 selectable time ranges with resolution down to 0.01 seconds
- High Contrast LCD display indicates both process time and preset value
- Simple button per digit interface
- Programmable security levels prevent unauthorized setpoint or program changes
- Universal Power Supply (24 - 240 VAC, 24 VDC)
- External Start and Reset Inputs
- IEC IP65 rated front panel
- Model with Instantaneous contacts also available

Index

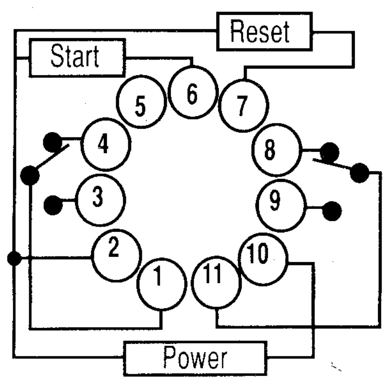
O V E R V I E W

INSTALLATION & WIRING

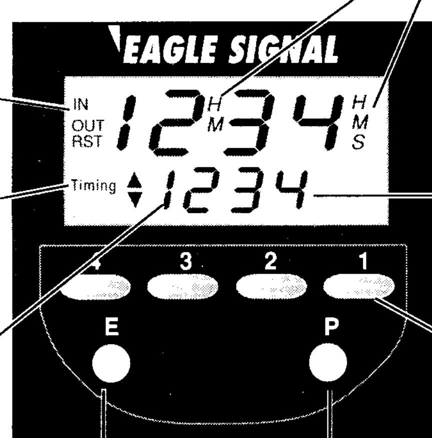


To wire the unit an 11 pin socket is required. The unit can then either be DIN rail mounted, or panel mounted using the supplied mounting bracket . For panel mounting, place the unit in the cutout, then slide the bracket forward over the rear of the unit so that the tabs catch in the grooves on the housing and the bracket is as far forward as possible. Tighten the panel mount screws until there is a snug fit against the panel. Do not overtighten.

For the -511 version, Pins 1, 3, 4 are the instantaneous contacts



FRONT PANEL OPERATION



I/O Status Indicators
Illuminates to display when an input or output is active: "IN" for the start input, "OUT" for the timed output, and "RST" for the External reset signal

Time Indicators
The word "Timing" Flashes when a timing function is taking place. The applicable arrow also lights to indicate if the display is set to time up or time down

Time Value
Indicates the elapsed/remaining time to preset

Time Range Indicator
Illuminates to show the time base: H for hours, M for minutes, S for seconds. Multiple indicators will be illuminated when the time base is Hours:Minutes or Minutes:Seconds

Set Value
Settable value used to trigger the timed output..

Numeric Keys
Each of the number keys is used to increment the value of the corresponding digit of the preset or a parameter value

Edit Key
Many of the parameters in Program Mode require selection of a specific choice as opposed to a numeric value. The Edit key is used to scroll through the available choices. In Operation mode the Edit key can be pressed simultaneously with the Program key to reset the timer

Program Key
Pressing the key continuously for 3 seconds moves the unit in and out of Program mode. Once in Program mode, pressing and releasing the key will scroll the display from one parameter to the next.

PROGRAM MODE

- Enter the Program Mode by holding down the "P" key for 3 seconds
- Press the "P" key to move the top display from one parameter to the next
- Press the "E" key to scroll the bottom display through the available choices for that parameter
- While in Program Mode the unit will stop timing and the output will retain its last state. The new settings will only become effective after returning to Operation Mode by holding down the "P" key for 3 seconds
- If there is no key activity for 60 seconds, the unit will automatically return to Operation Mode and maintain the previous settings

P For 3 Seconds

Func
OndL

Operating Function: Determines how outputs will operate in relation to the set value. Choices are:

- On-Delay (OndL)
- Off Delay (OFdL)
- Interval (int)
- Repeat Cycle (CYCL)
- Delay/Interval (dint)

See Appendix A for timing charts

P

FrSt
On

First Operation: Determines whether the Repeat Cycle will start with an On or an Off Operation

Note: This parameter will only appear if Repeat Cycle is chosen as the Operating Function

P

int
1.0s

Interval Time: Sets the amount of time the output will be active after the On-Delay function has timed out. Use the 1 through 4 keys to set the value in a range from 0.1 to 999.9 seconds.

Note: This parameter will only appear if Delay/Interval is chosen as the Operating Function

P

trnG
s

Time Range: Sets the unit of measure for the time values that will be shown on the display in Operation Mode. Choices are:

- Seconds
- Minutes
- Hours
- Minutes:Seconds
- Hours:Minutes

P

dEcP
0s

Decimal Position: Sets the decimal position for the time display. Choices are: no decimal point (0) 1/10ths position (0.0), or Hundredths position (0.00). The time range selected in the previous parameter will remain illuminated for reference.

Note: This parameter will not appear if Minutes:Seconds or Hours:Minutes is selected as the time range

PROGRAMMING

P

tdir
uP

Timing Direction: Determines whether the time value will increment from zero and change the state of the output at the set value (uP) or decrement from the set value and change the state of the output at zero (dn)

P

PrSt
On

Power Reset Enable: After a loss of power the unit can be programmed to either reset upon reapplication of power (On), or continue from the point of power interruption (Off).

P

FrSt
On

Front Panel Reset Enable: When active (On), the timing operation can be reset in Operation Mode by simultaneously pressing the "E" and "P" keys. If inactive (Off), the timing operation can only be reset through the remote input.

P

SLuL
0

Security Level: 4 different levels of security are available:

0 = Full Access

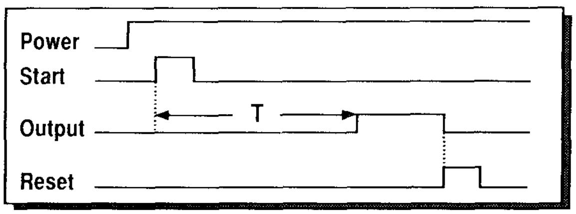
1 = SP Locked Out

2 = Access to Program Mode only by holding the "P" key for 10 seconds

3 = SP Locked Out and access to Program Mode only by holding the "P" key for 10 seconds

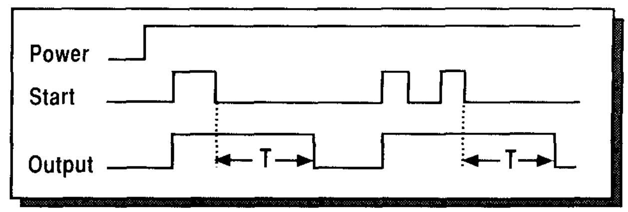
TIMING DIAGRAMS

On-Delay



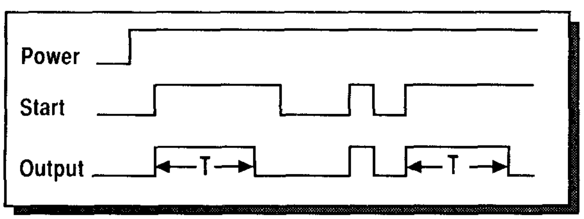
Timing begins on the leading edge of the start input. The output will activate at the completion of the preset time (T) and will remain active until the reset signal is applied or power is interrupted*.

Off-Delay



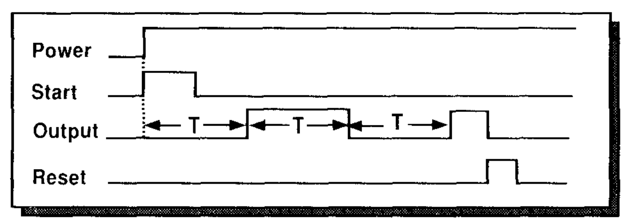
The output is activated at the leading edge of the start signal. Timing begins on the trailing edge. The output will remain active until the preset time (T) has elapsed or power is interrupted*. Reapplying the start signal before T has elapsed will reset the time value. The reset input is not used.

Interval



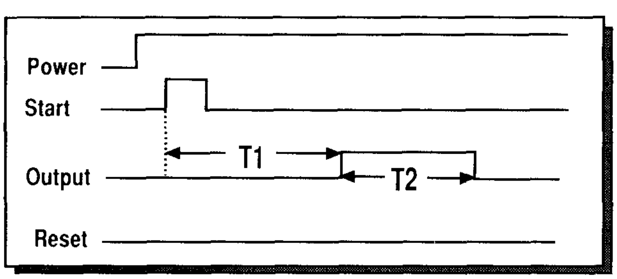
On the leading of the start input, the output is activated and timing begins. The output will remain active until the preset time (T) has elapsed or power is interrupted*. Removal of the start signal will also cause the output to be deactivated and the time value reset. The reset input is not used.

Repeat Cycle



Timing begins on the leading edge of the start signal. A cycle is initiated where the output will be OFF for the preset time (T), then ON for the preset time. This cycle will continue until a reset signal is applied or power is interrupted*. The unit can also be programmed for the timing sequence to begin with an ON cycle.

ON Delay/Interval



The delay cycle begins upon application of the start signal. The output will activate at the completion of the preset time (T1). Upon activation of the output the Interval cycle will begin. The output will be deactivated at the and the end of the Interval time (T2). T1 is the primary preset value and is set in Operation Mode. T2 is set in Program Mode in a range from 0.1 to 999.9 seconds. The timing sequence and output can also be reset through the reset input or interruption of power*.

* The Power Reset parameter in Program Mode can be set so that a timing sequence will not be reset upon power interruption but instead continue on when power is restored

GENERAL

SPECIFICATIONS

Inputs

Start:	NPN or Dry Contact
Reset:	NPN or Dry Contact

Outputs

Timed (B856-500):	DPDT - 5 amp
Timed (B856-511):	SPDT - 5 amp
Instantaneous (B856 -511):	SPDT - 5 amp

Physical

Dimensions:	48mm x 48mm, 81mm deep
Mounting	Panel Mounting 45 x 45 cutout, or DIN rail
Wiring Connection	Via 11 pin plug in socket

Operation

Supply Voltage:	24 - 240 VAC 50/60Hz, or 24 VDC
Power Consumption:	< 10 VA
Time Ranges:	Hours, Minutes, Seconds, Hours:Minutes, Minutes:Seconds
Resolution:	Settable for XXXX or XX.XX for Hours, Minutes and Seconds ranges
Operating Modes:	On Delay, Off Delay, Interval, Repeat, Delay/Interval
Repeat Accuracy:	± 0.03%
Electrical Service Life:	100,000 cycles at full load
Mechanical Service Life:	10 million cycles at min. load
Weight:	100 grams (3.5 ounces)

Environmental

Front Panel Rating:	IEC IP65
Operating Temperature:	0° to 55° C (32° to 131° F)
Storage Temperature:	-40° to 90° C (-40° to 194° F)
Humidity:	5% to 95% RH non-condensing

ORDERING INFORMATION

Description	Model #
Multifunction Timer, 24 - 240 VAC, 24 VDC	B856-500
[illegible] 24 - 240 VAC, 24 VDC	B856-511
11 Pin Socket	60SR3P06

WARRANTY

Standard [illegible] products manufactured by the Company are warranted to be free from defects in workmanship and material for a period of two years from the date of shipment, and products which are defective in workmanship or material will be repaired or replaced, at the option of the Company, at no charge to the Buyer. Final determination as to whether a product is actually defective rests with the Company. The obligation of the Company hereunder shall be limited solely to repair and replacement of products that fall within the foregoing limitations, and shall be conditioned upon receipt by the Company of written notice of any alleged defects or deficiency promptly after discovery within the warranty period, and in the case of components or units purchased by the Company, the obligation of the Company shall not exceed the settlement that the Company is able to obtain from the supplier thereof. No products shall be returned to the Company without its prior consent.

Products which the Company consents to have returned shall be shipped F.O.B. the Company's factory. The Company cannot assume responsibility or accept invoices for unauthorized repairs to its components, even though defective. The life of the products of the Company depends, to a large extent, upon the type of usage thereof, and THE COMPANY MAKES NO WARRANTY AS TO FITNESS OF ITS PRODUCTS FOR SPECIFIC APPLICATIONS BY THE BUYER NOR AS TO PERIOD OF SERVICE UNLESS THE COMPANY SPECIFICALLY AGREES OTHERWISE IN WRITING AFTER THE PROPOSED USAGE HAS BEEN MADE KNOWN TO IT.

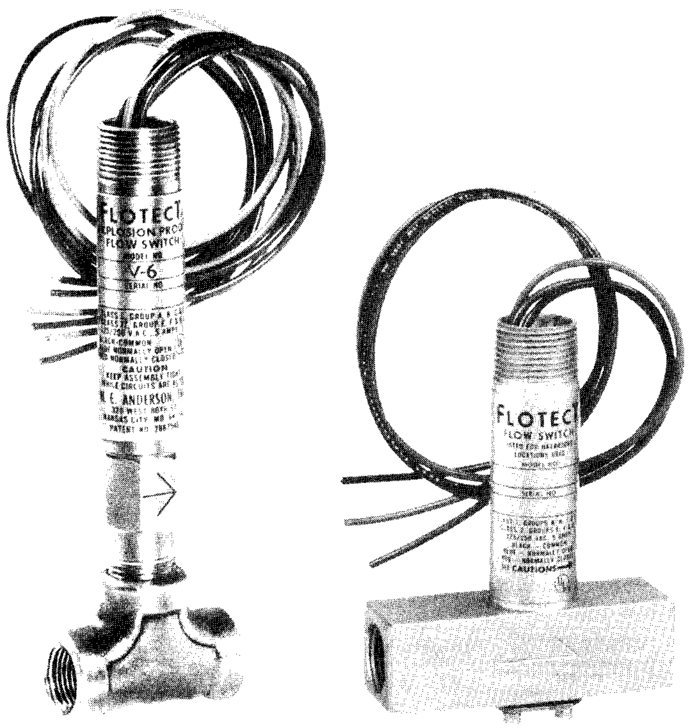
THE FOREGOING WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO ANY WARRANTY OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE.

Printed in U.S.A.
#702070-0001
January 1997
Revision none

Danaher Controls
1675 N. Delany Road
Gurnee, IL 60031–1282
Phone: 847.662.2666
Fax: 847.662.6633
Email: dancon@dancon.com

FLOTECT® MODEL V6 FLOW SWITCH

Installation and Operating Instructions



Explosion-Proof; U.L. and C.S.A. Listed –
Class I, Groups *A, B, C & D
Class II, Groups E, F & G
CENELEC: EExd IIC T6 (T amb=75°C)
*(Group A, stainless steel body only)

The Flotect® Model V6 is an inexpensive, explosion-proof flow switch for use on air, water or other compatible gases and liquids. Three configurations are available – 1. Factory installed in a tee. 2. With a trimmable vane for field adjustment and installation in a suitable tee. 3. Low flow models with an integral tee and adjustable valve. All are available with an optional enclosure which is U.L. and C.S.A. listed, CENELEC approved.

PHYSICAL DATA

Maximum Temperature: 220°F (105°C); 400°F (205°C) with high temperature (MT) option – Not U.L., C.S.A. or CENELEC approved.

Maximum Pressure: See chart.

Electrical Ratings: U.L. – 5A @ 125/250 VAC. C.S.A. and CENELEC – 5A @ 125/250 VAC, 5A resistive, 3A inductive @ 30 VDC. Gold contacts (MV option) for dry circuits – 0.1A @ 125 VAC. High temperature (MT) option – 5A @ 125/250 VAC. Not U.L., C.S.A. or CENELEC approved.

Wiring: U.L., C.S.A. models – 18 AWG × 18″ (46 cm) length. CENELEC models – terminal block.

Switch Body: Lower housing (wetted), brass or stainless steel. Upper housing, brass or stainless steel.

Vane: Stainless steel.

Pipe Connection: 1/2″ – 2″ NPT tee standard. 1/2″ NPT for Low Flow models and models with field trimmable vane.

Installation: Install in any position with index arrow pointing in direction of flow.

Weight: 2 – 6 lbs. (.9 – 2.7 kg) depending on size and construction.

Options: DPDT relays, custom calibration, Teflon coated wetted parts and more.

MAXIMUM PRESSURE CHART

MODEL	LOWER HOUSING	TEE	MAXIMUM PRESSURE PSI (KG/CM²)
V6 Low Flow	Brass	Brass	1450 (102)
V6 Low Flow	Stainless Steel	Stainless Steel	1450 (102)
V6	Brass	Brass	250 (17)
V6	Brass	Iron	1000 (70)
V6	Stainless Steel	Iron	1000 (70)
V6	Stainless Steel	Forged Steel	2000 (140)
V6	Stainless Steel	Stainless Steel	2000 (140)

INSTALLATION

Unpack and remove any packing material found inside lower housing or tee.

Switch can be installed in any position but the actuation/deactuation flow rates in the charts are based on horizontal pipe runs and are nominal values. For more precise settings, units can be factory calibrated to specific flow rates.

V6 Models with Tee are supplied in 1/2″ – 2″ NPT sizes. Install in piping with arrow pointing in direction of flow.

V6 Low Flow Models have 1/2″ NPT connections and are field adjustable. Install in piping with arrow pointing in direction of flow. To adjust, loosen the four socket head cap screws on bottom. The adjustment valve rotates 90° between "O" (open) and "C" (closed). See flow charts for approximate ranges. Tighten screws once the required flow rate has been set.

V6 with Field Trimmable Vane. These models enable the installer to choose approximate actuation/deactuation points by trimming the full size vane at appropriate letter-designated marks on a removable template. Flows are defined in the following charts. Note that the charts are based on either brass or cast iron reducing tees or stainless or forged steel straight tees with bushings where necessary. Install in piping with arrow pointing in direction of flow.

When bushings are used, they must be back drilled to allow proper clearance for unrestricted vane travel. Bore the I.D. to 13/16″ (20 mm) on 1/2″×3/4″ bushings or 1″ (25 mm) on larger bushings. The depth of the bore must leave internal threads 9/16″ (14 mm) high for proper engagement between the lower housing of the switch and the bushing. Check for proper vane travel and switch operation after installation.

W.E. ANDERSON DIV., DWYER INSTRUMENTS, INC.
P. O. BOX 358 • MICHIGAN CITY, INDIANA 46360, U.S.A.
Telephone 219/879-8000
Fax 219/872-9057

ELECTRICAL CONNECTIONS:

Connect wire leads in accordance with local electrical codes and switch action required. N.O. contacts will close and N.C. contacts will open when flow increases to the actuation point. They will return to "normal" condition when flow decreases to the deactuation point. Black = Common, Blue = Normally Open and Red = Normally Closed.

For units supplied with both internal and external grounds, the ground screw inside the housing must be used to ground the control. The external ground screw is for supplementary bonding when allowed or required by local code. Some C.S.A. listed models are furnished with a separate green ground wire. Such units must be equipped with a junction box, not supplied but available on special order.

CENELEC certified models include a junction box. Cable should enter enclosure through an approved EX cable gland, not supplied. Push stripped and tinned leads into appropriate openings in terminal block(s). To connect fine stranded leads or to remove any wire, depress spring release with small screwdriver first.

All wiring, conduit and enclosures must meet applicable codes for hazardous areas. Conduits and enclosures must be properly sealed. For outdoor or other locations where temperatures vary widely, precautions should be taken to prevent condensation inside switch or enclosure. Electrical components must be kept dry at all times. **CAUTION:** To prevent ignition of hazardous atmospheres, disconnect the device from the supply circuit before opening. Keep assembly tightly closed when in use.

V6 With Tee

Cold Water – Factory Installed Tee
Approximate actuation/deactuation flow rates
GPM upper, **M³/HR** lower

1/2″ NPT	3/4″ NPT	1″ NPT	1¼″ NPT	1½″ NPT	2″ NP
1.5 1.0	2.0 1.25	3.0 1.75	4.0 3.0	6.0 5.0	10.0 8.5
0.34 0.23	0.45 0.28	0.68 0.40	0.91 0.68	1.36 1.14	2.27 1.93

Air-Factory Installed Tee
Approximate actuation/deactuation flow rates
SCFM upper, **NM³/M** lower

1/2″ NPT	3/4″ NPT	1″ NPT	1¼″ NPT	1½″ NPT	2″ NPT
6.5 5.0	10.0 8.0	14 12	21 18	33 30	43 36
.18 .14	.28 .23	.40 .34	.59 .51	.93 .85	1.19 1.02

V6 Low Flow, Field Adjustable

Cold Water – Low Flow Models
Approximate actuation/deactuation flow rates
GPM upper, **M³/HR** lower

MINIMUM	MAXIMUM
.04 .03	.75 0.60
.009 .007	0.17 0.14

Air – Low Flow Models
Approximate actuation/deactuation flow rates
SCFM upper, **NM³/M** lower

MINIMUM	MAXIMUM
.18 .15	2.70 2.0
.005 .004	.08 .06

V6 With Field Trimmable Vane

Cold Water – Brass or Cast Iron Reducing Tee
Approximate actuation/deactuation flow rates
GPM upper, **M³/HR** lower

Vane	½″ NPT	¾″ NPT	1″ NPT	1¼″ NPT	1½″ NPT	2″ NPT
Full Size						9.0 8.5 2.0 1.9
A						9.5 9.0 2.2 2.0
B						10.0 9.3 2.3 2.1
C						11.0 10.0 2.5 2.3
D					6.2 5.5 1.4 1.2	12.0 10.0 2.7 2.3
E					7.0 6.5 1.6 1.5	13.0 11.0 3.0 2.5
F				4.3 3.9 1.0 0.9	7.6 7.1 1.7 1.6	14.0 12.0 3.2 2.7
G				4.9 4.4 1.1 1.0	8.0 7.3 1.8 1.7	
H				5.5 5.0 1.2 1.1	9.0 8.2 2.0 1.9	
I			3.5 3.1 0.8 0.7	6.0 5.6 1.4 1.3	10.0 9.0 2.3 2.0	
J			4.0 3.5 0.9 0.8	7.0 6.6 1.6 1.5	13.0 11.0 3.0 2.5	
K			4.6 4.2 1.04 0.95	8.0 7.6 1.8 1.7	15.0 13.0 3.4 3.0	
L		2.6 2.3 0.6 0.5	5.6 5.2 1.3 1.2	10.0 9.0 2.3 2.0		
M	1.6 1.3 0.4 0.3	3.5 3.1 0.8 0.7	6.3 6.1 1.43 1.39	12.0 10.0 2.7 2.3		
N	2.2 1.8 0.5 0.4	4.3 3.8 1.0 0.9	8.0 7.5 1.8 1.7			
O	3.0 2.4 0.7 0.5					

Air – Brass or Cast Iron Reducing Tee
Approximate actuation/deactuation flow rates
SCFM upper, **NM³/M** lower

Vane	½″ NPT	¾″ NPT	1″ NPT	1¼″ NPT	1½″ NPT	2″ NPT
Full Size						39.0 37.0 1.10 1.05
A						40.0 38.0 1.13 1.08
B						42.0 40.0 1.19 1.13
C						50.0 44.0 1.42 1.25
D					27.0 25.0 0.76 0.71	55.0 46.0 1.56 1.30
E					30.0 28.0 0.85 0.79	
F				20.0 18.0 0.57 0.51	32.0 30.0 0.91 0.85	
G				21.0 19.0 0.59 0.54	34.0 32.0 0.96 0.91	
H				23.0 21.0 0.65 0.59	37.0 34.0 1.05 0.96	
I			16.0 15.0 0.45 0.42	24.0 22.0 0.68 0.62	39.0 36.0 1.10 1.02	
J			18.0 16.0 0.51 0.45	28.0 25.0 0.79 0.71	51.0 45.0 1.44 1.27	
K			19.0 17.0 0.54 0.48	33.0 30.0 0.93 0.85	69.0 57.0 1.95 1.61	
L		13.0 12.0 0.37 0.34	22.0 20.0 0.62 0.57	38.0 35.0 1.08 0.99		
M	6.4 3.8 0.18 0.11	15.0 14.0 0.42 0.40	25.0 23.0 0.71 0.65	45.0 42.0 1.27 1.19		
N	10.0 7.0 0.28 0.20	20.0 16.0 0.57 0.45	32.0 28.0 0.91 0.79			
O	12.0 9.0 0.34 0.25					

Cold Water – Stainless or Forged Steel Straight Tee and Bushing
Approximate actuation/deactuation flow rates
GPM upper, **M³/HR** lower

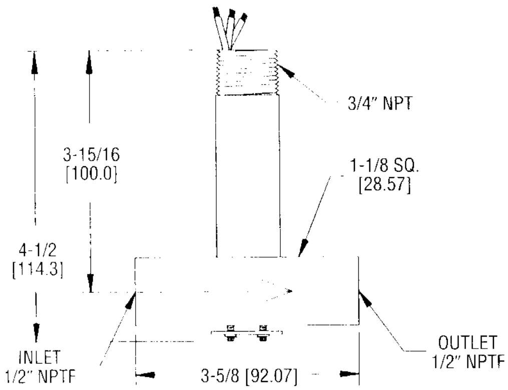
Vane	½″ NPT	¾″ NPT	1″ NPT	1¼″ NPT	1½″ NPT	2″ NPT
Full Size				5.0 4.5 1.1 1.0	8.5 7.8 1.9 1.8	
A				5.5 5.0 1.2 1.1	9.2 8.6 2.1 2.0	
B				6.2 5.7 1.4 1.3	9.8 9.0 2.2 2.0	
C				6.8 6.3 1.5 1.4	12.0 10.0 2.7 2.3	
D			2.8 2.4 0.6 0.5	8.5 7.8 1.9 1.8	13.0 11.0 3.0 2.5	
E			3.4 3.0 0.8 0.7	10.0 9.2 2.3 2.1		
F			4.0 3.6 0.91 0.82	12.0 10.0 2.7 2.3		
G		2.0 1.5 0.5 0.3	5.0 4.5 1.1 1.0			
H		2.5 2.0 0.6 0.5	6.5 6.1 1.48 1.39			
I		3.5 3.0 0.8 0.7	9.0 8.2 2.0 1.9			
J		7.0 5.5 1.6 1.2				
K		10.0 8.0 2.3 1.8				

Air – Stainless or Forged Steel Straight Tee and Bushing
Approximate actuation/deactuation flow rates
SCFM upper, **NM³/M** lower

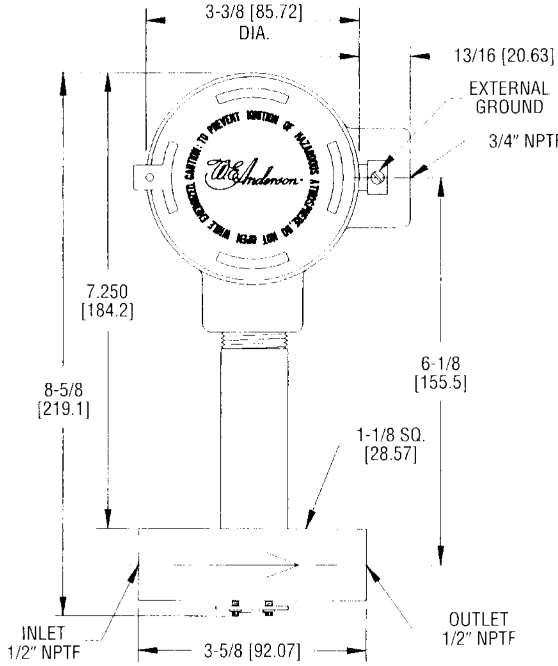
Vane	½″ NPT	¾″ NPT	1″ NPT	1¼″ NPT	1½″ NPT	2″ NPT
Full Size				21.0 18.0 0.59 0.51	33.0 30.0 0.93 0.85	
A				22.0 20.0 0.62 0.57	39.0 36.0 1.10 1.02	
B				24.0 22.0 0.68 0.62	42.0 38.0 1.19 1.08	
C				28.0 26.0 0.79 0.74	51.0 46.0 1.44 1.30	
D			12.0 10.0 0.34 0.28	33.0 30.0 0.93 0.85	55.0 50.0 1.56 1.42	
E			14.0 12.0 0.40 0.34	37.0 34.0 1.05 0.96		
F			16.0 14.0 0.45 0.40	43.0 40.0 1.22 1.13		
G		8.0 6.5 0.23 0.18	19.0 17.0 0.54 0.48			
H		11.0 10.0 0.31 0.28	26.0 24.0 0.74 0.68			
I		14.0 13.0 0.40 0.37	32.0 30.0 0.91 0.85			
J		27.0 24.0 0.76 0.68				
K		39.0 36.0 1.10 1.02				

DIMENSIONS

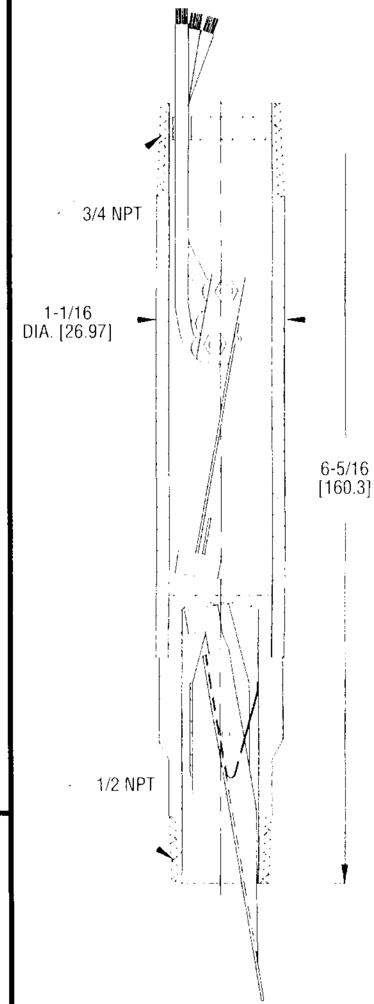
FloTect® Model V6



V6 Low Flow

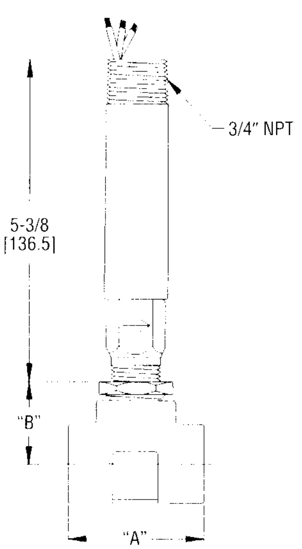


V6 Low Flow with C.S.A., CENELEC Conduit Enclosure

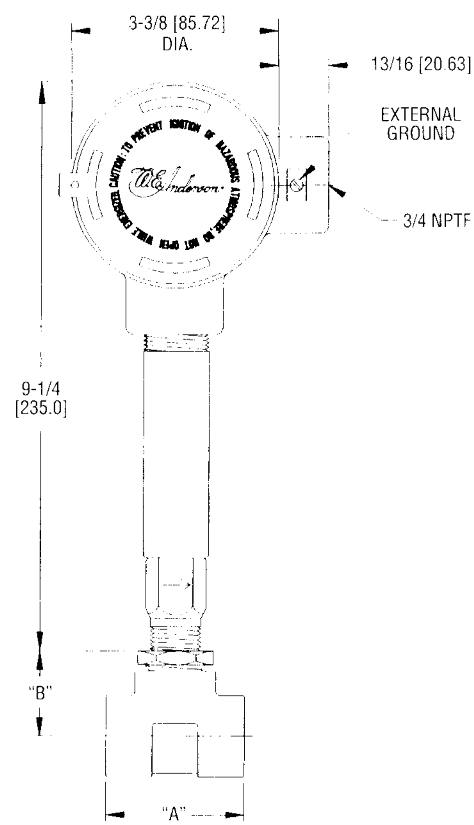


V6 with Field Trimmable Vane

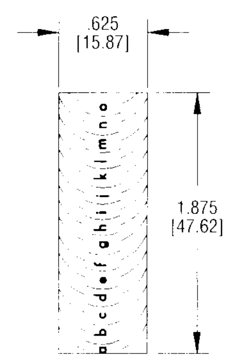
PIPE SIZE	BRASS/DUCTILE IRON		FORGED/STAINLESS STEEL		MALLEABLE IRON	
	DIM. A	DIM. B	DIM. A	DIM. B	DIM. A	DIM. B
1/2"	2-1/4(57)	1-1/8(29)	2-1/4(57)	1-1/8(29)	2-1/2(64)	1-1/4(32)
3/4"	2-3/8(60)	1-1/4(32)	2-5/8(67)	1-7/8(47)	2-5/8(67)	1-3/8(35)
1"	2-1/2(64)	1-3/8(35)	3(76)	2-1/8(54)	2-7/8(73)	1-1/2(38)
1-1/4"	2-5/8(67)	1-1/2(38)	3-1/2(89)	2-1/2(64)	3(76)	1-3/4(44)
1-1/2"	2-7/8(73)	1-5/8(41)	4(102)	2-3/4(70)	3-1/4(83)	1-7/8(48)
2"	3(76)	1-7/8(48)	4-3/4(121)	3-1/8(79)	3-1/2(89)	2-1/8(54)



V6 with Tee



V6 with Tee and C.S.A., CENELEC Conduit Enclosure



Trimmable Vane

W.E. ANDERSON DIV., DWYER INSTRUMENTS, INC.
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Series 358

Granville-Phillips® Series 358 Micro-Ion® Vacuum Gauge Controller

Instruction Manual

Instruction manual part number 358013

Revision 09 - June 2008

Series 358

Granville-Phillips® Series 358 Micro-Ion® Vacuum Gauge Controller

This Instruction Manual is for use with all Granville-Phillips Series 358 Micro-Ion Vacuum Gauge Controllers.
A list of applicable catalog numbers is provided on the following page.

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Instruction Manual

Granville-Phillips® Series 358 Micro-Ion® Vacuum Gauge Controller

Catalog numbers for Series 358 Micro-Ion Controllers

Controller for a Micro-Ion gauge, with 3-line display, electron bombardent degas, and remote input/output interface - CE Marked (1)

Half-rack mount:	358501 - # # # - # #
Left mount for 19-inch rack:	358502 - # # # - # #
Center mount for 19-inch rack:	358503 - # # # - # #
Black Case & Half-rack mount:	358504 - # # # - # #
Black Case & Left mount for 19-inch rack:	358505 - # # # - # #

Interface options (Slot X):

None	0
RS-232	A
RS-485/422	B

Gauge options (Slot Y):

None	0
Dual Convectron	1
Capacitance Manometer/Convectron (1)	2

Setpoint options (Slot Z):

None	0
2 setpoint relays for Micro-Ion gauge	A
6 setpoint relays, 2 per channel	B

Display options (Measurement units):

Torr	T
mbar	M
Pascal	P

Powercord options:

North America 115 V	1
North America 240 V	2
Universal Europe 220 V	3
United Kingdom 240 V	4

NOTE: (1) The Capacitance Manometer/Convectron Gauge option is not CE Marked.

Table of Contents

Chapter 1 Before You Begin

1.1 Caution and Warning Statements

This manual contains caution and warning statements with which you *must* comply to prevent inaccurate measurement, property damage, or personal injury.

> **CAUTION**
>
> **Caution statements alert you to hazards or unsafe practices that could result in minor personal injury or property damage.**
>
> Each caution statement explains what you must do to prevent or avoid the potential result of the specified hazard or unsafe practice.

> **WARNING**
>
> **Warning statements alert you to hazards or unsafe practices that could result in severe property damage or personal injury due to electrical shock, fire, or explosion.**
>
> Each warning statement explains what you must do to prevent or avoid the potential result of the specified hazard or unsafe practice.

Caution and warning statements comply with American Institute of Standards Z535.1–2002 through Z535.5–2002, which set forth voluntary practices regarding the content and appearance of safety signs, symbols, and labels.

Each caution or warning statement explains:

a. The specific hazard that you *must* prevent or unsafe practice that you *must* avoid,

b. The potential result of your failure to prevent the specified hazard or avoid the unsafe practice, and

c. What you *must* do to prevent the specified hazardous result.

1.2 Reading and Following Instructions

You must comply with all instructions while you are installing, operating, or maintaining the module. Failure to comply with the instructions violates standards of design, manufacture, and intended use of the module. Brooks Automation, Inc./ Granville-Phillips disclaim all liability for the customer's failure to comply with the instructions.

- *Read instructions* – Read all instructions before installing or operating the product.
- *Retain instructions* – Retain the instructions for future reference.

- *Follow instructions* – Follow all installation, operating and maintenance instructions.
- *Heed warnings and cautions* – Adhere to all warnings and caution statements on the product and in these instructions.
- *Parts and accessories* – Install only those replacement parts and accessories that are recommended by Granville-Phillips. Substitution of parts is hazardous.

1.3 Damage Requiring Service

Disconnect the product from the wall outlet and all power sources and refer servicing to qualified service personnel under the following conditions:

1. When any cable or plug is damaged.
2. If any liquid has been spilled onto, or objects have fallen into, the product.
3. If the product has been exposed to rain or water.
4. If the product does not operate normally even if you follow the operating instructions. Adjust only those controls that are covered by the operation instructions. Improper adjustment of other controls may result in damage and will often require extensive work by a qualified technician to restore the product to its normal operation.
5. If the product has been dropped or the enclosure has been damaged.
6. When the product exhibits a distinct change in performance. This indicates a need for service.

WARNING

Substitution or modifying parts can result in product damage or personal injury due to electrical shock or fire.

- Install only those replacement parts that are specified by Brooks Automation, Inc./ Granville–Phillips.
- Do not install substitute parts or perform any unauthorized modification to the controller.
- Do not use the controller if unauthorized modifications have been made.

1.4 Pressure Relief Devices

⚠ WARNING

Failure to install appropriate pressure relief devices for high–pressure applications can cause product damage or personal injury.

For automatic backfilling and other applications in which malfunction or normal process conditions can cause high pressures to occur, install appropriate pressure relief devices.

Suppliers of pressure relief valves and pressure relief disks are listed in the *Thomas Register* under “Valves, Relief”, and “Discs, Rupture”.

Confirm that these safety devices are properly installed before installing the product. In addition, check that:

1. The proper gas cylinders are installed,
2. Gas cylinder valve positions are correct on manual systems, and
3. The automation is correct on automated gas delivery systems.

Vacuum gauges with compression fittings may be forcefully ejected if the vacuum system is pressurized.

1.5 Certification

Brooks Automation, Inc./ Granville-Phillips certifies that this product met its published specifications at the time of shipment from the factory. Brooks Automation, Inc./ Granville-Phillips further certifies that its calibration measurements are traceable to the National Institute of Standards and Technology to the extent allowed by the Institute's calibration facility. See also CE Declaration of Conformity inside envelope for CE tests performed.

1.6 Warranty Information

Brooks Automation, Inc./ Granville-Phillips provides an eighteen (18) month warranty from the date of shipment for new Granville-Phillips products. The Brooks Automation, Inc./ Granville-Phillips general terms and conditions of sale provide the complete and exclusive warranty for Brooks Automation, Inc./ Granville-Phillips products. This document is located on our web site at www.brooks.com, or may be obtained by a contacting Brooks Automation, Inc./ Granville-Phillips customer service representative.

1.7 Service Guidelines

Some minor problems are readily corrected on site. If the product requires service, please contact our Customer Service Department for troubleshooting help over the phone.

For customer service:

- Phone **1-303-652-4400** or **1-800-776-6543** within the USA.
- Phone **1-800-367-4887** 24 hours per day, 7 days per week within the USA.

- Email *co-csr@brooks.com*
- For Global Customer Support, go to www.brooks.com, click on Contact Us, then click on Global Offices to locate the Brooks Automation office nearest you.

If a product must be returned for service, request a Return Authorization (RA) from Brooks Automation, Inc. / Granville-Phillips. Do not return products without first obtaining an RA. In some cases a hazardous materials document may be required. The Brooks Automation / Granville-Phillips Customer Service Representative will advise you if the hazardous materials document is required.

When returning equipment to Brooks Automation Inc. / Granville-Phillips, be sure to package the products to prevent shipping damage. Circuit boards and modules separated from the controller chassis must be handled using proper anti-static protection methods and must be packaged in anti-static packaging. Brooks Automation, Inc. / Granville-Phillips will supply return packaging materials at no charge upon request. Shipping damage on returned products as a result of inadequate packaging is the Buyer's responsibility.

1.8 FCC Verification

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the U.S. Federal Communications Commission (FCC) Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment uses and can radiate radio frequency energy and, if not installed and used in accordance with this instruction manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment OFF and ON, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio or television technician for help.

For information about FCC and EU compliance, see *FCC and EU Installation Requirements* on page 49.

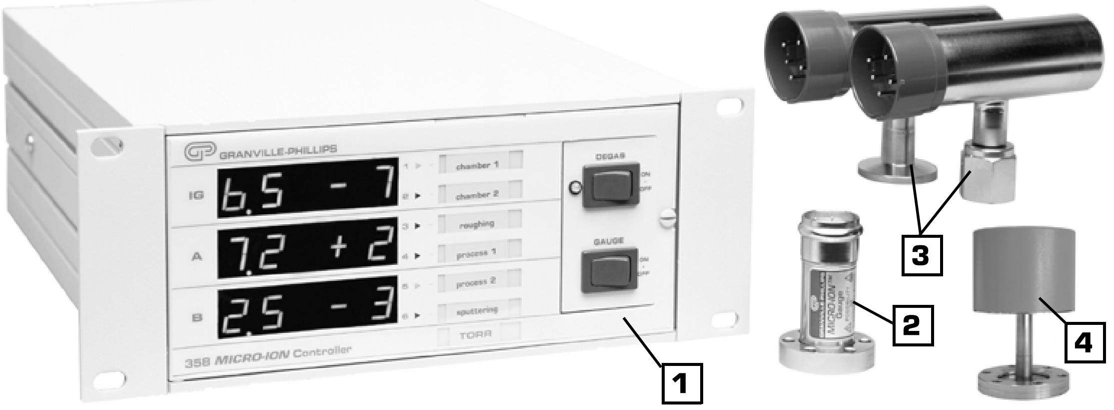
Chapter 2 System Components

The Series 358 Micro-Ion Vacuum Measurement System can operate one Micro-Ion gauge along with two Convectron Gauges simultaneously, or one Micro-Ion gauge along with one Convectron Gauge and one Capacitance Manometer Gauge simultaneously.

Pressure readout is via three front panel displays, analog output, and available computer interface.

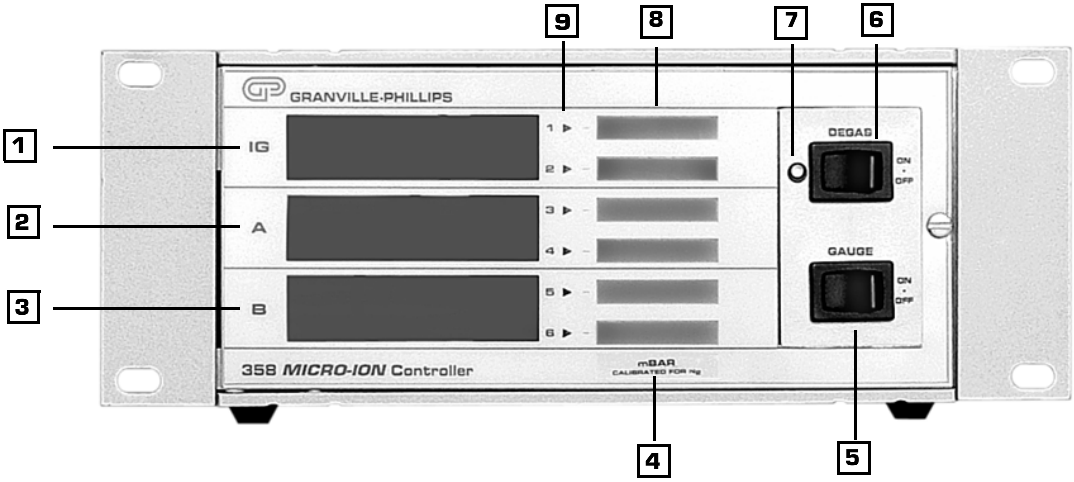
The Series 358 Micro-Ion Vacuum Measurement Controller is a modular instrument that can easily be customized to fit most user's exact needs. Infrequently used controls are housed behind a hinged front panel, reducing front panel clutter and allowing the Controller to reside in a half rack space.

Figure 2-1 Micro-Ion Vacuum Measurement System



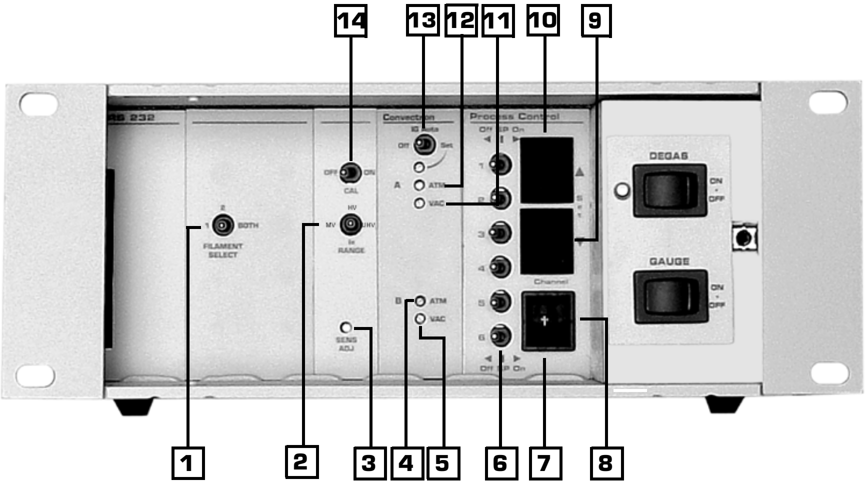
1. 358 Controller
2. Micro-Ion Gauge
3. Convectron Gauges
4. Capacitance Manometer Gauge

Figure 2-2 Controller Front Panel



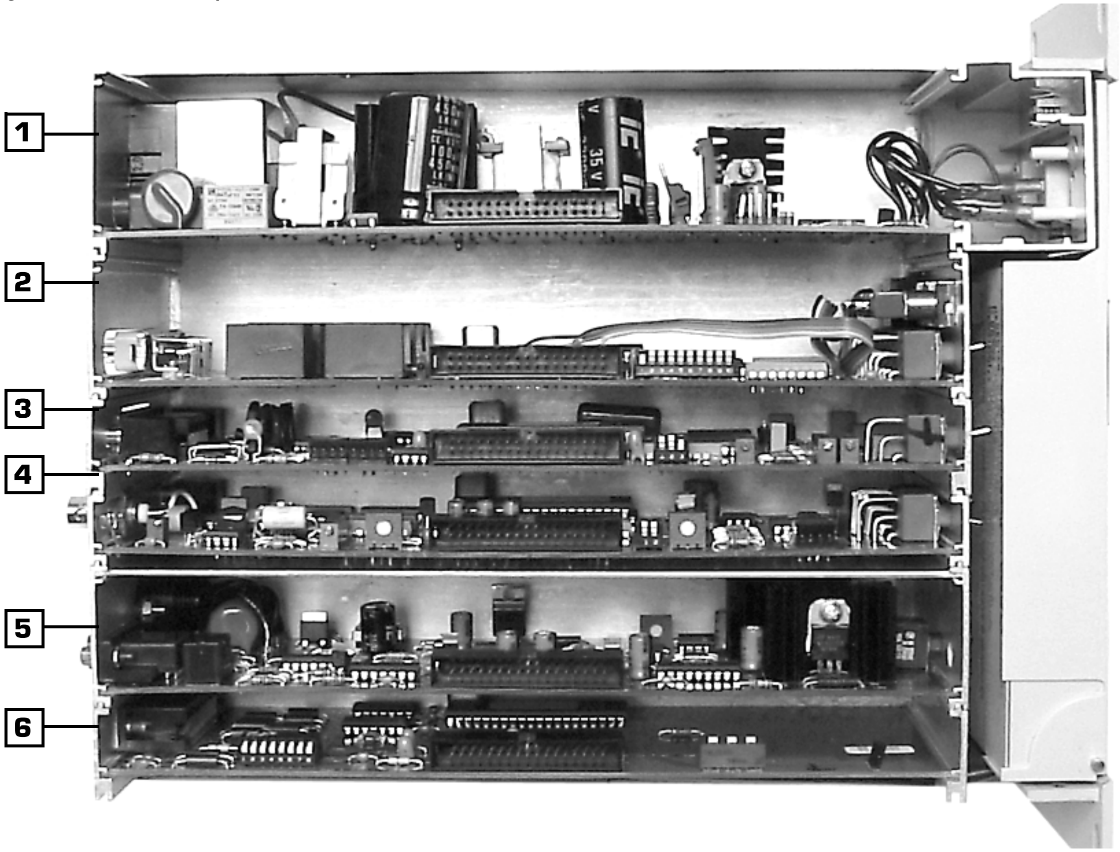
1. Micro-Ion display
2. Convectron Gauge A display
3. Convectron Gauge B or Capacitance Manometer display
4. Unit of measure label: Torr, mbar or pascal, user selectable
5. Micro-Ion Gauge “momentary” ON/OFF switch
6. Degas “momentary” ON/OFF switch
7. Degas LED
8. Process control channel labels
9. Process control channel indicator lights

Figure 2-3 Controller Front Panel with Door Open



1. Filament select switch: filament 1, filament 2, or both
2. Pressure range selector
3. Sensitivity adjustment
4. Atmosphere adjustment, Convectron or Capacitance Manometer gauge B
5. Vacuum zero adjustment, Convectron or Capacitance Manometer gauge B
6. Process control setpoint 3-position manual override switches.
   Center = relay is controlled automatically.
   Left = relay is deactivated.
   Right = relay is activated.
7. Process control channel indicator
8. Process control channel selector thumbwheel
9. “Down” process control setpoint pressure set pushbutton
10. “Up” process control setpoint pressure set pushbutton
11. Vacuum zero adjustment, Convectron gauge A
12. Atmosphere adjustment, Convectron gauge A
13. Micro-Ion gauge auto ON switch (via Convectron gauge)
14. Calibration / sensitivity ON switch

Figure 2-4 Controller Top View with Cover Removed



1. Power supply board
2. Process control setpoint option board
3. Convectron or Capacitance Manometer gauge option board
4. Electrometer board
5. Filament/grid supply board
6. Interface option board (RS-232 or RS-485)

2.1 Options

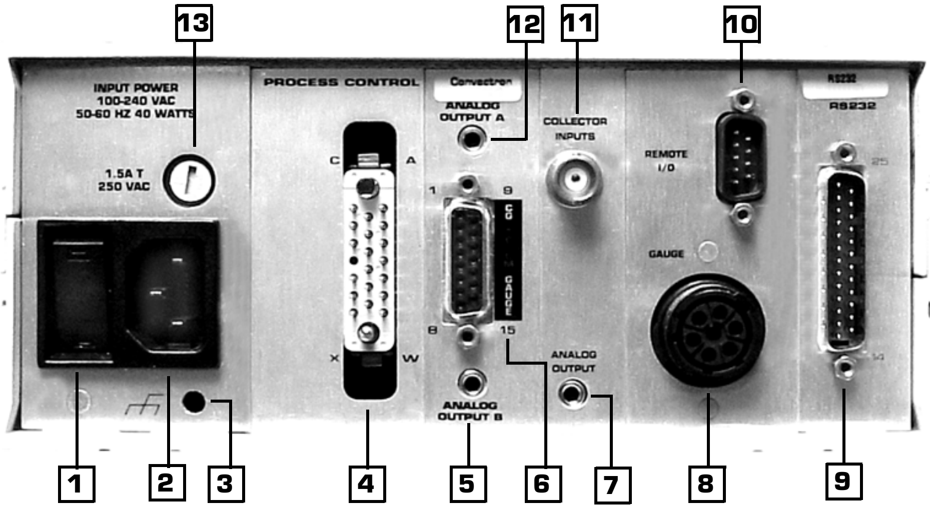
Process Control Relay

A 2-setpoint or 6-setpoint relay option can either be factory installed or added at any time by the user. The set points are adjustable from atmosphere to 1 x 10^{-10} Torr with override switches and front panel status indication.

RS-232 or RS-485/422 Computer Interface Module

Provides readout of pressure, process control relay status, and Micro-Ion gauge control.

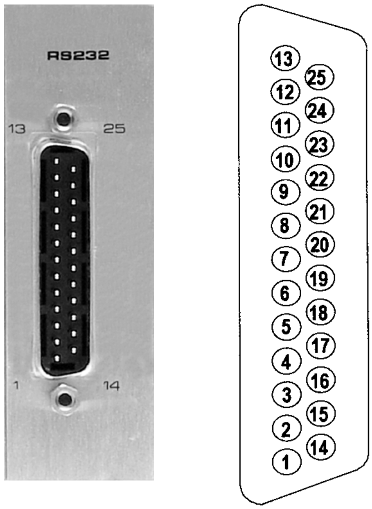
Figure 2-5 Controller Rear Panel (with RS-232 Option)



1. Power switch
2. Power input connector
3. Grounding lug to be connected to earth ground with 12 AWG conductor
4. 20-pin connector for process control relay contacts
5. Connector for analog output voltage from Convectron or Capacitance Manometer gauge B
6. DA15P connector for Dual Convectron or Capacitance Manometer gauge cable
7. Connector for analog output voltage from Micro-Ion gauge
8. Micro-Ion gauge power connector
9. DB25S connector for RS-232 computer interface
10. DE9S connector for remote parameter selection inputs/outputs
11. Collector connector for Micro-Ion gauge
12. Connector for analog output voltage from Convectron gauge A
13. Fuse holder

2.2 RS-232 Specifications

Figure 2-6 RS-232 Wiring Connector



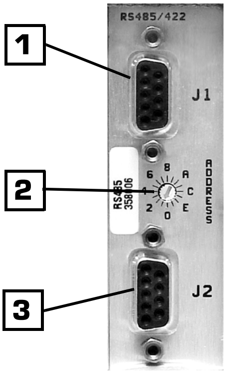
DB–25S connector

Table 2-1 RS-232 Specifications

Item	Specification
Format	EIA standard RS-232-C, half duplex, asynchronous
Data Rates	75,150,300,600,1200,2400,4800,9600 baud
Character length	7 or 8 bit ASCII, switch selectable
Parity	Odd, even, or none, switch selectable
Stop bits	1 or 2. 8 character bits plus parity allows only 1 stop bit
Handshake	Outputs: DTR,RTS. RTS polarity selectable. Inputs: DSR, CTS, DCD. May be forced to logic “TRUE” with switches
Logic levels	Inputs: Logic 1, 2.0 Vdc minimum,15 Vdc maximum, logic 0, –15 Vdc minimum, 0.75 VDC maximum Input Current: 4.0 mA max @ Vin = +15 Vdc, –4.0 mA max @ Vin = –15 Vdc

2.3 RS-485 Specifications

Figure 2-7 RS-485 Wiring Connector



1) J 1 DE9P Connector for RS-485/422 computer interface

2) Address dial

3) J 2 DE9P Connector for RS-485/422 computer interface

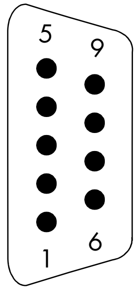


Table 2-2 RS-485 Specifications

Item	Specification
Format	Half duplex, asynchronous.
Data Rates	19200, 9600, 4800, 2400, 1200, 600, 300, 150 baud
Character Length	8 bit or 7 bit ASCII
Parity	No parity, even, or odd
Stop Bits	1 or 2
Handshake	None.
Address	256 selectable combinations
Number of Connections	Up to 32 devices
Total Cable Length	4000 ft. maximum

2.4 Specifications

Table 2-3 Specifications

Micro-Ion System	
Pressure Range for N_2 or air* Lower Measurement Limit Upper Measurement Limit	 < 1 x 10^{-9} Torr (1.3 x 10^{-9} mbar) (1.3 x 10^{-7} pascal) at 4 mA emission Atmosphere
Controller	
Electronic accuracy	Typical ± 3% of reading at ambient temperature of 25 ± 5 °C
Display Units Update Rate	Digital, green LED, 2 digits plus exponent Torr, mbar, pascal (user selectable) 0.5 sec. typical as shipped. Internal switch selectable to 3 sec./reading averaged
Filament Control	Switch selectable: filament 1, filament 2, or both
Degas	Electron bombardment, approximately 4 W with 2 minute timer
Maximum Micro-Ion Gauge Cable Length	15 m (50 ft) with standard cable
Remote I/O Gauge and Degas On/Off Inputs Filament Status Relay Contact Rating	Momentary ground controls filament selection and degas Less than 0.4 Vdc @ 10 µA for 25 msec (minimum). Must be greater than 3.5 Vdc for 105 msec (minimum) before next low state Micro-Ion gauge status relay rated at 1.0 A, 30 Vdc
Environment	Indoor use Altitude up to 2000 meters Temperature 0 °C to 40 °C Maximum relative humidity 80% for temperatures up to 31 °C decreasing linearly to 50% relative humidity at 40 °C Transient overvoltages according to installation category (overvoltage category) II Pollution degree 2 in accordance with IEC 664
Operating Temperature	0 °C to +40 °C ambient, noncondensing
Non-operating Temperature	–40 °C to +70 °C
Analog Output	0 to 10 Vdc, logarithmic, 1 V/decade
Overpressure Protection	Gauge turns OFF if pressure rises above factory set upper pressure limit
Emission Current Settings	0.02 mA (MV), 1 mA (HV), 4 mA (UHV)
Operating Voltage and Power	100 to 240 VAC, 50 to 60 Hz, 50 W maximum
Fuse Rating	250 V, 1.6 A, 5 x 20mm Time Lag (T), low breaking capacity
Weight	1.8 kg (4 lb)

* Measurement limits are determined by the controller emission current setting and X-ray limit of the gauge.

Table 2-3 Specifications

Controller Options	
Process Control Relay Configuration Contact Rating Channels Hysteresis Setpoint adjustment	 SPDT, Form C 5A @ 120 VAC, 4A @ 240 VAC resistive or 5A @ 30 Vdc 6 maximum, 2 per operating gauge maximum 10% Digital, 2 significant digits plus exponent
Digital Interfaces	RS-232 or RS-485/422
Dual Convectron Gauge Pressure Range Display Units Maximum Cable Length Analog Output Display Resolution	 999 to 1 x 10^{-4} Torr for N_2 or air Torr, mbar, pascal (user selectable) 150 m (500 ft) 0 to 7 V, logarithmic, 1 V/decade, adjustable offset of +1 to –7 Vdc 2 significant digits, except for lowest two decades
Micro-Ion Gauge	
Sensitivity	3/Torr to 50/ Torr (factory setting is 20/Torr)
Emission Current	20 µA, 1 mA, 4 mA
Collector Potential	0 V
Grid Potential	+180 Vdc
Filament Potential	+30 Vdc
Degas	Electron bombardment: 15 mA DC, 250 Vdc, auto shutoff, 2 minutes
Analog Output	0 to 10 Vdc, logarithmic, 1 V/decade
Filaments	Dual yttria-coated iridium, or tungsten†
Operating Temperature	0 °C to +50 °C ambient, noncondensing
Gauge Bakeout Temperature	+200 °C maximum
Cable Bakeout Temperature	+150 °C maximum
Materials Exposed to Vacuum	Vacuum fired, UHV compatible
Internal Volume	10.8 cm^3 (0.66 $in.^3$)
Weight	0.1 kg (4 oz.) (with 1 5/16 in. Conflat® type flange)

† Tungsten filaments are for applications involving gases containing fluorine, chlorine, or other gas species that poison yttria-coated iridium filaments. Tungsten filaments are not recommended for general vacuum applications because they may burnout when exposed to high pressures.

System Components

Table 2-3 Specifications

Convectron Gauge	
Pressure Range	1 x 10^{-4} Torr to 990 Torr, N_2 equivalent
Display Resolution	2 significant digits, except for 1 significant digit in 1 x 10^{-4} Torr decade
Gas Type	N_2, air (for direct reading)
Display Update Time	0.5 sec. typical. Switch selectable to 3 sec./reading, averaged
Analog Output	0 – 7 Vdc, logarithmic, 1 V/decade
Ion Gauge Turn-On Range	Less than or equal to 100 mTorr (1 x 10^{-1} Torr)
Sensor Material	Gold-plated tungsten
Mounting Orientation	Gauge axis must be horizontal to provide accurate measurement above about 1 Torr
Operating Temperature	+4 °C to +50 °C ambient, noncondensing
Bakeout Temperature	+150 °C maximum, nonoperating, cable disconnected
Cable Bakeout Temperature	+105 °C maximum
Ion Gauge Pressure Range* See Table 3-1 on page 30	

Table 2-3 Specifications

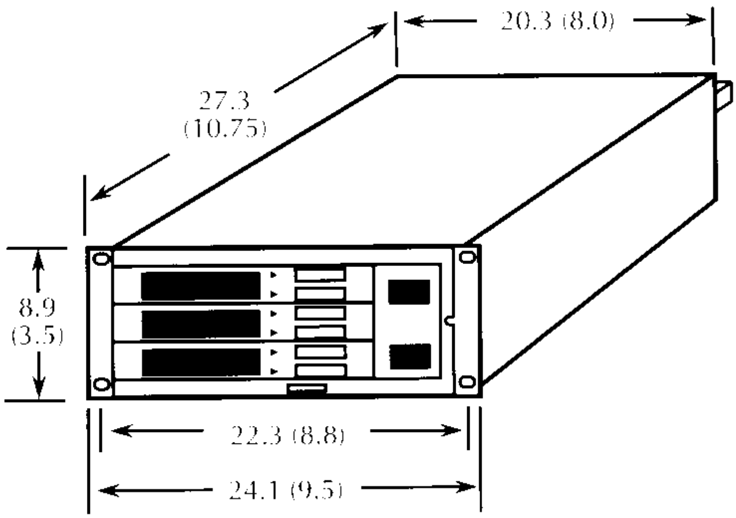
Capacitance Manometer	
Gauge Type	Any capacitance manometer transducer that requires ± 15 Vdc power at < 250 mA and outputs 0–10 Vdc proportional to pressure
Accuracy	0.01% of full scale (as limited by display resolution)
Display Resolution	Highest 3 decades – 2 digits, lowest decade – 1 digit, scientific notation
Maximum Pressure Scales	1, 10, 100, 1000 Torr max heads, 4 decades of pressure
Display Update Time	Unfiltered: 0.5 sec. typical. Switch selectable filtering: 3 sec. (average of 6 readings)
Output to Head	± 15 V ± 2% at 250 mA
Input from Head	0 to 10 Vdc into 100 kΩ
Analog Output	5 mA maximum
Analog Output Speed	Limited by transducer speed
Cable Connection	Cable termination is bare tinned wire, user terminates to transducer

2.5 Dimensions

The dimensions of the controller in a half rack (standard) mounting are shown in Figure 2-8.

Dimensions are in centimeters (inches).

Figure 2-8 Controller Dimensions

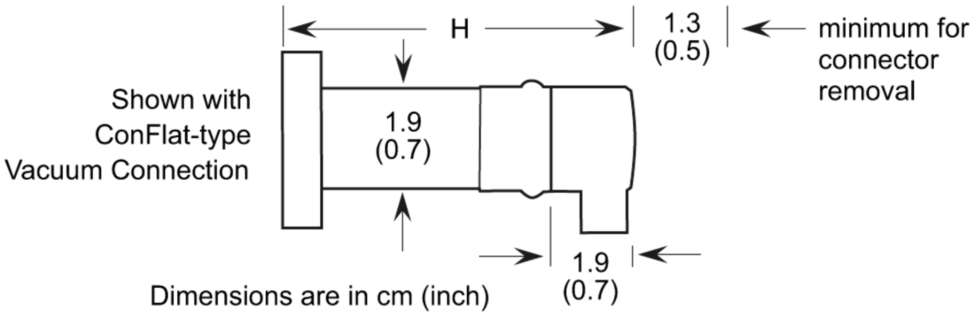


The dimensions of the Micro-Ion gauge are shown in Figure 2-9.

Dimensions are in cm (in.).

H dimensions are given in Table 2-4.

Figure 2-9 Micro-Ion Gauge with Connector



The dimensions of the Convectron gauge are shown Figure 2-10.

Dimensions are in cm (in.).

J dimensions are given in Table 2-4.

Figure 2-10 Convectron Gauge with Connector

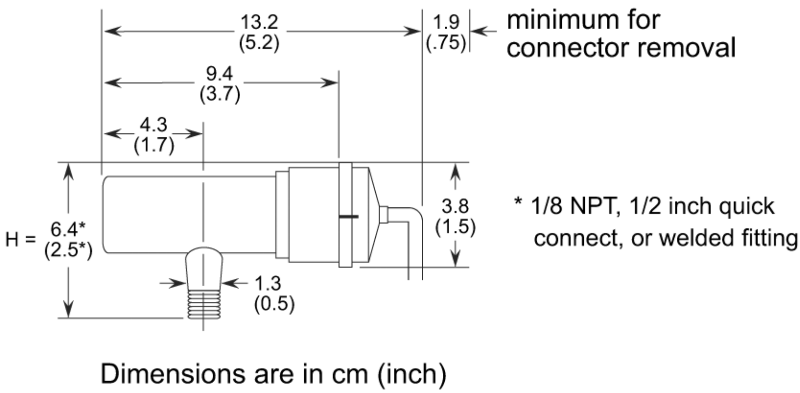
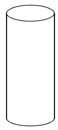
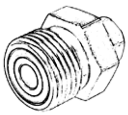


Table 2-4 Fittings

Fitting	Description	Dimension H	Dimension J
	0.75 inch port diameter 1.0 inch port diameter 15 mm port diameter 18 mm port diameter	9.4 cm (3.7 in.) 9.4 cm (3.7 in.) 9.4 cm (3.7 in.) 9.4 cm (3.7 in.)	Not applicable Not applicable Not applicable Not applicable
	1/4 inch VCR® type 1/2 inch VCR type	Not applicable 8.6 cm (3.4 in.)	8.1 cm (3.2 in.) 8.1 cm (3.1 in.)
	NW16KF flange NW25KF flange NW40KF flange	7.3 cm (2.9 in.) 7.3 cm (2.9 in.) 7.3 cm (2.9 in.)	6.9 cm (2.7 in.) 6.9 cm (2.7 in.) Not applicable
	1.33 inch ConFlat® 2.75 inch ConFlat	7.3 cm (2.9 in.) 7.3 cm (2.9 in.)	6.4 cm (2.5 in.) 6.4 cm (2.5 in.)

VCR® is a registered trademark of Swagelok Company; ConFlat® of Varian, Inc.

2.6 Mounting Options

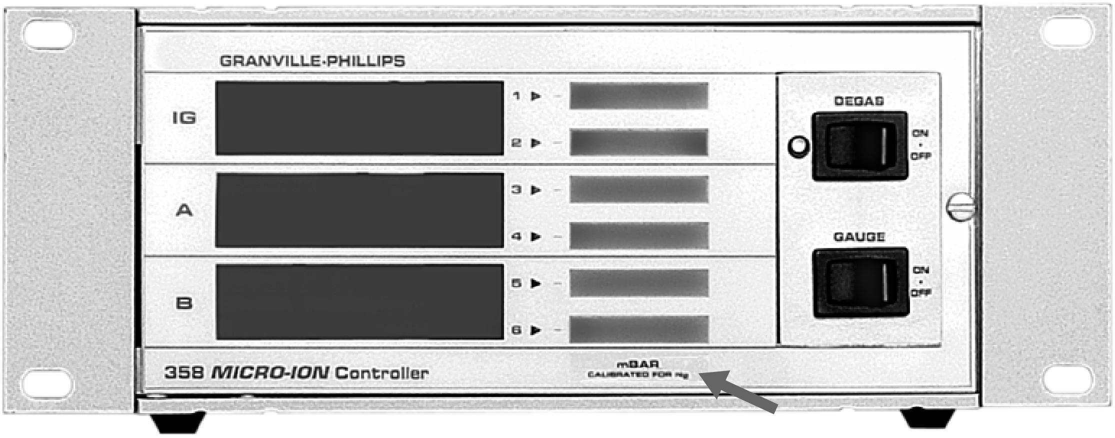
The controller can be ordered with a variety of mounting options to fit your needs. This includes half rack (standard), full rack, or two units in a full rack. See *Controller Installation* on page 50 and Figure 4-1 on page 52.

3.1 Controller Setup

Now is a convenient time to make any required switch changes before mounting the Controller in its desired location.

If the pressure display units of measure are correct (see Figure 3-1), and you do not want to change the degas power timer from the factory setting of 10 minutes, skip to *Process Control Setup* on page 32.

Figure 3-1 Units of Measure Label

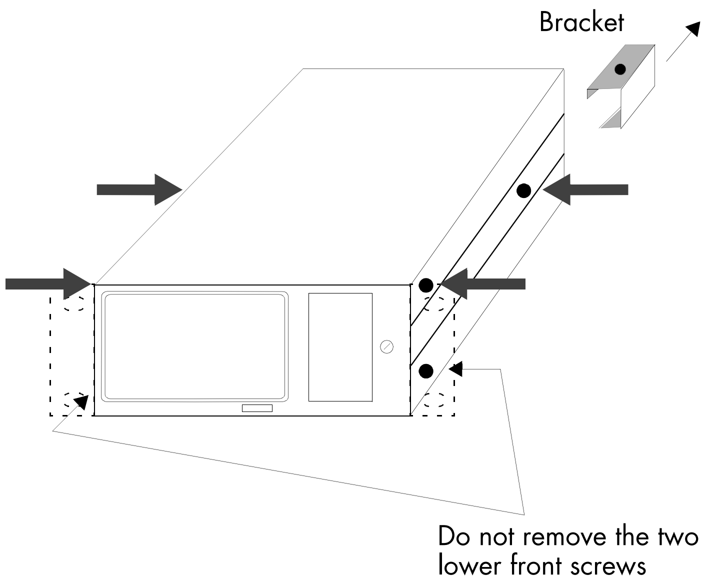


If you want to change the units of measure, the display rate, or the degas timer, you must remove the top cover of the Controller.

3.2 Top Cover Removal

1. With power OFF, remove any cables from Controller rear panel.
2. Observe antistatic precautions to avoid damaging static sensitive components inside the chassis. Use a grounded, conductive work surface. Do not handle integrated circuits (IC) devices more than necessary, and only when wearing a high impedance ground strap. (A high impedance helps protect human life in case of inadvertent contact with high voltage.)
3. Remove the four Phillips head screws identified in Figure 3-2. If the unit is equipped with a rear bracket, remove the Phillips head screw on the bracket, and slide the bracket off.

Figure 3-2 Location of Screws for Top Cover Removal



3.3 Pressure Units Setup

If units of measure are as desired (see Figure 3-1), skip to *Changing Display Update Rate on Electrometer Module* on page 30.

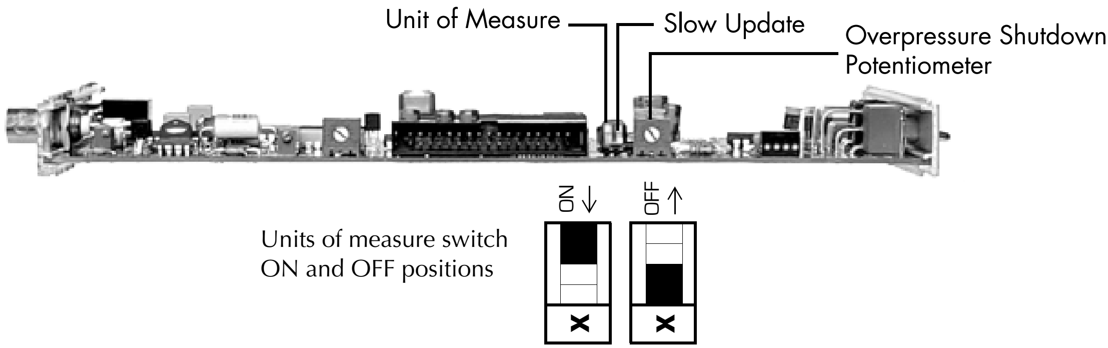
3.4 Changing Units of Measure for Electrometer Module

Your unit will have been shipped from the factory preset to display the unit of measure, Torr, mbar, or pascal, that you requested. Selection between Torr and mbar units is done by adjusting the Micro-Ion gauge tube sensitivity to the appropriate units. For example, a tube has a sensitivity of 20/Torr or 15/mbar. Thus, for this tube, adjusting the sensitivity for a display reading of 2.0+1 will result in display of pressure in Torr (see *Sensitivity Adjustment* on page 99). Adjusting to 1.5+1 will result in display in mbar.

If you want to change pascal units, change the switch on the electrometer module as follows:

1. Shut OFF power to the Controller.
2. Remove the top cover as described in *Top Cover Removal* on page 27.
3. Locate the Micro-Ion gauge electrometer module. See Figure 2-4 and Figure 3-3.
4. Locate the Unit of Measure display units control switch.

Figure 3-3 Ion Gauge Electrometer Module TopView

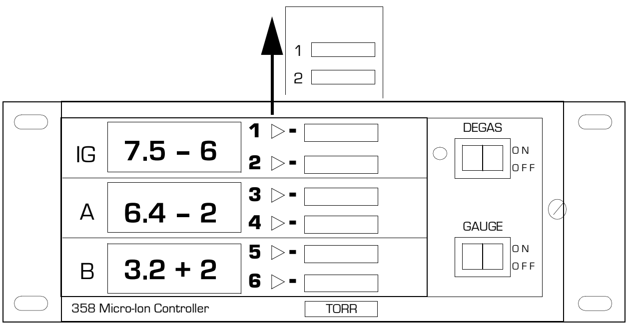


5. Set the switch to the desired position: Off = Torr/mbar units; On = pascal units.

   You must also change the setting of the unit of measure switch on the Dual Convectron gauge as described in *Changing Units of Measure for Convectron Gauge* on page 30.

6. To change the units of measure label on the front of the Controller, open the door and lift the label card from its slot in the top of the front panel. Units of measure labels are included in the mounting hardware kit.

Figure 3-4 Removing the Units of Measure Label Card



Initial Setup

3.5 Overpressure Shutdown Adjustment

This control is factory set so the ion gauge will shut down when the pressure rises above the levels given in Table 3-1.

Table 3-1 Pressure Range Settings

Pressure Range Designation	MV (Medium Vacuum)	HV (High Vacuum)	UHV (Ultrahigh Vacuum)
Emission Current	20 µA	1 mA	4 mA
Recommended Upper Limit, Torr	5×10^{-2}	8×10^{-4}	2×10^{-4}
Recommended Lower Limit, Torr	1×10^{-6}	1×10^{-7}	Less than 1×10^{-9}

To adjust the overpressure shutoff point to a different level:

1. Maintain system pressure at the desired shutoff point.
2. Rotate the overpressure adjustment potentiometer fully counterclockwise.
3. Turn ON the ion gauge.
4. Rotate the adjustment potentiometer clockwise slowly until the ion gauge turns OFF.

3.6 Changing Display Update Rate on Electrometer Module

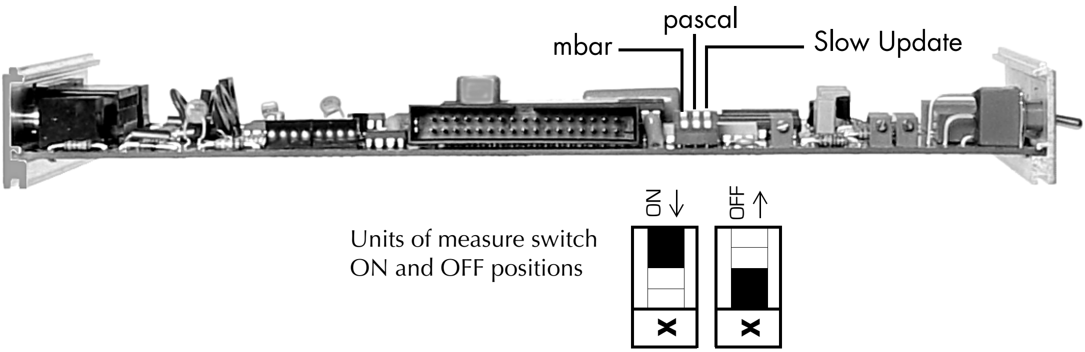
When “ON”, the Slow Update switch on the electrometer module enables pressure averaging. The display will be updated approximately every 3 seconds. When “OFF”, the update period is approximately 0.5 seconds. Refer to Figure 3-3 on page 29.

3.7 Changing Units of Measure for Convectron Gauge

The Series 358 Controller is shipped from the factory preset to display the units of measure, Torr, mbar, or pascal, that you requested. To change the units of measure for the Convectron Gauge:

1. Turn OFF power to the Controller.
2. Remove the top cover as described in *Top Cover Removal* on page 27.
3. Locate the Convectron gauge module. See Figure 2-4 and Figure 3-5.
4. Locate the mbar and pascal units switches.
5. Leave both switches “OFF” for Torr units. Turn ON the switch for either mbar or pascal units.
6. Modify the units of measure of the electrometer module to be consistent with the Convectron gauge. (See *Changing Units of Measure for Electrometer Module* on page 28.)
7. Slip the label card out of the top of the front panel and apply the appropriate pressure units label. See Figure 3-4.
8. Replace the top cover as described on page 47.

Figure 3-5 Convectron Gauge Module Top View



3.8 Display Update Rate Switch on Convectron Module

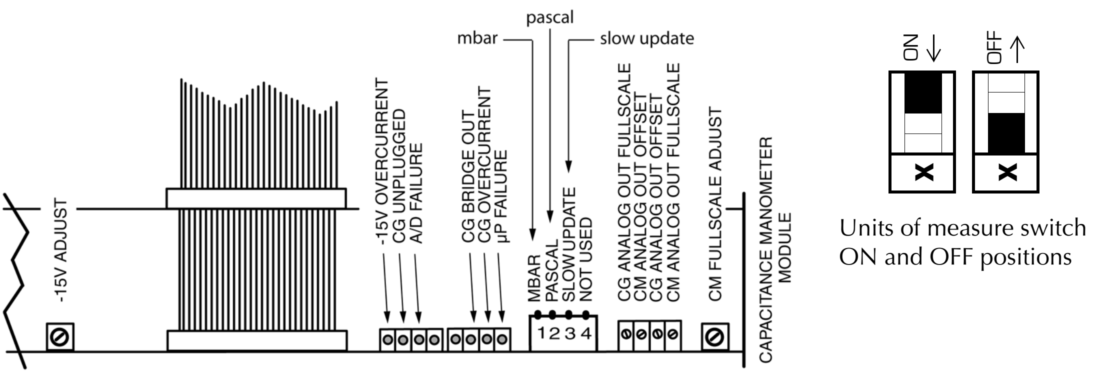
When "ON", this the Slow Update switch on the Convectron module enables pressure averaging. The display will be updated approximately every 3 seconds. When "OFF", the update period is approximately 0.5 seconds. Refer to Figure 3-5.

3.9 Changing Units of Measure for a Capacitance Manometer

The Series 358 Controller is shipped from the factory preset to display the units of measure, Torr, mbar, or pascal, that you requested. If you want to change units, proceed as follows:

1. Turn OFF power to the Controller.
2. Remove the top cover as described in *Top Cover Removal* on page 27.
3. Locate the Capacitance Manometer gauge module. See Figure 2-4 and Figure 3-6.

Figure 3-6 Capacitance Manometer Gauge Module Top View



4. Locate the mbar and pascal units switches.
5. Leave both switches "OFF" for Torr units. Turn ON the switch for either

mbar or pascal units.

6. Modify the units of measure of the electrometer module to be consistent with the Capcitance Manometer gauge. (See *Changing Units of Measure for Electrometer Module* on page 28.)
7. Slip the label card out of the top of the front panel and apply the appropriate pressure units label (see Figure 3-4 on page 29).
8. Replace the top cover as described in *Replacing the Controller Cover* on page 47.

3.10 Process Control Setup

CAUTION

Failure to check system programming before switching to automatic operation can cause measurement error.

To avoid measurement error due to inaccurate output signals, carefully check the system programming before switching to automatic operation.

WARNING

Failure to install appropriate pressure relief devices for high−pressure applications can cause product damage or personal injury.

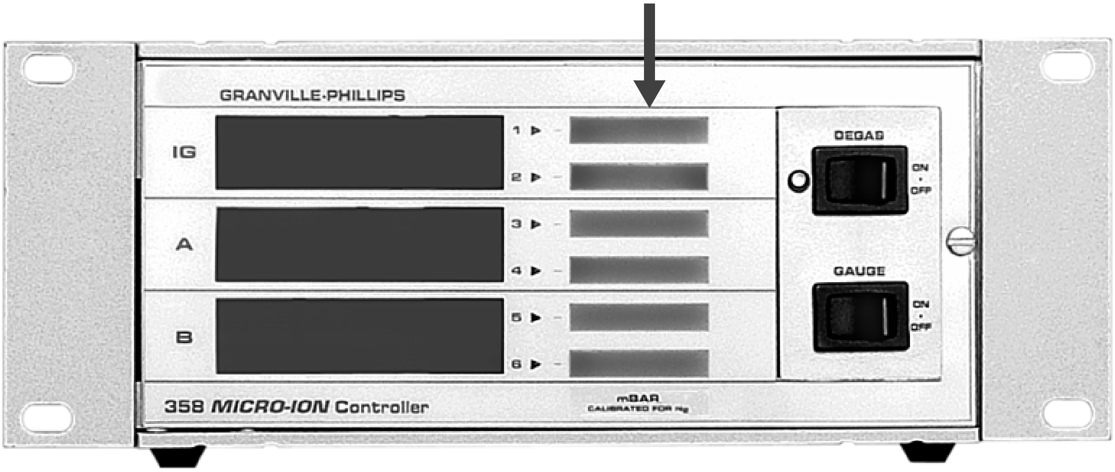
For automatic backfilling and other applications in which malfunction or normal process conditions can cause high pressures to occur, install appropriate pressure relief devices.

A process control module provides the controller with single-pole, double-throw relays that may be controlled either by digital setpoints or by the built-in manual override switches.

Process Control Channel Identification Windows

A channel identification label is included in the accessory kit to enable you to customize your controller for your application (see Figure 3-7).

Figure 3-7 Process Control Identification Windows



Developing a Logic Diagram of Control Logic

Prior to connecting the process controls to the system, it is recommended that the following steps be followed. If application assistance is desired, contact a Brooks Automation Inc./Granville-Phillips application engineer.

1. Use the catalog number on the front of the process control module together with Figure 3-8 and Figure 3-9 to identify the process control capability installed in your unit.
2. Even if the control logic is simple and obvious, we recommend that you develop a logic diagram of the process control function.
3. Prepare a specification table which lists the proposed pressure setting, system measurement point, and relay status for each process control channel.
4. Draw a circuit schematic which specifies exactly how each piece of system hardware will be connected to the process control relays.

Do not exceed the relay ratings:

Table 3-2 Relay Ratings

Parameter	Rating
Relay Configuration	SPDT (single pole, double throw)
Relay Contact Rating	5 A, 120 VAC; or 4A, 240 VAC; or 5A, 30 Vdc
Relay Contact Type	1 Form C type (gold plated for low level switching)

If the relay contacts are used to switch high currents, the gold plating may be consumed. This may make the contacts unsuitable for low level signal switching in the future.

5. Attach a copy of the process control circuit diagram to this manual for future reference and troubleshooting.
6. The required process control connections may be made later. (See *Connecting Process Control Relays* on page 63.)
7. If application assistance is desired, contact a Brooks Automation Inc./Granville-Phillips application engineer.

Figure 3-8 2-Channel Process Control Option Card

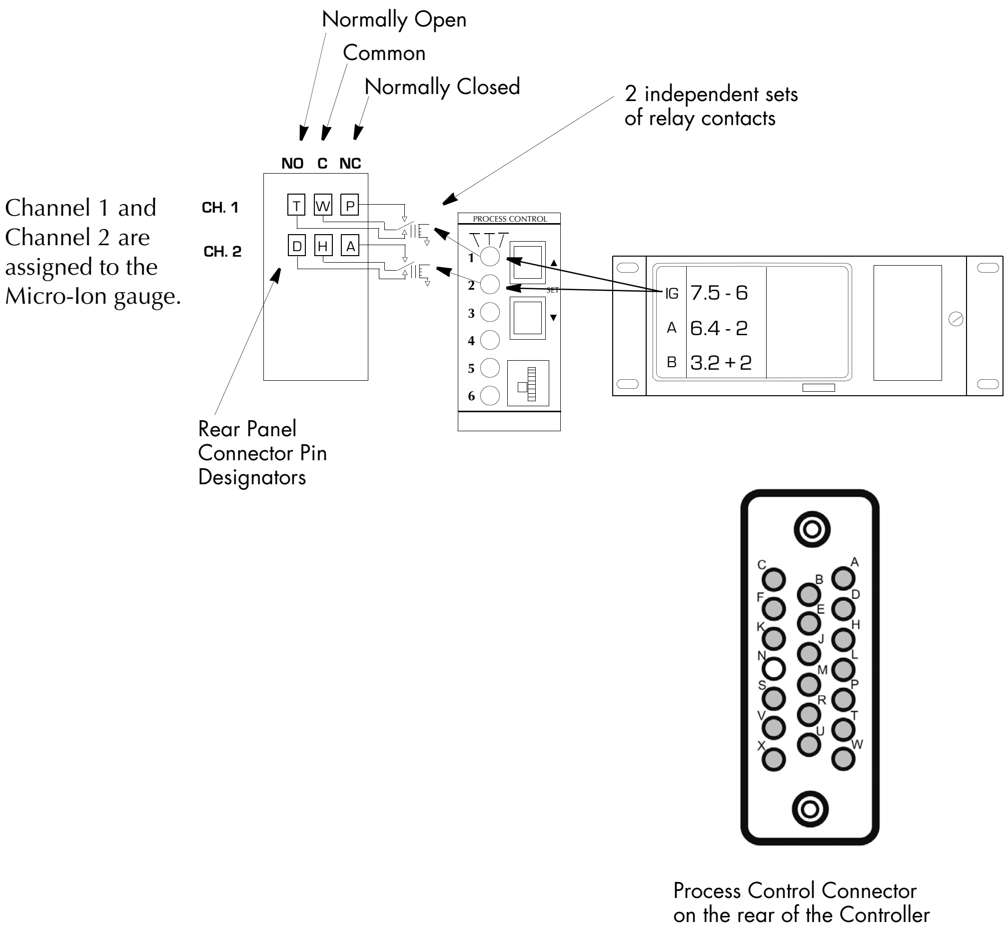
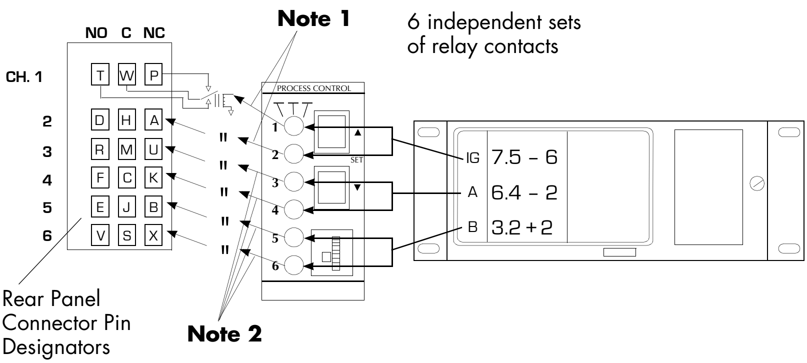


Figure 3-9 6-Channel Process Control Option Card



Channel 1 and Channel 2 are assigned to the Micro-Ion Gauge.

Channels 3 and 4 are factory assigned to Convectron Gauge A.

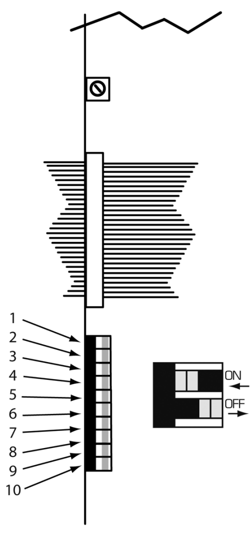
Channels 5 and 6 are factory assigned to Convectron Gauge B or capacitance manometer gauge B.

3.11 Relay Polarity Setting

The relays can be set to activate as pressure either rises above or falls below the setpoint. A DIP switch is provided for each channel. Refer to the numbers on the printed circuit board (not on the switch body) for the channel number. Use Table 3-3 to assign relay polarity settings.

The switches are factory preset as shown below for relay activation below the pressure setpoint. This is most commonly desired when you want the relay to be de-energized under a high pressure condition.

Figure 3-10Process Control Relay Polarity Switches



Initial Setup

Table 3-3 Relay Polarity Switch Settings

Switch Settings	Channel Activated	Pressure Indication Relative to Setpoint	Switch Settings	Channel Activated	Pressure Indication Relative to Setpoint
1 OFF →	6	Below (factory setting)	4 OFF →	3	Below (factory setting)
1 ON ←	6	Above	4 ON ←	3	Above
2 OFF →	5	Below (factory setting)	5 OFF →	2	Below (factory setting)
2 ON ←	5	Above	5 ON ←	2	Above
3 OFF →	4	Below (factory setting)	6 OFF →	1	Below (factory setting)
3 ON ←	4	Above	6 ON ←	1	Above

Process Control Tips

1. The process control override switches can be used to hold relays ON or OFF during initial setup or during non-typical process conditions.
2. When the Micro-Ion gauge is OFF, channels 1 and 2 are inoperative.
3. When Convectron gauges are disconnected, channels 3 through 6 are inoperative.
4. The status of relays 1 and 2 will not change during degas. The controller pressure will remain at the reading when degas began.
5. Relay actuation occurs when the pressure indication differs from the setpoint value by one display unit. A 10% hysteresis is automatically programmed into each setpoint for returning pressures. Table 3-4 exemplifies this using a setpoint pressure of 6.3×10^{-7}, and assuming the polarity is set for falling pressure activation.

Table 3-4 Setpoint Hysteresis

Setpoint Pressure	Pressure Change	Relay Actuation Pressure
6.3×10^{-7}	Falling	6.2×10^{-7}
6.3×10^{-7}	Rising	$6.3 \times 10^{-7} + 10\% = 7.0 \times 10^{-7}$

3.12 RS-232 Computer Interface Setup

If your Controller does not have this capability, skip to *RS-485 Computer Interface Setup* on page 42.

This available capability permits data output to, and gauge control by, a host computer. Output is either by a command-response mechanism or by a talk-only mode which is invoked via a switch on the RS-232 board. If you have this module in your unit, configure it to your system requirements by setting the switches as instructed in *Selecting Byte Format for RS-232 Module* on page 39.

A variety of baud rates and byte framing options are available, as well as switches to force the handshake lines to an "always true" condition.

Controller RS-232 factory defaults are: 9600 BAUD, 8 data bits, no parity, 1 stop bit; DCD, CTS, DSR forced "true".

The interface protocol is set using 8 switches.

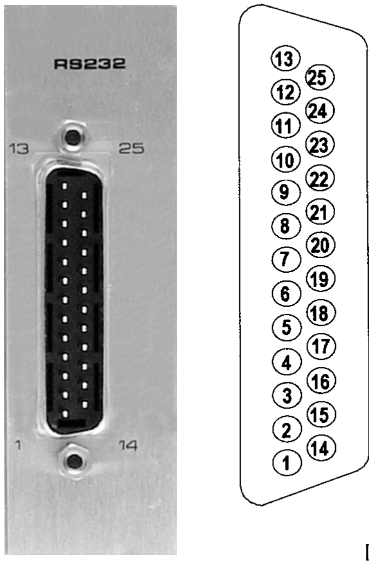
Internal switches are read upon controller power up. Changes in settings will take effect upon next power-up cycle.

Connector Pinouts for RS-232 Computer Interface

This factory or field-installed option has pin functions as shown in Table 3-5.

A mating DB-25S connector is supplied in the hardware kit. Use shielded cable to minimize electromagnetic radiation or susceptibility.

Figure 3-11 RS-232 Connector



DB–25S connector

Table 3-5 RS-232 Connector Pin Assignments

Signal	Pin Number	Direction
Protective Ground	1	–
Transmitted Data	2	To computer
Received Data	3	To controller
Request to Send (RTS)	4	To controller
Clear to Send (CTS)	5	To controller
Data Set Ready (DSR)	6	To controller
Signal Ground (common return)	7	–
Data Carrier Detect (DCD)	8	To controller
Data Terminal Ready (DTR)	20	To computer

Selecting Byte Format for RS-232 Module

Baud Rate for RS-232 Module

Dip switches 6-8 are used to control the baud rate. The settings are listed in Table 3-6.

Figure 3-12 RS-232 Module Top View

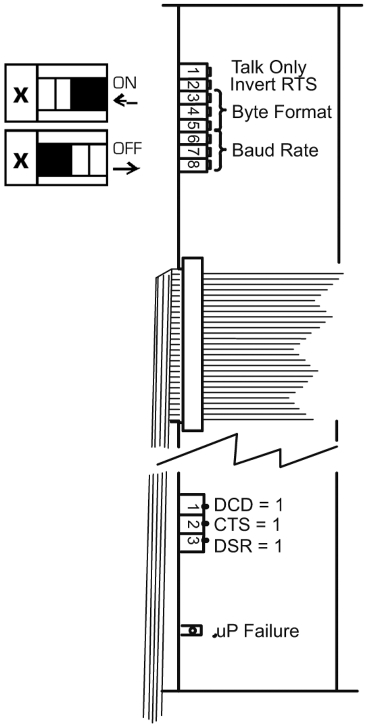


Table 3-6 RS-232 Baud Rates

S6	S7	S8	Baud Rate
On (factory setting)	On (factory setting)	On (factory setting)	9600 (factory setting)
On	On	Off	4800
On	Off	On	2400
On	Off	Off	1200
Off	On	On	600
Off	On	Off	300
Off	Off	On	150
Off	Off	Off	75

Character Framing for RS-232 Module

Switches 3-5 control the number of characters, parity, and number of stop bits.

Table 3-7 RS-232 Character Framing

S3	S4	S5	Character Bits	Parity	Stop Bits
On (factory setting)	On (factory setting)	On (factory setting)	8 (factory setting)	None (factory setting)	1 (factory setting) or 2
On	On	Off	8	Even	1
On	Off	On	8	Odd	1
On	Off	Off	8	None	1
Off	On	On	7	Even	1
Off	On	Off	7	Odd	1
Off	Off	On	7	Even	2
Off	Off	Off	7	Odd	2

Talk-Only Mode for RS-232 Module

Switch S1, if OFF at power-up, puts the interface in talk-only mode. The pressure data from all three displays will be output in a single message string, separated by commas, approximately every 5 seconds.

Table 3-8 RS-232 Talk-Only Mode

S1	Mode
Off	Talk-only
On	Command-response (factory setting)

Handshake Line Control Switches for RS-232 Module

Refer to *Connecting the RS-232 Computer Interface Handshake Lines* on page 65 for more detailed information on the handshaking mechanism.

Table 3-9 RS-232 Handshake Line Control Switches

Line	Switch	Description	Internal Switch Function	Factory Setting
CTS	2	CLEAR to SEND and DATA SET READY: When used, both must be TRUE in order for controller to send the next byte in its message or data.	CTS=1 and DSR=1: When ON, forces the functions TRUE and thus assumes host is always ready to receive.	Both ON (factory setting)
DSR	3			
DCD	1	DATA CARRIER DETECT: Must be TRUE at the time each character is received or that character will be ignored by controller.	DCD=1: When ON, forces DCD function TRUE so controller will receive all characters sent to it (as long as RTS is in de-asserted state).	ON (factory setting)

Invert RTS Switch for RS-232 Module

As shipped from the factory, the request-to-send (RTS) control line is set to operate as a modem line per the RS-232 standard. In some implementations it is necessary to invert this line and hook it directly to the clear-to-send (CTS) line of the host computer. Switching S2 to OFF tells the RS-232 interface to invert the polarity of the RTS line when the controller goes through its power-up sequence. See *Connecting the RS-232 Computer Interface Handshake Lines* on page 65 for more details.

When the controller receives a start bit on the received data line, it will input and buffer a character. The controller will continue to receive and buffer characters until the terminator (LF) is received.

Table 3-10 RS-232 Controller Outputs

Line	Pin	Description	Internal Switch Function	Factory Setting
RTS	2	REQUEST TO SEND: De-asserted by controller on power-up. Asserted by controller upon receipt of a message terminator as a holdoff to prevent the host computer from attempting to transmit data until the message just received has been parsed and a reply has been output. De-asserted after transmitting the terminator of controller's response to that message.	INVERT RTS: When OFF inverts the polarity of the RTS line allowing nonstandard connection directly to host computer CTS line. When ON, set to operate as a modem line per RS–232 standard.	ON

3.13 RS-485 Computer Interface Setup

If your Controller does not have this capability, skip to *Replacing the Controller Cover* on page 47.

RS-485 capability permits data output to, and gauge control by, a host computer. Output is by a command-response mechanism. If you have this module in your unit, configure it to your system requirements by setting the switches as instructed in *Selecting Byte Format for RS-485 Module* on page 46.

A variety of baud rates and byte framing options are available, as well as switches to force the handshake lines to an “always true” condition.

The controller RS-485 factory defaults are: 19.2Kbd, 8 character bits, no parity, 1 stop bit, address = 01.

Internal switches are read upon controller power up. Changes in settings will take effect upon next power-up cycle.

Connector Pinouts for RS-485 Computer Interface

Connectors J1 and J2 on the rear panel are wired in parallel and are interchangeable. Connection can easily be made by “daisy chaining” gauge Controllers together with the signal from the host computer going into one connector then out the other to another gauge Controller, and so on.

The maximum total cable length is 4,000 ft. No more than 32 devices can be connected to one RS-485 communications line. When an RS-485 network is in an idle state, all nodes are in listen (receive) mode. Under this condition there are no active drivers on the network. To maintain the proper idle voltage state, bias resistors must be applied to force the data lines to the idle condition. Figure 3-16 illustrates the placement of bias resistors on a host computer, 2-wire configuration, for the typical 5 volt and 24 volt systems.

Figure 3-13 RS-485 Bias Resistors

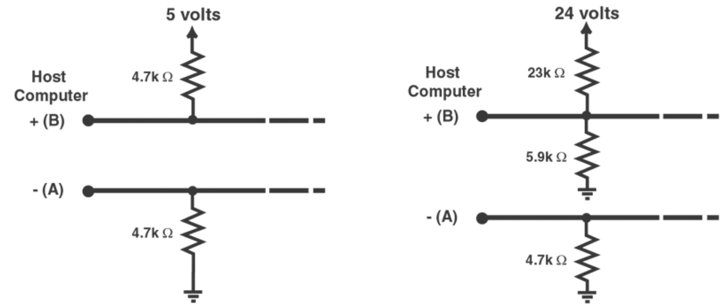


Figure 3-14 RS-485 Wiring Connector

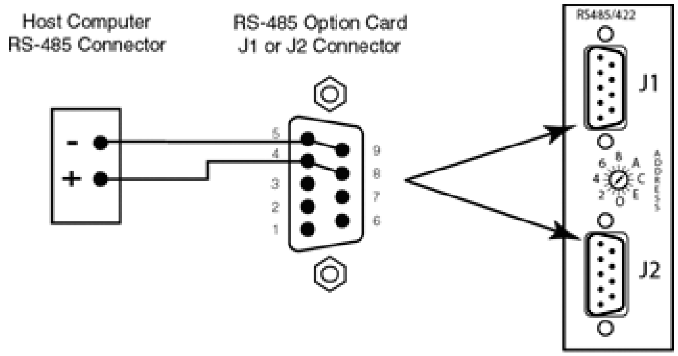


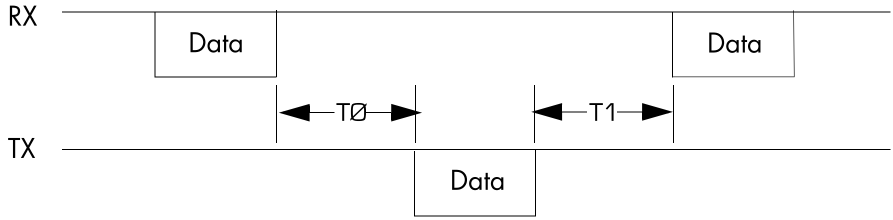
Table 3-11 RS–485 Connector Pins

Signal	Pin Number
+TX	4
–TX	5
+RX	8
–RX	9
Ground	3

1. Connect TX on the gauge Controller to RX on the host computer and connect RX on the gauge Controller to TX on the host computer.
2. Connect TX to TX and RX to RX on all controllers. If the computer sends and receives data on 2 wires, connect +TX to +RX and connect –TX to –RX.
3. The polarity may have to be reversed on the computer and other instruments—you may have to try it both ways. No damage will result if connections are wrong.

The timing of the data transfer is shown in Figure 3-15.

Figure 3-15 RS-485 Data Timing



TØ = 10 to 13 mS + 10 bits with S2.1 OFF.
TØ = 700 µS with S2.1 ON.
T1 = 300 µS minimum.

RS-485 Address

The address switch on the RS-485 module on the back of the Controller (see Figure 3-14) and Switch S1 (see Figure 3-16) determine the RS-485 module's address. This address can be any hex code from 00 to FF.

The address switch on the RS-485 module on the back of the Controller determines the value of the least significant digit and S1 determines the value of the most significant digit. S1 switch positions are binary. The weights of switches when OFF are listed in Table 3-12.

Figure 3-16 RS-485 Module - Top View

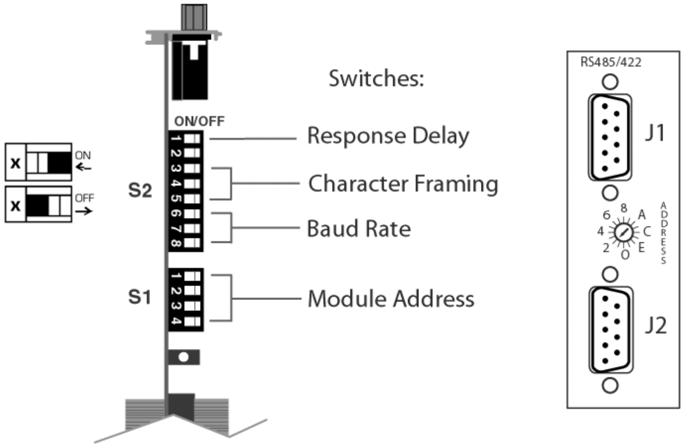


Table 3-12 RS-485 Switch Weight when S1 Switches are set to OFF

S1	Weight
S1.1	10_{hex}
S1.2	20_{hex}
S1.3	40_{hex}
S1.4	80_{hex}

- To prevent data contentions, no two of the controller modules should be set with the same address.
- It is not recommended that address 00 be used because some manufacturers use this address for configuration.

Selecting Byte Format for RS-485 Module

Baud Rate for RS-485

Baud rate for the RS-485 computer interface is determined by S2.6, S2.7, S2.8.

Table 3-13 RS-485 Baud Rates

S2.6	S2.7	S2.8	Baud Rate
On	On	On	19200 (factory setting)
On	On	Off	9600
On	Off	On	4800
On	Off	Off	2400
Off	On	On	1200
Off	On	Off	600
Off	Off	On	300
Off	Off	Off	150

Character Framing for the RS-485 Computer Interface

Character framing for the RS-485 computer interface is determined by S2.3, S2.4, S2.5.

Table 3-14 RS-485 Character Framing

S2.3	S2.4	S2.5	Character Bits	Parity	Stop Bits
On	On	On	8	None	2
On	On	Off	8	Even	1
On	Off	On	8	Odd	1
On	Off	Off	8 (factory setting)	None (factory setting)	1 (factory setting)
Off	On	On	7	Even	1
Off	On	Off	7	Odd	1
Off	Off	On	7	Even	2
Off	Off	Off	7	Odd	2

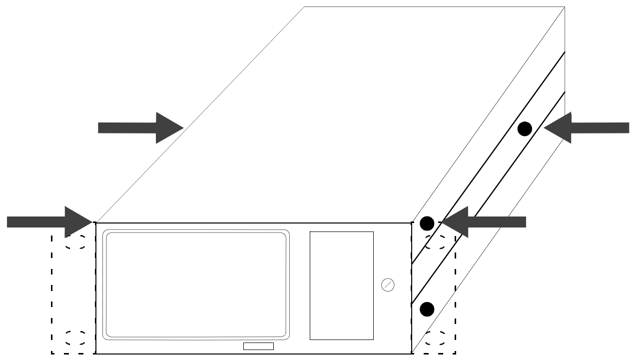
Response Delay for the RS-485 Computer Interface

Switch S2.1 (Figure 3-16 on page 45) enables a delay in the response from the module of 13 MS + 10 bits when OFF. When S2.1 is ON the delay is 700 µS. Default is ON.

3.14 Replacing the Controller Cover

Assuming you have completed the above instructions, the Controller setup is now complete. Replace the top cover. Make sure the door hinge pin is seated correctly. Replace the four top cover Phillips head screws and the side-by-side clamp, if used.

Figure 3-17 Location of Screws forReplacing the Top Cover



Chapter 4 Installation

> **⚠ CAUTION**
>
> **Failure to check system programming before switching to automatic operation can cause measurement error.**
>
> To avoid measurement error due to inaccurate output signals, carefully check the system programming before switching to automatic operation.

> **⚠ WARNING**
>
> **Failure to install appropriate pressure relief devices for high–pressure applications can cause product damage or personal injury.**
>
> For automatic backfilling and other applications in which malfunction or normal process conditions can cause high pressures to occur, install appropriate pressure relief devices.

4.1 Gauge Installation Tips

For best results locate pressure gauges close to the point where pressure needs to be measured. Gas sources, long tubulation or other constrictions can cause large errors in indication. Note that if placed near the pump, the pressure in the gauge may be considerably lower than in the rest of the system. If placed near a gas inlet or source of contamination, the pressure in the gauge may be much higher. See Section 4.9 on page -53 for detailed gauge mounting instructions.

To minimize temperature effects, locate pressure gauges away from internal and external heat sources in a region where the ambient temperature is reasonably constant.

Parts of the gauge can get quite hot during degassing, especially if there is poor ventilation. This will not damage the gauge. However, care should be taken to prevent low temperature rated materials such as plastic wire insulation from touching hot parts of the gauge.

4.2 FCC and EU Installation Requirements

To maintain compliance with FCC Part 15 rules and European Union’s electromagnetic interference (EMI) directives, install shielded cable with a braided shield and metal or metallized plastic backshells that connect directly to the cable shield at the 15-pin I/O connector. Connect the shield to ground at your equipment. Failure to install the controller as described above can result in failure of the controller to the requirements for radiated emissions and susceptibility.

4.3 Cable Installation

It is intended that all wiring either to or from the controller, whether supplied by Brooks Automation, Inc. or not, be installed in accordance with the safety requirements of NEC/NFPA 70. Cables provided by Brooks Automation for connection to sensors or transducers is, at a minimum, designed for use as appliance wiring material (UL category AVLV2), and is constructed of appropriate material and dimensions for the voltages and currents provided by the controller. It is emphasized that it is the user's responsibility to install cables to/from the controller whether provided by Brooks Automation, Inc., or not, in accordance with the applicable local, state and national safety requirements.

Raceway and/or conduit may be needed for certain installations.

4.4 Environmental Conditions

- Indoor Use.
- Altitude up to 2000 meters.
- Temperature 0 °C to 50 °C.
- Maximum relative humidity 80% for temperatures up to 31 °C decreasing linearly to 50% relative humidity at 50 °C.
- Transient overvoltages according to installation category (overvoltage category) II.
- Pollution degree 2 in accordance with IEC664.

4.5 Controller Installation

The controller is designed to operate a Series 355 Micro-Ion Gauge. This is an all-metal miniature gauge with dual yttria-coated iridium or dual tungsten filaments and a nominal sensitivity of 20/Torr.

The Micro-Ion Gauge electrometer module provides ion gauge pressure readout from 1×10^{-10} Torr (1.3×10^{-10} mbar or 1.3×10^{-8} pascal) to 5×10^{-2} Torr, N_2 equivalent, depending on the emission current used.

Adjustment is provided for gauge sensitivity. See *Gauge Electrometer Operation* on page 98. Adjustment and an internal switch allow change to mbar or pascal pressure units, and a user selectable “slow update” feature triggers measurement averaging, resulting in a display update frequency of about once every three seconds. The overpressure shutdown threshold is internally adjustable.

1. Provide adequate ventilation for the Controller to dissipate 15 W.
2. Do not mount the Controller above other equipment that generates excessive heat.
3. This product is designed to operate over the range 0 to 50 °C. Ambient temperatures above 50 °C may damage the product. For optimum electrometer calibration stability, the Controller ambient temperature should be 25 ±5 °C.

Table 4-1 Installation Hardware Part Numbers

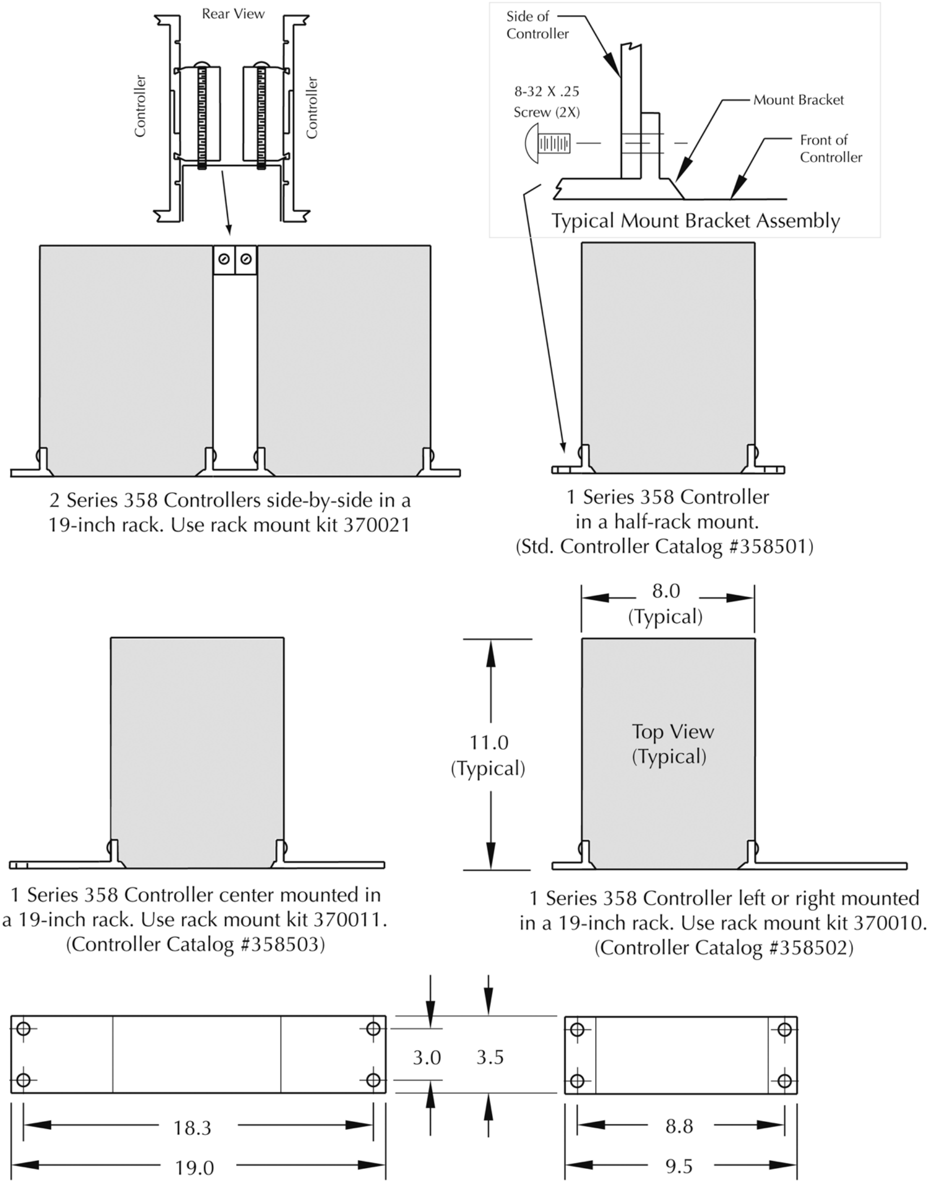
Adapter Hardware Description	Mounting Hardware Part Number	Series 358 Controller Catalog Number
To mount the Controller only on the left side of a 19 inch rack	370010	358502
To mount the Controller in the center of 19 in. rack	370011	358503
To mount two Controllers side-by-side in a 19 in. rack	370021	
To mount 1/2-rack (Standard)	N/A	358501

4.6 Mounting Configurations

Figure 4-1 illustrates the various configurations available for mounting the controller. The standard mounting configuration is 1/2-rack mount (358501). Other configurations are available using the mounting hardware kits listed in Table 4-1, and shown in Figure 4-1. Contact a Brooks Automation/Granville-Phillips Customer Service Representative for specail mounting configurations. See page 4 of this instruction manual for more information and catalog numbers.

The controller should be mounted in a location with free air flow and ambient temperature less than 50 °C.

Figure 4-1 Controller Mounting Configurations



Series 358 Micro-Ion Gauge Controller Mounting Configurations.
Dimensions are in Inches. Not to scale.

4.7 Line Voltage

The controller will operate over a line voltage range of 100 to 240 VAC, 50 to 60 Hz. All that is required is that a line cord be selected to match your available power receptacle to the power input connector located on the rear of the Controller.

Fuse type: 5 x 20 mm time lag (T); low breaking capacity
1.6 A, 250 V; manufacturer, Schurter, Part No. FST034.3119

Replacement fuses are available from Brooks Automation, Inc. Contact information is provided in the Service section, on page 3, and the back cover of this instruction manual.

4.8 Fuse Replacement

1. On the rear panel, turn the power switch OFF and unplug the power cord.
2. Use a flat tip screwdriver (or similar tool) to turn the fuseholder counterclockwise.
3. Pull out the fuseholder, then remove and replace the fuse.
4. Insert the fuseholder and turn clockwise to lock position.
5. Plug in the power cord and turn the power switch ON.

4.9 Vacuum Gauge Installation

The following information pertains to the the proper installation of a Micro-Ion Gauge, a Convectron Gauge, and a capacitance manometer gauge. The gauges are illustrated in Figure 2-1 on page 13, and the cable connectors are illustrated in Figure 2-5 on page 17.

The Series 358 Micro-Ion Vacuum Gauge Controller is capable of operating a Micro-Ion gauge located up to 50 feet away, and Convectron Gauge located up to 200 feet away by using standard cables provided by Brooks Automation, Inc./Granville-Phillips.

After the gauges are installed on the chamber, be sure the system is properly grounded as outlined in Section 4.11 on page -55 and Figure 4-3 on page 58.

- Cleanliness pays. Keep the port cover in place until moments before installation.
- Do not mount a vacuum gauge in a manner such that deposition of process vapors upon the internal surfaces can occur through line-of-sight access to its interior. If condensates may be present, orient the port downward to help liquids drain out.
- For proper operation above about 1 Torr, install Convectron gauges with the gauge axis horizontal. To minimize pressure indication errors, avoid installing the Convectron gauge where it will vibrate. Vibration causes convection cooling of the sensor and will cause the pressure indication to be high.

- Physical dimensions of Micro-Ion and Convectron Gauges are shown in Figure 2-9 on page 24 and Figure 2-10 on page 24.
- Mounting clearance dimensions for Convectron Gauges are shown in Figure 4-2.

4.10 Mounting Options

Compression Mount/Quick Connect

Do not use for positive pressure applications. The gauge may be forcefully ejected.

The gauge port is designed to fit a standard 1/2 in. compression/quick connect mounting such as an Ultra-Torr® fitting.

Remove the caplug from the gauge tube port, insert the gauge tube port into the compression fitting and finger tighten the press ring. If a seal is not achieved it may be due to extreme cleanliness of the O-ring. A light film of vacuum grease such as Apiezon® grease will ensure sealing and is normally preferable to the use of pliers or pipe wrench to further tighten the press ring. You may point the electrical pins of the gauge tube anywhere you wish in a 360° horizontal circle for optimum routing of the gauge tube cable.

1/8 NPT Mount

Fits standard 1/8 NPT female fitting. Wrap the threads of the gauge port with Teflon® tape and hand tighten. Do not use a wrench or tool. Tighten only sufficiently to achieve a seal.

VCR®/VCO Mount

Remove the plastic or metal bead protector cap from the bead. When using gasket, place it into the female nut where applicable. Assemble components and snug finger-tight. While holding a backup wrench stationary, tighten the female nut 1/8 turn past finger-tight for 316 stainless steel and nickel gaskets; or 1/4 turn past finger-tight for copper and aluminum gaskets.

NW10KF, NW16KF, NW25KF and NW40KF Flange Mount

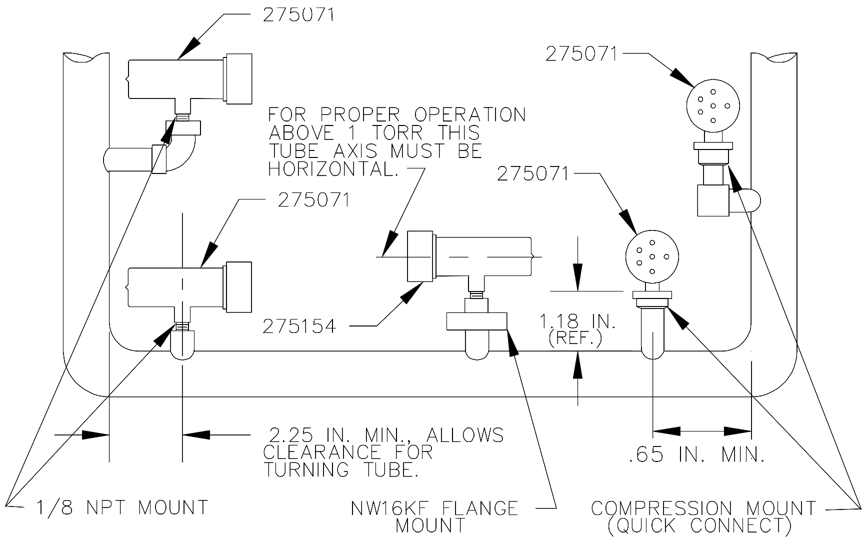
The KF mounting system requires an O-ring and centering ring to be placed between the mating flanges. The flanges are then held together with the aluminum flange clamp by tightening the wing nut. Maximum pressure for this style mounting system is 1000 Torr absolute.

ConFlat Flange Mount

To minimize possibility of leaks with ConFlat flanges, use high strength stainless steel bolts and a new, clean OFHC copper gasket. Avoid scratching the seal surfaces. To avoid contamination, do not use nonmetal gaskets.

After finger tightening all bolts, continue tightening about 1/8 turn in crisscross order, e.g., 1, 4, 2, 5, 3, 6, 4 . . . until flanges are in contact. After contact, further tighten each bolt about 1/16 turn.

Figure 4-2 Convectron Gauge Installation



4.11 Grounding the System

When high voltages are used within the vacuum system and the gauge envelope is not reliably grounded through its vacuum connection, either a separate ground wire must be added, or the envelope must be shielded to positively prevent human contact. The gauge envelope may be grounded byusing a metal hose clamp on the gauge connected by a #12 awg copper wire to the grounded vacuum chamber. See Figure 4-3.

⚠ WARNING

Improper grounding can cause product damage or personal injury.

Follow ground network requirements for the facility.

- Maintain all exposed conductors at earth ground.
- Connect the power cord to a properly grounded outlet.
- Make sure the vacuum port to which the gauge is mounted is properly grounded.
- Connect the gauge envelope to a facility ground. If necessary, use a ground lug on the flange bolt.

High voltage can couple through a gas to the internal electrodes of a gauge. Do not touch the exposed pins on any gauge installed on a vacuum system where high voltage is present.

WARNING

Touching the pins on the gauge in a high–voltage environment can cause an electrical discharge through a gas or plasma, resulting in property damage or personal injury due to electrical shock.

Vent the vacuum chamber to atmospheric pressure and shut OFF power to the controller before you touch the pins on the gauge.

1. Connect a heavy duty ground wire #12 AWG or larger from the ground lug on the back of the Controller to your facility grounding electrode system (see item 3 on Figure 2-5 on page 17). This will provide an earth ground for the Controller in the event the interconnect cables are not in place. Do not connect the ground lug to the vacuum system or other component. Connect it directly to the facility grounding system such as a grounded outlet box or a grounded copper water supply pipe. Do not rely on small metal water lines to ground a component. Later on someone may replace the metal tubing with plastic tubing thus unwittingly causing a potentially dangerous situation.
2. Provide a connection to ground for other instruments with electrodes in the vacuum system possibly exposed to high voltage electrical discharges.
3. Provide a connection to ground for each ungrounded metal component in, on or around the vacuum system, including the gauge envelopes, which personnel may touch and which can potentially be exposed to high voltage electrical discharges within the vacuum system. For example, a metal bell jar resting on an organic O-ring must be connected to ground if a Micro-Ion gauge is to be used or if other high voltage sources are present in the vacuum system.

System Ground Test Procedure

- Physically examine the grounding of both the controller and the vacuum chamber to assure that all exposed conductors of the system are properly grounded.
- Note that a horizontal “O” ring or “L” ring gasket, without metal clamps, can leave the chamber above it electrically isolated.
- Power can be delivered to mechanical and diffusion pumps without any ground connections to the system frame or chamber.
- Water line grounds can be lost by a plastic or rubber tube interconnection. What was once a carefully grounded vacuum system can, by innocent failure to reconnect all ground connections, become a very dangerous device.

Procedure for Testing Grounding of Systems

Use the following procedure to test each of your vacuum systems that incorporate an Micro-Ion gauge.

This procedure uses a conventional volt-ohm meter (VOM) and a resistor (10 Ω, 10 W).

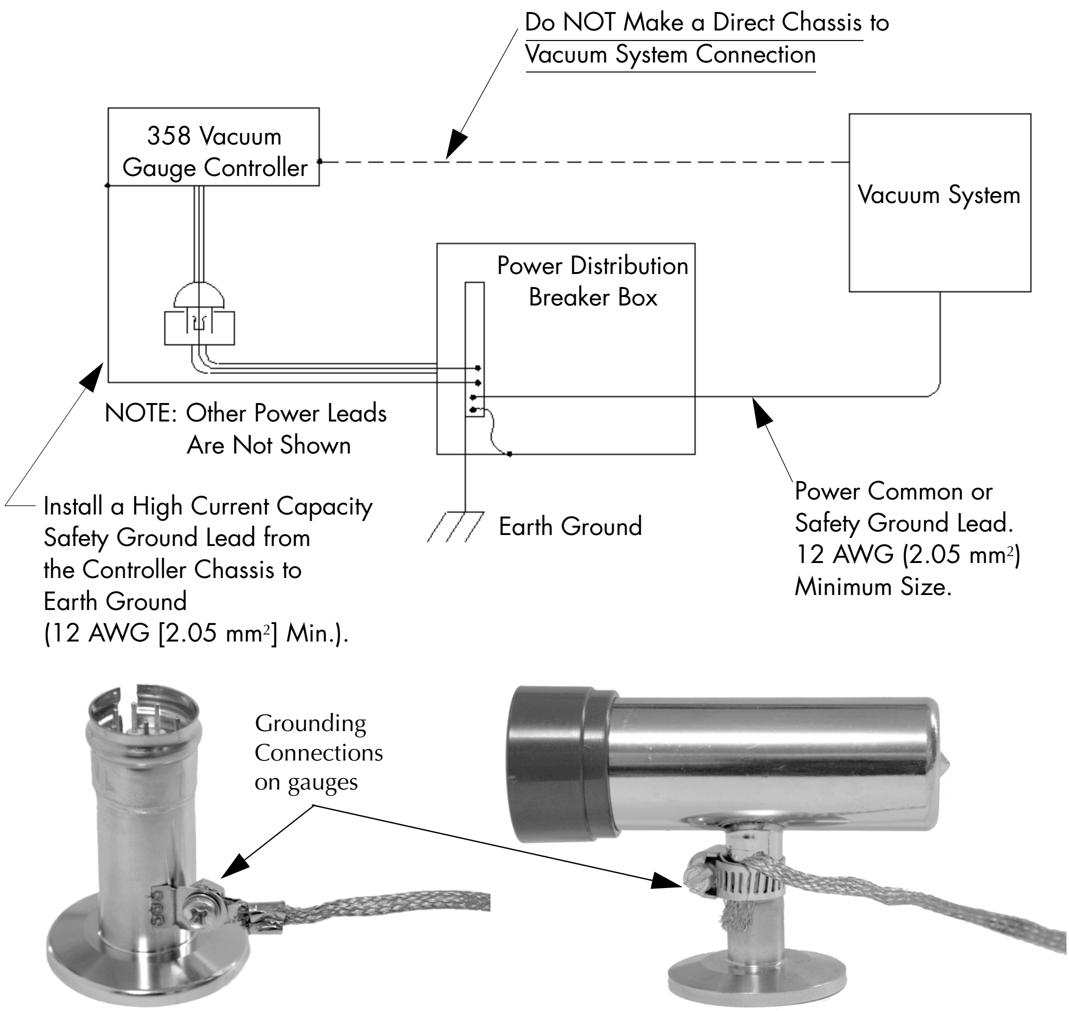
1. With the Controller turned OFF, test for both DC and AC voltages between the metal parts of the vacuum chamber and the power supply chassis.
2. If no voltages exist, measure resistance. The resistance should not exceed 2 Ω. Two ohms or less implies commonality of these grounds that should prevent the plasma from creating a dangerous voltage between them. This test does not prove that either connection is earth ground, only that they are the same. If more than 2 Ω is indicated, check with your electrician.
3. If AC or DC voltages exist and are less than 10 V, shunt the meter with a 10 Ω, 10 W resistor. Repeat the voltage measurement. With the shunt in place across the meter, if the voltage remains at 83% or more of the unshunted value, commonality of the grounds is implied. Repeat the measurements several times to be sure that the voltage ratio is not changing with time. If the condition in the following equation exists, this should prevent the plasma from creating a dangerous voltage between these grounds. If more than 10 V exists between grounds, check with your electrician.

$$\frac{\text{Voltage (shunted)}}{\text{Voltage (unshunted)}} = 0.83 \text{ or more}$$

4. If the voltage calculation in Step 3 is less than 0.83, due to the placement of the shunt, it complicates the measurement. The commonality of the grounds may be satisfactory and the coupling poor, or the commonality could be poor! Your electrician should be asked to check the electrical continuity between these two ground systems.

NOTE: The placement of a second ground wire, (dashed line in Figure 4-3), between the vacuum chamber and the controller chassis is not a safe grounding procedure. Large currents could flow through it.

Figure 4-3 System Grounding



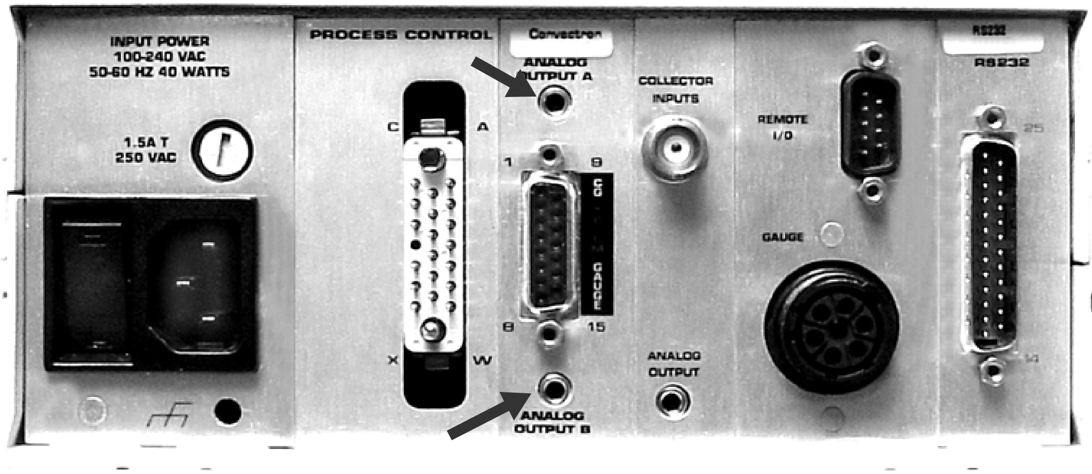
4.12 Connecting Analog Outputs

Electrometer Module Analog Output Signal

This voltage is proportional to the logarithm of the pressure, scaled to 1 V per decade with 0 V at 1 x 10^{-11} Torr. When the Micro-Ion gauge is turned OFF, the output will switch to slightly over +10 V. See Figure 5-5 on page 70.

A standard 1/8″ miniature phono jack connector is supplied.

Figure 4-4 Convectron Gauge Analog Output Connector



Convectron Gauge Analog Output Signal

If you have Convectron gauge capability installed, signal voltages proportional to the logarithm of the Convectron gauge display indications are provided on the back of the Convectron gauge module via a standard 1/8″ miniature phono jack. See Figure 4-4. Two mating connectors are supplied with this capability. See *Convectron Gauge Analog Output Signal* on page 82 pertaining to the characteristics of these signals.

An analog output jack is provided on the rear panel. This is a DC voltage proportional to the logarithm of the pressure, scaled to 1 V per decade:

0 V = 1 x 10^{-4} or less, Torr or mbar, 1 V = 1 x 10^{-3}, etc.

For pascal units, the analog output will be scaled to 0 V = 1 x 10^{-2} pascal.

Internal offset adjustments are provided that allow a shift in the analog output at 1 x 10^{-4} Torr away from 0 V to anywhere in the range –7 to +1 V. This adjustment does not affect the slope of the analog output vs pressure curve.

4.13 Connecting a Capacitance Manometer

If you have a Capacitance Manometer capability installed, signal voltages are provided on the back of the Convectron Gauge module via a standard 1/8 in. miniature phone jack - the Analog Output B port shown in Figure 4-4. Two mating connectors are supplied with this capability.

The wires provided for the capacitance manometer are terminaed as bare wires. Refer to the documentation provided with the capacitance manometer for connection instructions. Be sure to protect all unused leads from shorting.

Figure 4-5Capacitance Manometer PCB

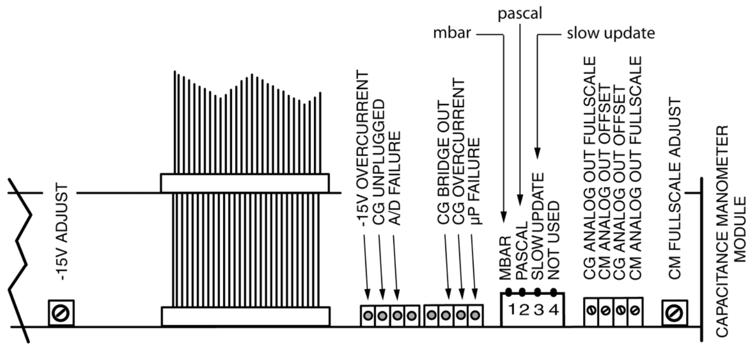
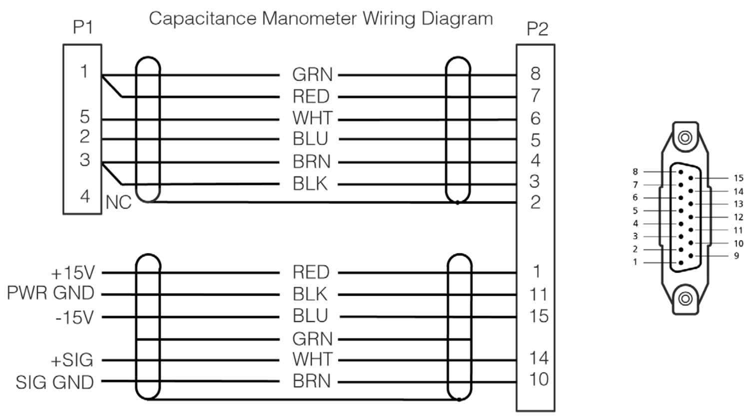


Figure 4-6 Capacitance Manometer Wiring Diagram



Capacitance Manometer Analog Output Signal

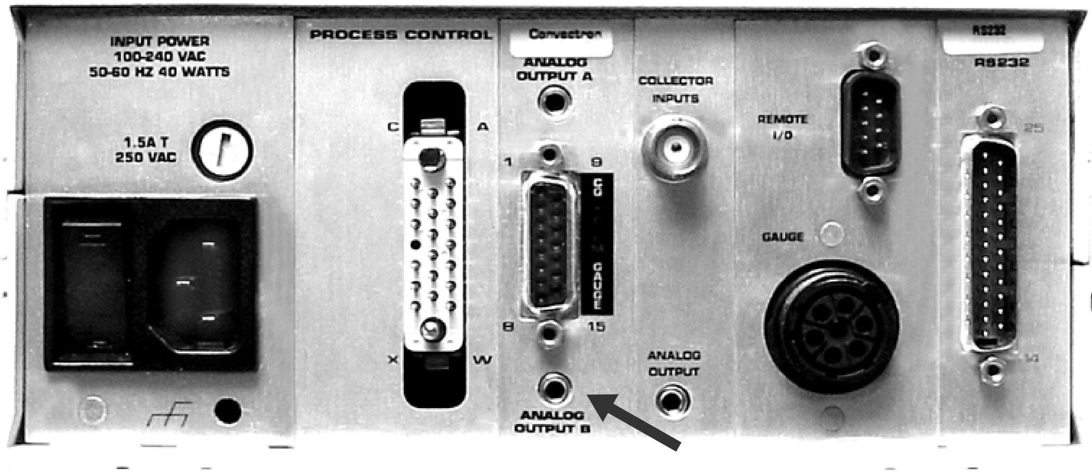
The analog output for the capacitance manometer is a dc voltage proportional to the pressure with a range of 0 to 10 volts, proportional to the transducer output. Refer to the documentation provided with your transducer for a description of this output.

Internal adjustments are provided for zero offset and full-scale (gain) control.

Capacitance Manometer Analog Output Offset Adjustment

Adjust the *CM Analog Output Offset* potentiometer (Figure 4-5) to set the analog output "B" at Base pressure. The output can be adjusted between -0.2 and +0.2 volts at Base pressure for the capacitance manometer.

Figure 4-7 Analog Output Connectors A and B



Capacitance Manometer Analog Output Full-scale Adjustment

There are 4 switch selections for the maximum output range of the capacitance manometer gauge. Use the selection switch on the front panel of the 358 Controller (See Figure 5-15 on page 84) to select the maximun pressure to match the capacitance manometer transducer on your system. See Table 4-2.

The analog output full scale adjustment is a span or gain control, with a range of 0.93 to 1.3. The factory setting is for a gain of 1.0, thus 10 volts in from the transducer (maximum readable pressure) = 10 volts out at the factory setting.

Table 4-2 Capacitance Manometer Analog Output Voltage/Pressure

Volts	Pressure Torr	Pressure Torr	Pressure Torr	Pressure Torr
	1000 Torr Head	100 Torr Head	10 Torr head	1Torr Head
10	1000	100	10	1
1	100	10	1	.1
.1	10	1	.1	.01
.01	1	.1	.01	.001

Pressure = Volts multiplied by Scaling #
P = V x 100 (1000 Torr Head)
P = V x 10 (100 Torr Head)
P = V x 1 (10 Torr Head)
P = V x .1 (1 Torr Head)

Capacitance Manometer Full-scale Adjustment

The full-scale adjustment potentiometer (Figure 4-5) controls the full-scale readout of the capacitance manometer display. The control is adjusted at the factory for a full-scale display with an input of 10.0 volts. After zeroing the Controller as described above, the Controller can be calibrated to the transducer by adjusting the full-scale adjust potentiometer so the Controller display corresponds to the pressure of the manometer at or near the maximum pressure.

This reference pressure may be determined by a certified standard gauge, a dead weight calibration system, or a standard voltage reference. The full-scale adjust potentiometer and the CM analog out full-scale potentiometer do not interact and can be adjusted independently.

4.14 Connecting Process Control Relays

For instructions for setting up this module, see *Process Control Setup* on page 32.

The process control connector is embossed with letters identifying corner pins. Table 4-3 shows the letters designating the 3 pins assigned to each of the 6 setpoint channels.

Figure 4-8 Process Control Output Connector

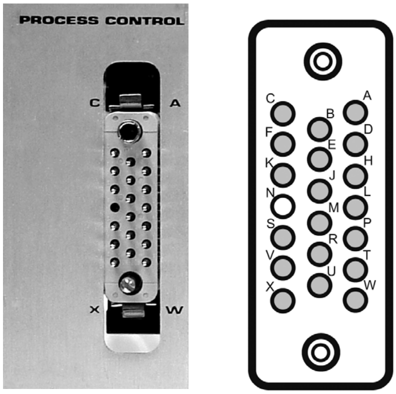


Table 4-3 Process Control Output Connector Pin Assignments

Process Control Channel	Micro-Ion Gauge		Convectron Gauge A		Convectron Gauge B	
	1	2	3	4	5	6
Common (or Pole)	W	H	M	C	J	S
Normally Closed (NC)	P	A	U	K	B	X
Normally Open (NO)	T	D	R	F	E	V
CHASSIS GND – PIN L		NO CONNECTION – PIN N				

A mating connector is supplied in the hardware kit.

CAUTION

Failure to check system programming before switching to automatic operation can cause measurement error.

To avoid measurement error due to inaccurate output signals, carefully check the system programming before switching to automatic operation.

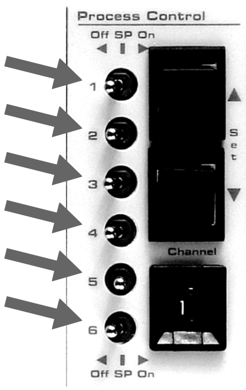
⚠ WARNING

Failure to install appropriate pressure relief devices for high–pressure applications can cause product damage or personal injury.

For automatic backfilling and other applications in which malfunction or normal process conditions can cause high pressures to occur, install appropriate pressure relief devices.

1. Using Figure 4-8 and Table 4-3, and circuit schematics you have prepared, make up a cable to connect the various system components which are to be controlled. Unambiguous labeling of each lead will help prevent costly mistakes.
2. Ensure that the Process Control channel override switches are all set to OFF.
3. Connect the component end of the cable to the system component to be controlled.
4. Plug the connector into the back of the Controller.
5. Refer to *Preparing for Process Control Operation* on page 85 for instructions for setting setpoints.

Figure 4-9 Override Switches



4.15 Connecting the RS-232 Computer Interface Handshake Lines

For instructions for setting up this interface, see *RS-232 Computer Interface Setup* on page 37.

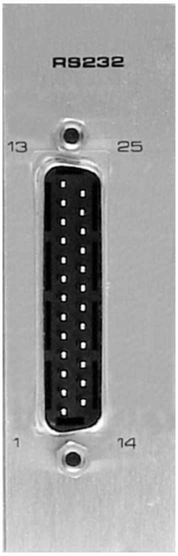
The DTR line is set true on power up to indicate it is on line. When the controller receives a start bit on the received data line it will input and buffer a character. The DCD line must be true at the time each character is received or that character will be ignored. The controller will continue to receive and buffer characters until the terminator (LF) is received.

Upon receiving the terminator, the controller will assert the RTS line as a holdoff, to prevent the host computer from attempting to transmit further data until the message just received has been decoded and a reply has been output.

During output of the reply, the incoming handshake lines CTS, and DSR are tested prior to beginning transmission of each character. The controller will wait until both are true before beginning transmission of a character, and will not test them again until ready to begin transmitting the next character.

After transmitting the terminator, the controller will negate RTS and wait for the next incoming message.

Figure 4-10 Controller Rear Panel with RS-232 Option



RS-232 Handshake Line Summary

CTS, DSR

Set the computer to indicate that controller may output the next byte in its message. As shipped from the factory these lines are forced "TRUE" by the switch settings of the controller RS-232 printed circuit board. Thus the controller will automatically assume the host is ready to receive. See Figure 3-12 on page 39 for the location of these switches.

DCD

Tested by controller when a character is received. The character will be ignored unless DCD is "TRUE". As shipped from the factory, this line is forced "TRUE" by the switch settings.

DTR

Always asserted by the controller. A "power ON" indication.

RTS

Negated by the controller on power-up. Asserted by the controller upon receipt of a message terminator. Negated after transmitting the terminator of the controller's response to that message.

Reversing RTS Polarity

If switch 2 is open on power-up, the controller will apply the opposite polarity to RTS from that described above. When used in this mode, RTS may be connected to the CTS input of the host computer. This violates the RS-232 standard, but is a commonly used implementation.

4.16 Connecting RS-485 Computer Interface

For instructions for setting up this interface, see *RS-485 Computer Interface Setup* on page 42.

Connectors J1 and J2 on the rear panel of the controller (Figure 3-16) are wired in parallel and are interchangeable. Connection can easily be made by "daisy chaining" gauge Controllers together with the signal from the host computer going into one connector then out the other to another gauge Controller and so on.

The maximum total cable length is 4000 ft. The maximum number of devices connected is 32.

The control of data over the RS-485 interface is handled by a Half-duplex Command/Response mechanism.

Chapter 5 Preparing for Operation

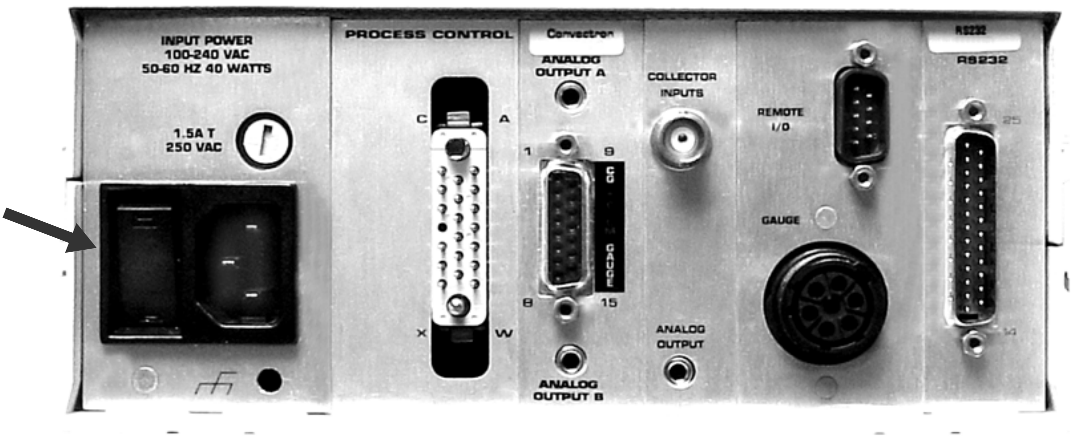
5.1 Preparing for Pressure Measurement

Before preparing to operate the controller, make sure that:

- the controller has been properly set up and installed per the instructions in *Chapter 3* and *Chapter 4*,
- the gas in your vacuum system is air or N_2. For other gases you must follow the instructions in *Preparing for Convectron Gauge Operation* on page 71 for using Convectron gauges, and
- you are reasonably familiar with the general theory of operation of hot cathode Micro-Ion gauges and thermal conductivity gauges.

1. Turn ON the controller by pressing the power switch labeled ON. See Figure 5-1.

Figure 5-1 Power ON/OFF Switch



2. Convectron gauge equivalent N_2 pressures will be displayed whenever power is applied if the gauges and cables are installed. See *Preparing for Convectron Gauge Operation* on page 71 for information on Convectron gauge pressure measurement.
3. The N_2 equivalent pressure within the Micro-Ion Gauge will be displayed in the pressure units you have specified (Torr, mbar or pascal). See *Pressure Units Setup* on page 28 to change pressure units.

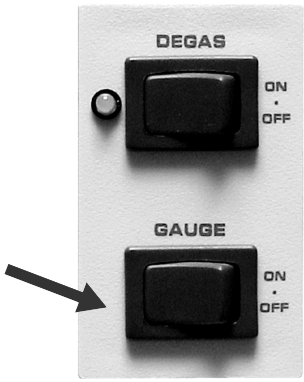
5.2 Alternate ON/OFF Gauge Control

The Micro-Ion Gauge can be turned ON and OFF in the following ways:

- Use the front panel Micro-Ion Gauge “momentary” GAUGE ON/OFF switch. See Figure 5-2.
- Automatically via the Auto ON function of the Convectron gauge module. See *Filament Auto ON* on page 80.
- Use the RS-232 or RS-485 Computer Interface modules. See *Command Syntax for RS-232 Computer Interface* on page 88 or *Command Syntax for RS-485 Computer Interface* on page 91.
- The ON/OFF toggle from the Remote Input/Output Connector. See *Micro-Ion Gauge Remote Input/Output* on page 68.

In addition, the Micro-Ion Gauge will be automatically turned OFF by excessive pressure.

Figure 5-2 Micro-Ion Gauge Momentary ON/OFF Switch

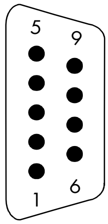


5.3 Micro-Ion Gauge Remote Input/Output

Two TTL compatible inputs are provided through the rear panel allowing control of the Micro-Ion gauge and degas. The function of the front panel keys is reproduced by either a contact closure or an asserted low (0V) logic state on these inputs. This low state must be held continuously at <0.4V@10µA (LOW) for at least 25 milliseconds. After this, the input must be allowed to pull high to >3.5V(HIGH) for at least 105 milliseconds before another low will be accepted. These inputs have passive pull-ups to +5 V internal supply.

A single-pole, double-throw relay is provided to indicate Micro-Ion gauge status (normally open contact is open when the Micro-Ion gauge is OFF).

Figure 5-3 Input/Output Wiring Connector



See Figure 2-5, Item #10

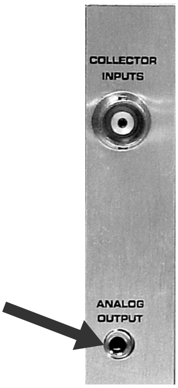
Table 5-1 Remote Input/Output Pin Functions

Pin Number	Function	Pin Number	Function
1	Gauge On/Off Remote*	6	Degas On/Off Remote*
2	Ground	7	Ground
3	Not Used	8	Not Used
4	Gauge Status Common	9	Gauge Status N.O. (Normally Open)
5	Gauge Status N.C. (Normally Closed)		
*Active low inputs			

5.4 Micro-Ion Analog Output Signal

A signal voltage proportional to the logarithm of the Micro-Ion pressure indication is provided on the back of the electrometer module via a standard 1/8 in. miniature phono jack.

Figure 5-4 Electrometer Analog Output Jack



Normal Measurement Operation

Pressure indication:
Pi = 10^{V-11} Torr or mbar
Pi = 10^{V-9} pascal

When Degassing

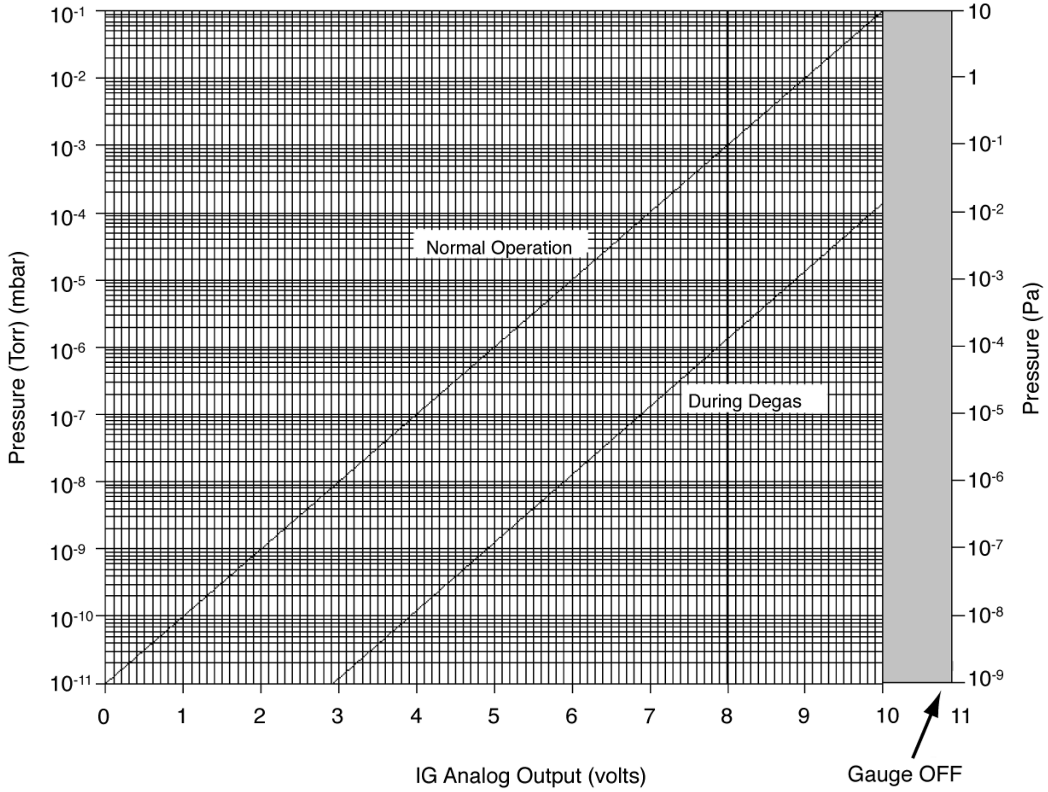
Pressure indication:
Pi = 10 $V^{-13.92}$ Torr or mbar
Pi = 10 $V^{-11.92}$ pascal

When the gauge is OFF

V = 11 volts

This signal voltage is determined by the pressure indicated on the Micro-Ion Gauge display.

Figure 5-5 Micro-Ion Gauge Analog Output Versus Pressure



5.5 Preparing for Convectron Gauge Operation

Convectron Gauge pressures are indicated on lines A and B of the Controller display.

> **⚠ WARNING**
>
> **Failure to use accurate pressure conversion data for N_2 or air to other gases can cause an explosion due to overpressurization.**
>
> If the controller will measure any gas other than N_2 or air, before connecting the controller to system control devices, adjust pressure outputs for the process gas that will be used.

Install suitable devices that will limit the pressure to the level that the vacuum system can safely withstand. In addition, install suitable pressure relief valves or rupture disks that will release pressure at a level considerably below that pressure which the system can safely withstand.

Suppliers of pressure relief valves and pressure relief disks are listed in the Thomas Register under "Valves, Relief", and "Discs, Rupture."

Confirm that these safety devices are properly installed before installing the product. In addition, check that (1) the proper gas cylinders are installed, (2) gas cylinder valve positions are correct on manual systems, and (3) the automation is correct on automated systems.

Vacuum gauges with compression fittings may be forcefully ejected if the vacuum system is pressurized.

5.6 Gases other than Nitrogen or Air

Convectron Gauges are thermal conductivity gauges of the Pirani type. These gauges transduce gas pressure by measuring the heat loss from a heated sensor wire maintained at constant temperature. For different gases, the heat loss is different at any given true pressure and thus the pressure indication can be very different.

It is important to understand that the indicated pressure of a Convectron gauge depends on the type of gas, the orientation of the gauge axis, and on the gas density in the gauge. Convectron gauges are normally supplied calibrated for N_2 (air has approximately the same calibration). With proper precautions, the Convectron gauge may be used to measure pressure of certain other gases.

The following information in this section applies only when the Convectron Gauge has been calibrated for N_2 and when the Convectron Gauge is mounted with its axis horizontal.

At pressures below a few Torr, there is no danger in measuring pressure of gases other than N_2 and air, merely inaccurate indications. A danger arises if the N_2 calibration is used without correction to measure higher pressures of some other gases. For example, N_2 or air at 24 Torr causes the same heat loss from the Convectron sensor as will argon at atmospheric pressure. Thus if the pressure indication of the Convectron gauge is not properly corrected for argon, an operator attempting to fill a vacuum system with 1/2 atmosphere of argon would observe an indication of only 12 Torr when the actual pressure had risen to the desired 380 Torr. Continuing to fill the system with argon to 760 Torr would result in only a 24 Torr indication. Depending on the pressure of the argon gas source, the chamber could be dangerously pressurized while the display continued to read about 30 Torr of N_2 equivalent pressure.

The same type of danger likely exists with other thermal conductivity gauges using convection to extend the range to high pressures; and with Convectron gauges calibrated for gas type Y when used with gas type X.

Understand that, with a Convectron Gauge calibrated for N_2, to measure the pressure of gases other than N_2 and air you must use the conversion curves specifically for the Convectron Gauge to translate between indicated pressure and true pressure. Do not use other data. Never use conversion curves for the Convectron Gauge with gauges of other manufacturers. Their geometry is very likely different and dangerously high pressures may be produced even at relatively low pressure indications. Also, you must ensure that the atmosphere adjustments for Convectron Gauges A and B are correctly set. See *Gauge Zero and Atmospheric Pressure Adjustment* on page 81.

Figure 5-6 through Figure 5-11 show the true pressure verses indicated pressure for eleven commonly used gases. The following list will help to locate the proper graph:

Table 5-2 True Pressure vs. Indicated N_2 Pressure

Figure and Page	Pressure Range and Units	Gases
Figure 5-6 on page 74	10^{-4} to 10^{-1} Torr	All
Figure 5-7 on page 75	10^{-1} to 1000 Torr	Ar, CO_2, CH_4, Freon 12, He
Figure 5-8 on page 76	10^{-1} to 1000 Torr	D_2, Freon 22, Kr, Ne, O_2
Figure 5-9 on page 77	10^{-4} to 10^{-1} mbar	All
Figure 5-10 on page 78	10^{-1} to 1000 mbar	Ar, CO_2, CH_4, Freon 12, He
Figure 5-11 on page 79	10^{-1} to 1000 mbar	D_2, Freon 22, Kr, He, O_2

Note that 1 mbar = 100 pascal, so the mbar charts may be used for pascal units by multiplying the values on the axes by 100.

A useful interpretation of these curves is, for example, that at a true pressure of 2×10^{-2} Torr of CH_4 the heat loss from the sensor is the same as at a true pressure of 3×10^{-2} of N_2. See Figure 5-6 on page 74. The curves at higher pressure vary widely from gas to gas because the thermal losses at higher pressures are greatly different for different gases.

If you must measure the pressure of gases other than N_2 or air, use Figure 5-6 through Figure 5-11 to determine the maximum safe indicated pressure for the other gas as explained below.

Examples

Maximum safe indicated pressure

Assume a certain system will withstand an internal pressure of 2000 Torr or 38.7 psia. For safety, you want to limit the maximum internal pressure to 760 Torr during backfilling. Assume you want to measure the pressure of Freon 22. In Figure 5-8 on page 76, locate 760 Torr on the left hand scale, travel to the right to the intersection with the Freon 22 curve, and then down to an indicated pressure of 11 Torr (N_2 equivalent). Thus, in this hypothetical situation, the maximum safe indicated pressure for Freon 22 is 11 Torr.

For the sake of safety, it is prudent to place a warning label on the instrument face which under the assumed conditions would read “DO NOT EXCEED 11 TORR FOR FREON 22".

If the Convectron gauge calibration is for a gas type other than N2 (or air), we suggest placing a label near the second and third lines of the display indicating the gas type or types used for calibration to prevent mix-ups.

Indicated to true pressure conversion

Assume you want to determine the true pressure of helium in a system when the Convectron Gauge is indicating 10 Torr. In Figure 5-7 on page 75, read up from 10 Torr (N_2 equivalent) indicated pressure to the Helium curve and then horizontally to the left to a true pressure of 4.5 Torr. Thus 4.5 Torr Helium pressure produces an indication of 10 Torr (N_2 equivalent).

True to indicated pressure conversion

Assume you want to set a process control setpoint at a true pressure of 20 Torr of CO_2. In Figure 5-7 on page 75, locate 20 Torr on the true pressure scale, travel horizontally to the right to the CO_2 curve and then down to an indicated pressure of 6.4 Torr (N_2 equivalent). Thus the correct process control setting for 20 Torr of CO_2 is 6.4 Torr (N_2 equivalent).

True to indicated pressure conversion

Assume you want to obtain a helium pressure of 100 Torr in the system. In Figure 5-7 on page 75, locate 100 Torr on the left hand scale, travel horizontally to the right to attempt to intersect the He curve. Because the intersection is off scale, it is apparent that this true pressure measurement requirement for helium exceeds the capability of the instrument.

For gases other than those listed, the user must provide accurate conversion data for safe operation. The Convectron gauge is not intended for use above approximately 1000 Torr true pressure.

Figure 5-6 True Pressure versus Indicated Pressure for Commonly used Gases, 10^{-4} to 10^{-1} Torr

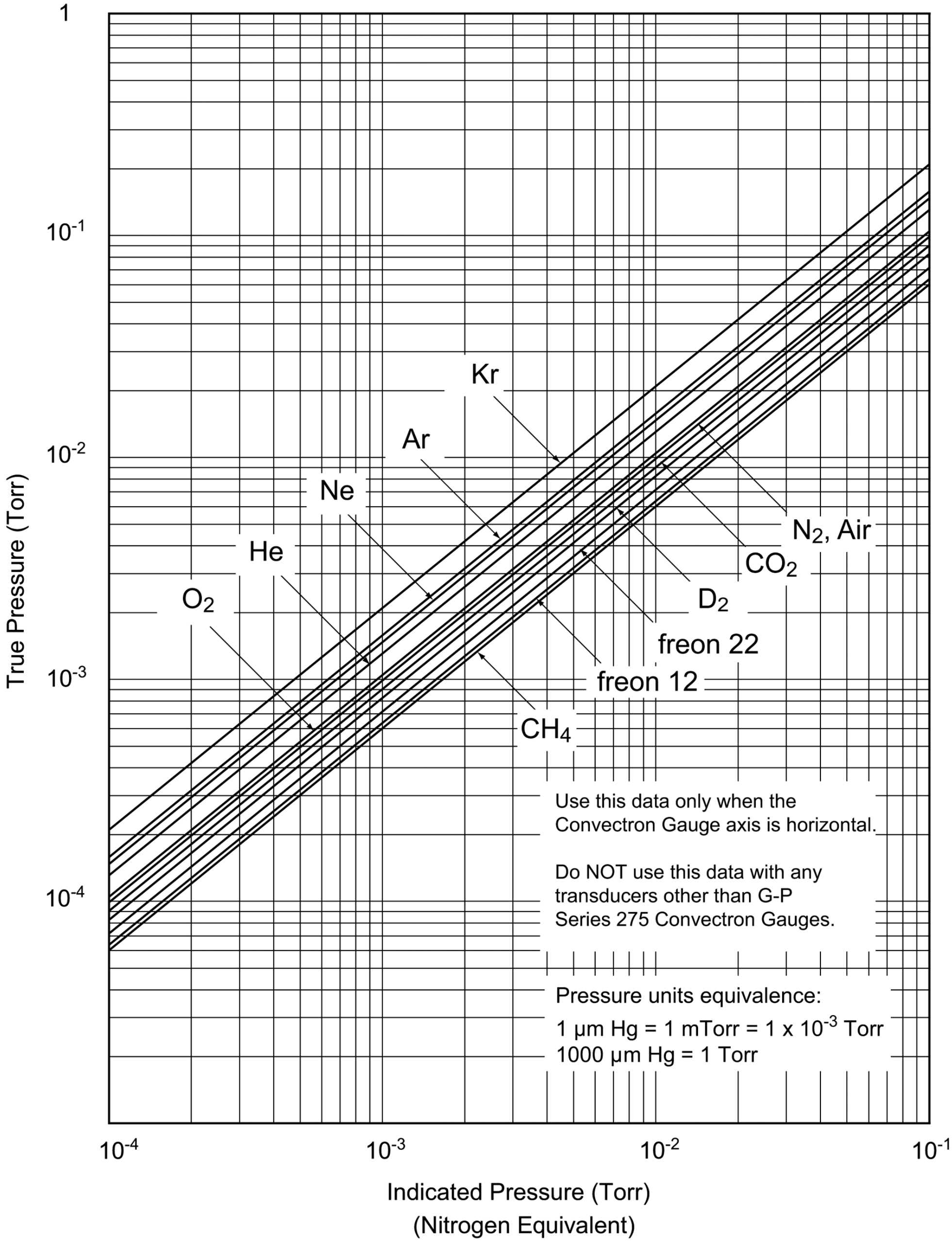


Figure 5-7 True Pressure versus Indicated Pressure for Commonly used Gases, 10^{-1} to 1000 Torr

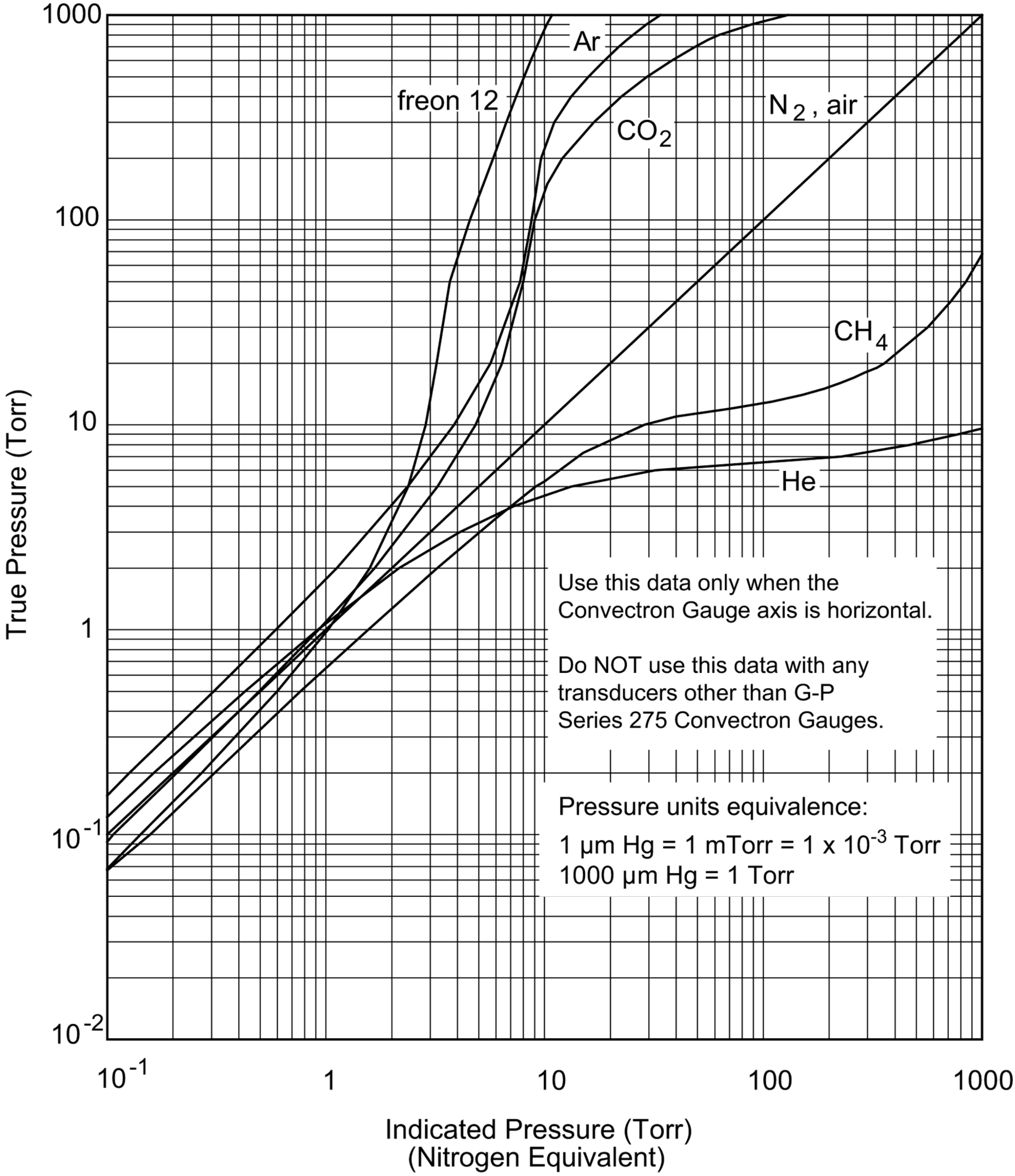


Figure 5-8 True Pressure versus Indicated Pressure for Commonly used Gases, 10^{-1} to 1000 Torr

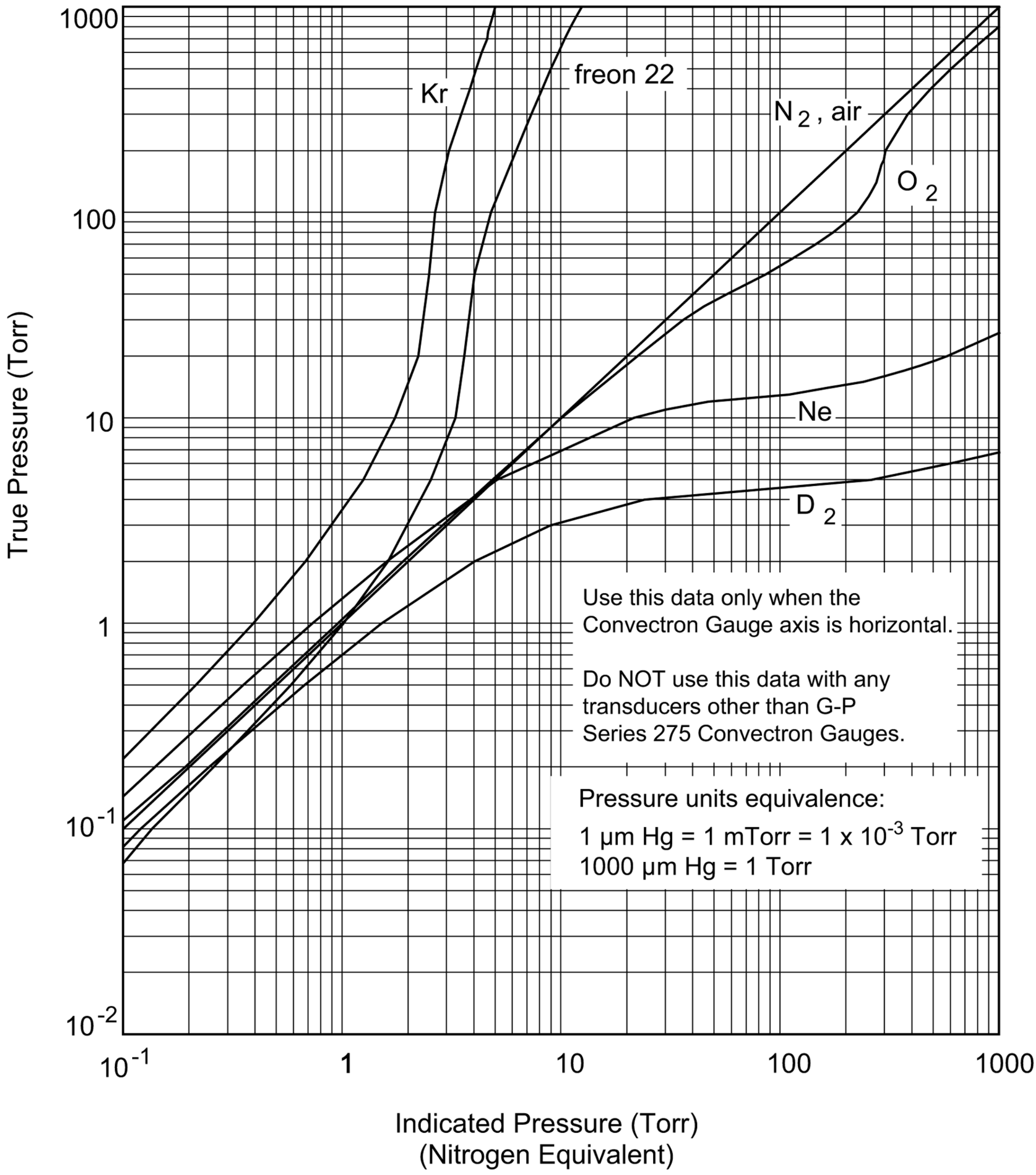


Figure 5-9 True Pressure versus Indicated Pressure for Commonly used Gases, 10^{-4} to 10^{-1} mbar

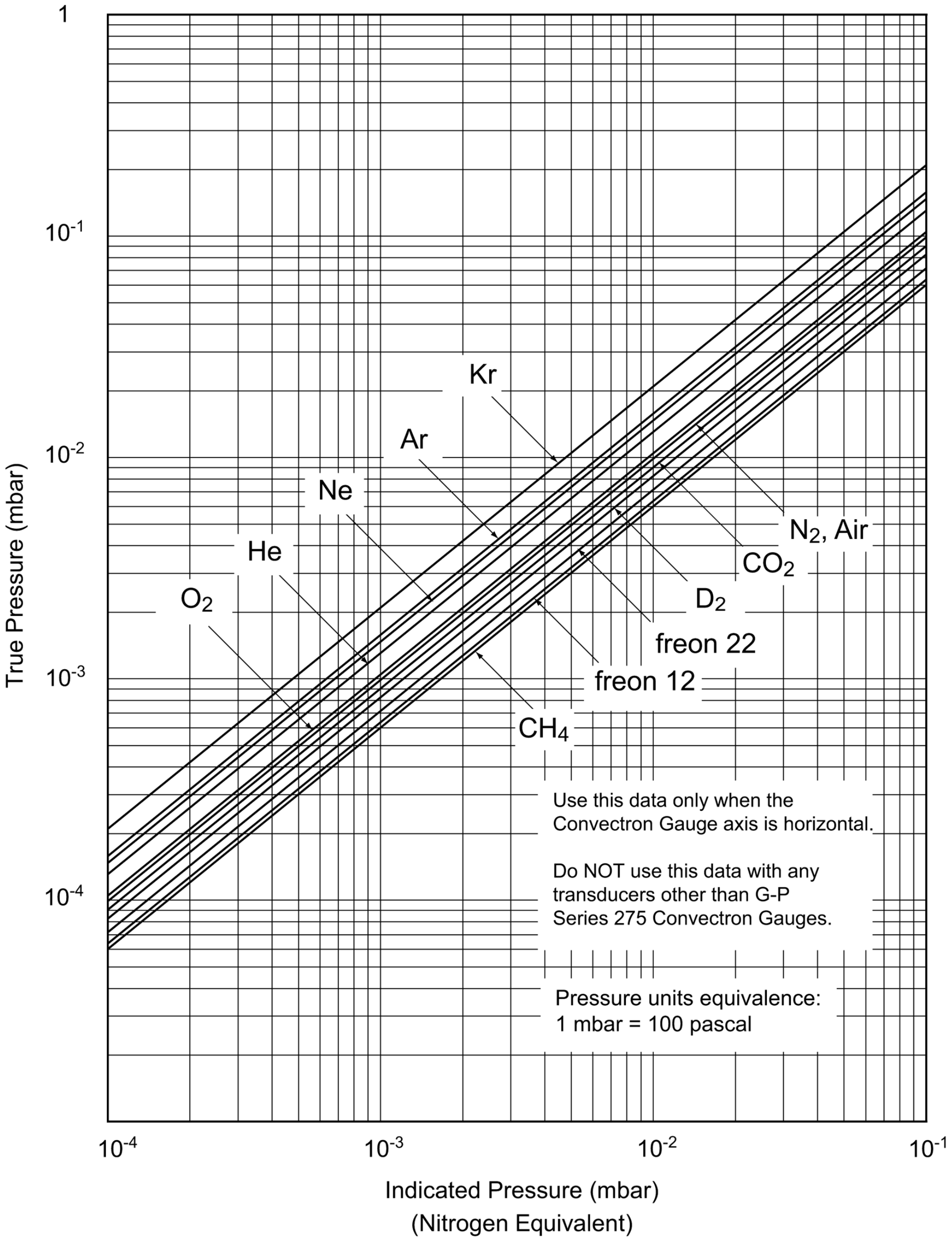


Figure 5-10 True Pressure versus Indicated Pressure for Commonly used Gases, 10^{-1} to 1000 mbar

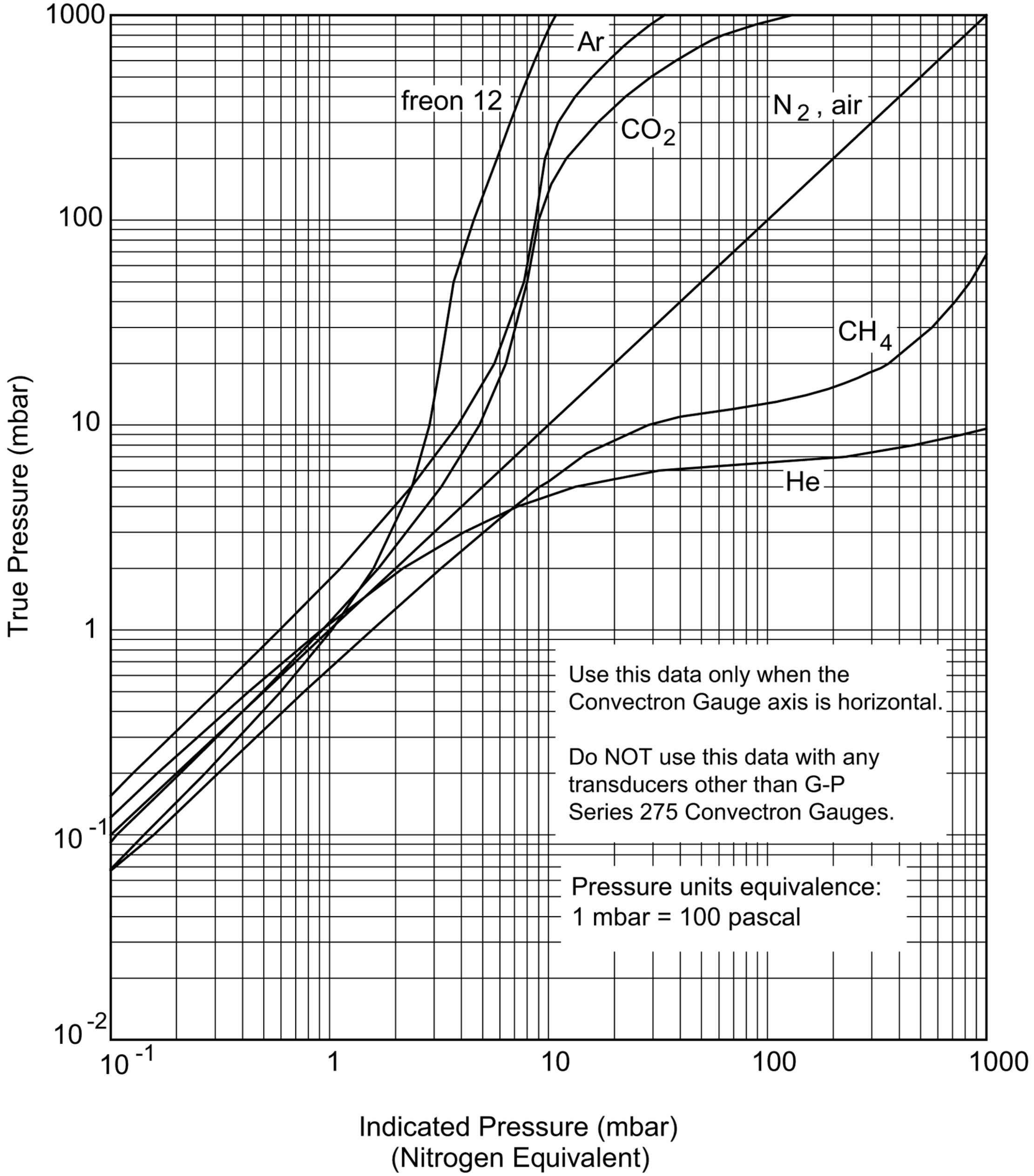
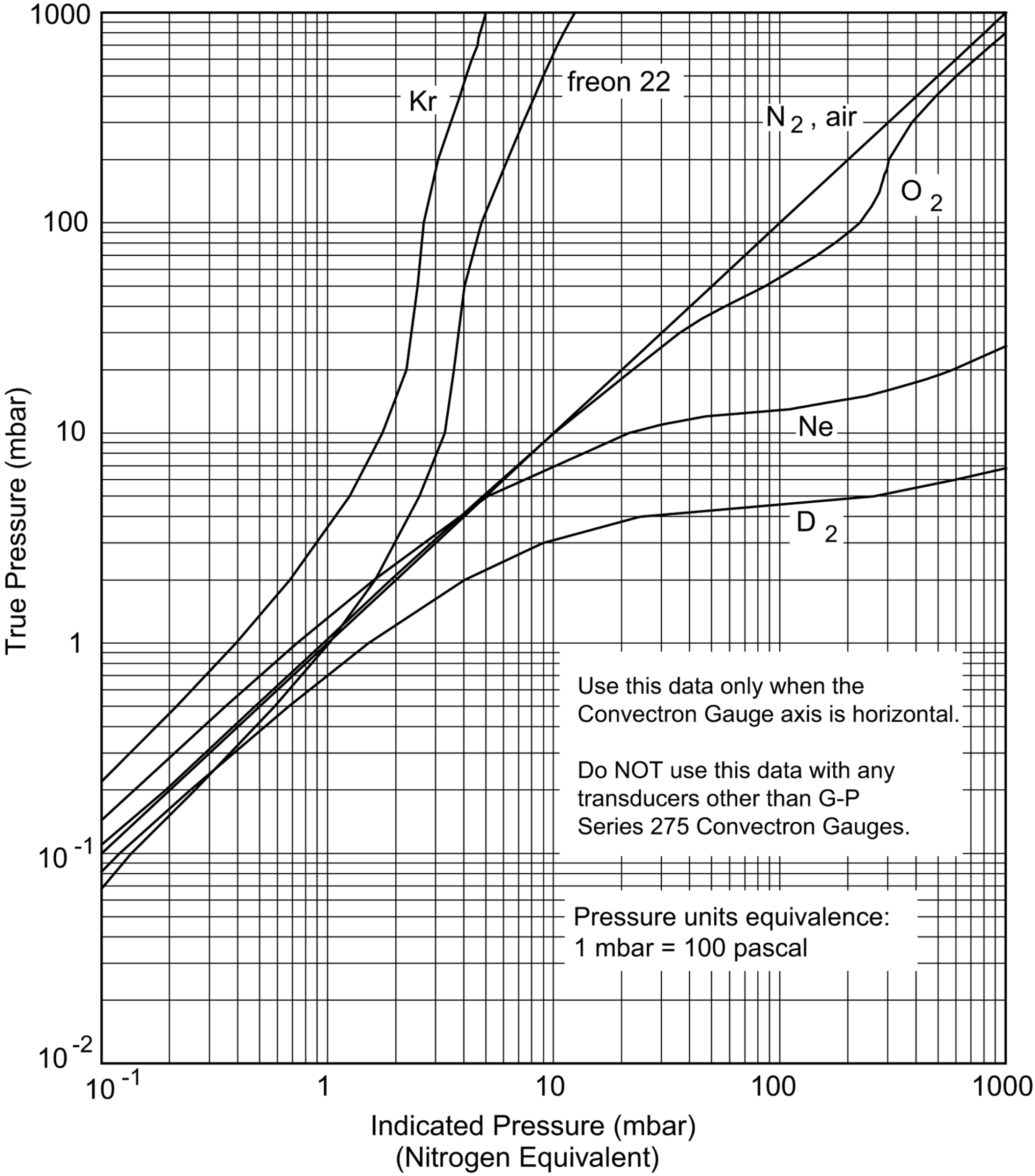


Figure 5-11 True pressTrue Pressure versus Indicated Pressure for Commonly used Gases, 10^{-1} to 1000 mbar



5.7 Micro-Ion Gauge Auto ON/OFF

⚠ WARNING

Failure to use accurate pressure conversion data for N_2 or air to other gases can cause an explosion due to overpressurization.

If the controller will measure any gas other than N_2 or air, before connecting the controller to system control devices, adjust pressure outputs for the process gas that will be used.

If a Convectron Gauge is exposed to the same pressure environment as a Micro-Ion Gauge, then the Convectron Gauge may be used to automatically turn ON the Micro-Ion Gauge. Convectron Gauge A can turn ON the Micro-Ion Gauge. Micro-Ion Gauge automatic turn-on occurs when the Convectron Gauge pressure drops below the auto turn-on setpoint defined by the auto turn-on setting. The Micro-Ion Gauge will also be turned OFF automatically when the pressure rises slightly above the auto turn-on setpoint if the electrometer overpressure setpoint does not trip first.

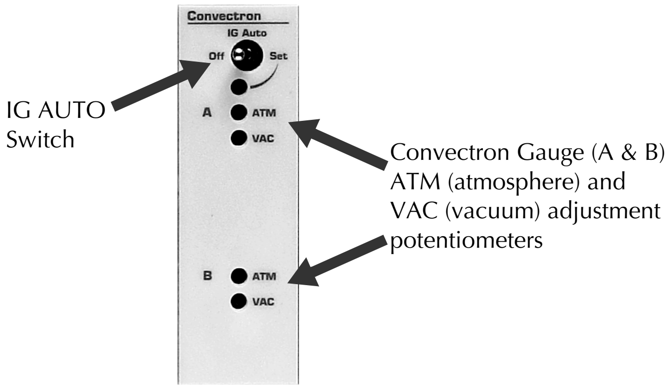
The automatic ON/OFF function will execute only once per setpoint crossing. For example, if the Micro-Ion Gauge is turned OFF manually when below the setpoint, the auto-on function will not turn it back ON until the Convectron Gauge pressure has risen above the setpoint and then dropped below it again.

5.8 Filament Auto ON

1. Place the IG Auto switch (Figure 5-12) on the ConvectronGauge module in the set position. (The Convectron pressure should at a higher pressure than the setpoint pressure when setting the Turn ON setpoint.)
2. The existing turn ON pressure is displayed on the A display.
3. Set the desired turn ON pressure with the auto set adjustment.
4. To deactivate this capability place the IG AUTO switch in the OFF position.

   NOTE: Do not leave the IG AUTO switch in the set position, as this prevents pressure from being displayed.

Figure 5-12 IG Auto Switch for Convectron Gauge



5.9 Gauge Zero and Atmospheric Pressure Adjustment

⚠ WARNING

Failure to use accurate pressure conversion data for N_2 or air to other gases can cause an explosion due to overpressurization.

If the controller will measure any gas other than N_2 or air, before connecting the controller to system control devices, adjust pressure outputs for the process gas that will be used.

Each Convectron gauge is individually computer-calibrated for N_2. Adjustment of the zero should not be necessary unless readout accuracy is required below 1 x 10^{-3} Torr. Adjustment of the atmospheric indication should not be necessary unless compensating for long cables or variations in mounting orientation. The Convectron gauge has a stable, temperature compensated design and each Controller is also calibrated to provide accurate readout of N2 pressure with any gauge when properly installed with the gauge axis horizontal.

1. Evacuate Convectron gauge A to a pressure known to be less than 1 x 10^{-4} Torr.
2. With power ON and at vacuum less than 1 x 10^{-4} Torr for at least 15 minutes, adjust VAC for gauge A (see Figure 5-12) until display A indicates 0.0 0 Torr/mbar or 0.0 0 pascal, not 1.0 –4, 1.0 –2, or 0.0 –0.
3. Let the pressure in the gauge increase to the local atmospheric pressure.
4. Read the local atmospheric pressure on a nearby, accurate barometer.
5. With power ON, adjust the ATM until the display on the front of the

controller indicates the local atmospheric pressure in the pressure units you have selected.

NOTE: 1 atmosphere at sea level is $7.6 \times 10^{+2}$ Torr; $1.0 \times 10^{+3}$ mbar; $1.0 \times 10^{+5}$ pascal.

6. Repeat this procedure for Convectron Gauge B.

5.10 Convectron Gauge Analog Output Signal

If the Convectron gauge capability is installed, a voltage output signal proportional to the common logarithm of the pressure indication is provided on the rear panel of the Convectron gauge module via a standard 1/8 in. miniature phono jack. See Figure 5-13.

If graphed on loglinear axes, the output voltage is linear with respect to the log of pressure. The analog output is 1 V per decade of pressure with a factory adjusted output of 0 V at 1.0×10^{-4} Torr. See Figure 5-14.

Offset adjustments are provided on the top edge of the Convectron gauge module that allow shifting the voltage corresponding to 1×10^{-4} Torr between –7 V and +1 V.

Figure 5-13 Convectron Module and Rear Panel

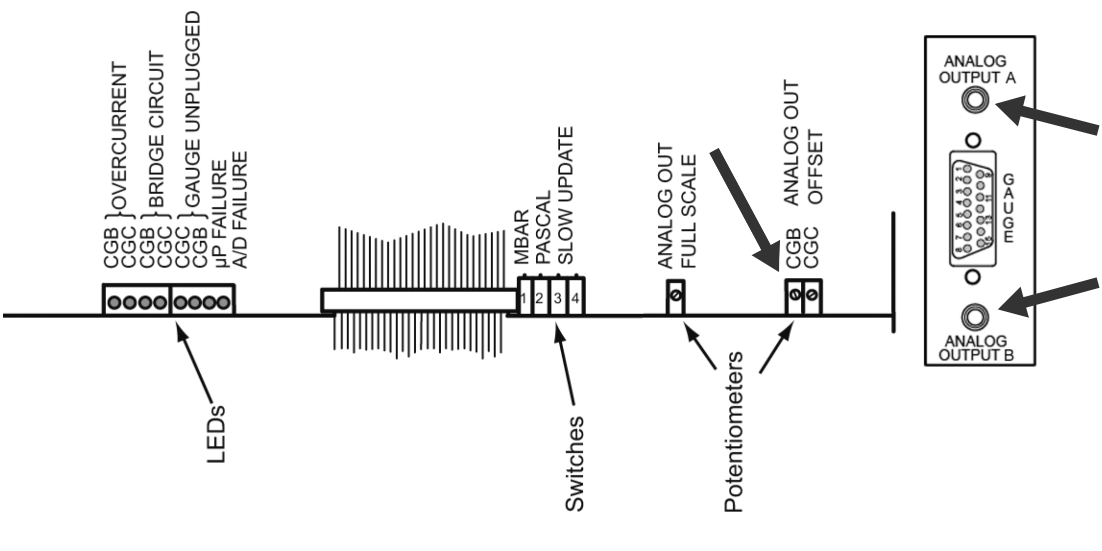
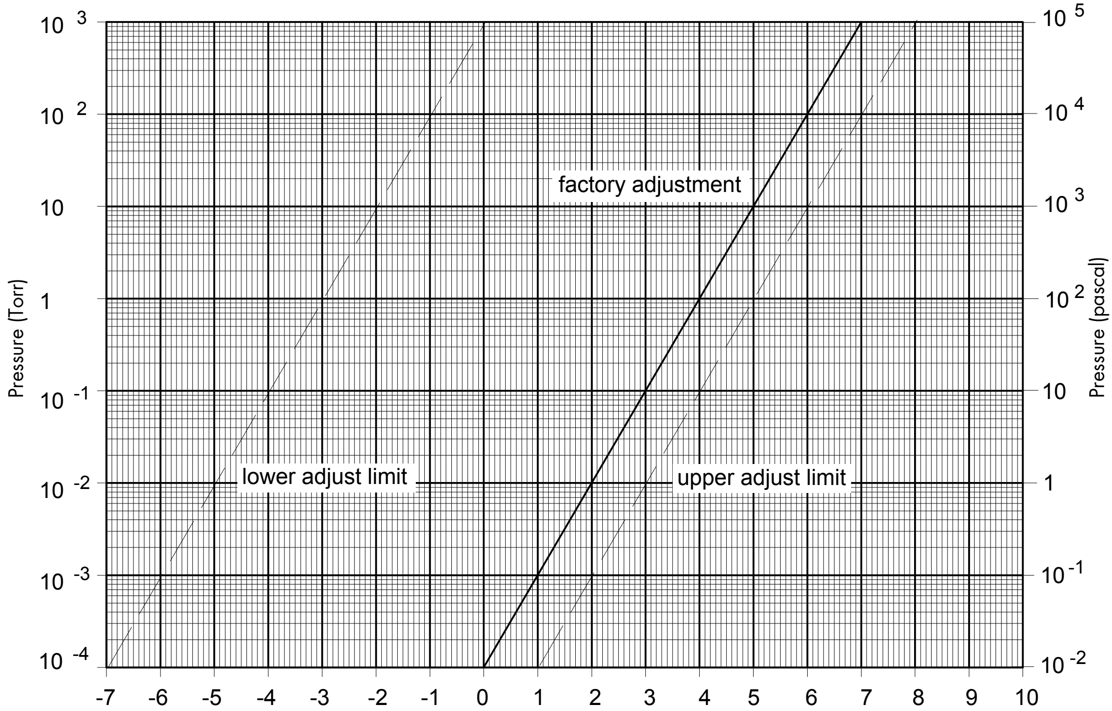


Figure 5-14 Convectron Gauge Analog Output versus Pressure



The voltage signal is smooth and continuous throughout all the decades of pressure measurement. This format is useful for computerized data acquisition because a simple equation (finding the common antilogarithm) may be programmed to calculate pressure from the voltage output.

The equation is: Pi = 10^{V-4} Torr/mbar, or Pi = 10^{V-2} pascal

where Pi = pressure indication,
V = analog output voltage

and: the offset is factory adjusted for 0 V at 1 x 10^{-4} Torr (1 x 10^{-2} pascal)

If the offset has been adjusted to other than 0V at 10^{-4} Torr (10^{-2} pascal), then the exponent value must be forced to –4 (–2 for Pa) when the pressure is at 1.0 x 10^{-4} Torr (1 x 10^{-2} pascal) by adding or subtracting a number other than –4 from the value of V.

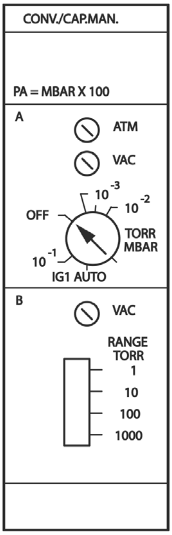
For example, if the offset has been adjusted so that the output voltage is –7 V at 1 x 10^{-4} Torr (1 x 10^{-2} pascal), then +3 (+5 for pascal) must be used in the equation instead of –4, i.e., $P = 10^{(-7+3)}$. Furthermore for the same offset, if the pressure were, say, 1 x 10^{-2} Torr, then the output voltage would be –5 V. The pressure would be calculated as $P = 10^{(-5+3)}$.

5.11 Preparing for Capacitance Manometer Operation

The capacitance manometer pressure is read in the third display line of the 358 Controller. The accompanying Convectron gauge is read in the second display line. If the cable is disconnected, the capacitance manometer will read Zero pressure.

See *Connecting a Capacitance Manometer* on page 60 for additional information regarding intial installation and setup and adjustments of the capacitance manometer module.

Figure 5-15 Convectron/Capacitance Manometer Module Panel



Use the IG AUTO potentiometer to set the auto turn ON pressure for the Micro-Ion Gauge. The IG AUTO turn-on potentiometer is marked with rough pressure calibration markings. To set the pressure at which the Micro-Ion Gauge will turn ON with falling pressure, and OFF with rising pressure, simply adjust the potentiometer to point to the desired pressure.

More precise control can be achieved by fixing the system pressure at the desired auto turn-on pressure, and adjusting the potentiometer slowly until the gauge comes ON.

To disable the auto turn on function, adjust the auto turn-on potentiometer completely counter-clockwise (OFF).

Initial Transducer Calibration

When first installed, the transducer zero-adjust should be set using a voltmeter to read Zero when at a system pressure below the minimum pressure range of the transducer. Refer to the documentation accompanying your capacitance manometer transducer for instructions on this procedure. You should also at this time adjust the VAC on the 358 controller, with the gauge not attached to the controller, per the instructions below. After this initial setup has been performed, the routine fine-tuning of the transducer zero can be performed with the module front panel VAC (zero) adjust potentiometer. The zero can be adjusted to 0 ± 200 mV.

Set The Controller Zero (Initial Controller Setup)

1. Disconnect the capacitance manometer cable either at the gauge head or at the controller.
2. Adjust the vacuum potentiometer (Figure 5-15) until the third display line shows a single "0". If the adjustment is turned too far, a minus sign will appear in the display. This proper calibration is achieved when only the "0" appears.

Zero the Controller with the Transducer

1. Be sure the transducer was zeroed properly on initial installation, see your transducer documentation. Connect the cable from the 358 Controller to the capacitance manometer transducer.
2. Evacuate your system to one decade below the minimum rated pressure of your transducer.
3. Adjust the vacuum potentiometer (Figure 5-15) until the third display line shows a single "0". If the adjustment is turned too far, a minus sign will appear in the display. This proper calibration is achieved when only the "0" appears.

5.12 Preparing for Process Control Operation

Setpoint Display and Adjustment

Setpoints are stored in non-volatile memory, and are specified by a 2-digit mantissa and 2-digit exponent. They may be set anywhere in the range 1×10^{-12} to 9×10^{5}. This allows for the entire pressure range of all supported transducer types and systems of units.

The setpoint is compared directly to the display data, so units of measure are implicit. Changing the units switch on the gauge control modules will not change the stored setpoints. They must be reprogrammed in the new system of units.

There is a programmed 10% hysteresis on each process control setpoint. For example, with a pressure setpoint of 6.3×10^{-6} Torr the relay will activate when the display reaches 6.2×10^{-6} Torr (for falling pressure) and will deactivate when the pressure rises to one significant digit above the setpoint plus 10%, i.e., $6.3 \times 10^{-6} + 0.6 \times 10^{-6} + 0.1 \times 10^{-6}$ or 7.0×10^{-6} Torr. For setpoints where the 2nd digit is 0.5 or greater the 10% value is rounded up.

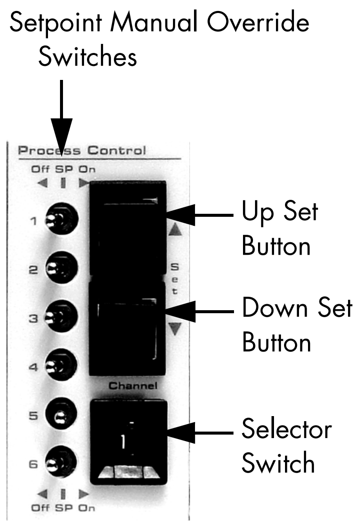
For example, if the setpoint is programmed to 6.6×10^{-6} Torr the relay will activate at 6.5×10^{-6} Torr (on falling pressure) and will deactivate when the pressure rises to $6.6 \times 10^{-6} + 0.7 \times 10^{-6} + 0.1 \times 10^{-6}$ or 7.4×10^{-6} Torr.

Since the process control and computer interface modules derive their pressure data directly from the display bus, they will be unable to update their pressure data while setpoints are being displayed. They will not mistakenly interpret setpoint data as pressure data, but will simply retain the last displayed pressure data until the SET key is released.

Manual Override

The 3-position switches on the front of the process control module allow override of the programmed setpoints at any time. When moved to the right, the relay is activated. When moved to the left, the relay is deactivated. When left in the center position, the relay is controlled automatically.

Figure 5-16 Process Control Module Front Panel



To Display a Setpoint

1. Be sure the “CAL” switch of the electrometer module is in its OFF position, or the calibration data in display line 1 will conflict with the display of setpoints 1 and 2.
2. Set selector switch 1 to the number of the channel you wish to display.
3. Press the setpoint display/set button (either the Up or Down button) and release. The setpoint will appear for 2 seconds in the corresponding display.

To Modify a Setpoint

1. Set the selector switch to the number of the channel you wish to modify (see Figure 5-16).
2. Press and hold one of the setpoint Set pushbuttons for the direction you wish the setpoint to change.
3. The setpoint will scroll until the switch is released. It will scroll slowly until a decade boundary is crossed and then will speed up to facilitate rapid changes across many decades. Release the switch when you have entered the desired decade, and then re-depress it to scroll slowly within the decade to reach the exact setpoint needed.

After the setpoint switch is released, the display will return to pressure data after two seconds. At this time, the new setpoint will be deposited in non-volatile memory.

If the ion gauge is OFF, PC relays 1 and 2 will deactivate.

5.13 Preparing to use RS-232 Computer Interface

Consult the user's manual for the host computer to be sure the protocol used is in accord with that established via the switch configuration you have chosen for the controller RS-232 module.

Communication with the controller VGC is via ASCII strings. A message to the controller consists of a command and a command modifier, followed by a terminator. The message may contain leading spaces, and the command and modifier may optionally be separated by spaces or commas. No spaces may appear within the command or the modifier, only between them.

The terminator expected by the controller is an ASCII carriage-return and line-feed, denoted here by CRLF. A carriage return, code CR, is hex 0D or decimal 13. A line feed, code LF, is hex 0A or decimal 10. The carriage-return is optional, and messages terminated with only the line-feed will be accepted. Note that the CRLF terminator is, in general, appended automatically by the host computer's interface software to the message string supplied by the user.

If extra characters are found in the message after it has been successfully interpreted but before the terminator, they will be ignored.

All characters should be upper-case.

All messages to the controller will receive a reply, consisting of an ASCII string terminated with CRLF. Numbers will be returned in the format X.XXE±XX.

Command Syntax for RS-232 Computer Interface

DG

Definition:	Turn degas ON or OFF.
Modifiers:	ON or OFF
Response:	OK if command accepted, or INVALID if rejected.
Example:	
From computer:	DG ON CRLF
From controller:	OKCRLF

- Command is INVALID if the Ion gauge is OFF.
- A response to the DG ON command of OK indicates only that a signal requesting degas has been sent to the electrometer. Degas may fail to activate if the pressure is above 5 x 10^{-5} Torr. Use the DGS command (see below) to verify that degas has been successfully initiated.

DGS

Definition:	Display degas status.
Modifiers:	None
Response:	ASCII 1 if degas is ON, 0 if degas is OFF.
Example:	
From computer:	DGS CRLF
From controller:	1CRLF (Indicating degas is ON.)

DS

Definition:	Display pressure reading.
Modifiers:	IG or CG1 or CG2.
Response:	ASCII string representing the pressure for the selected gauge.
Example:	
From computer:	DS IG CRLF
From controller:	1.20E-07CRLF

- The DS IG command will return pressure from the top display if either filament is ON, and 9.90E+09 if the gauge is OFF.
- The DS CG1 command will return pressure from the middle display.
- The DS CG2 command will return pressure from the bottom display.

IG1

Definition:	Turn the Ion gauge ON or OFF.
Modifiers:	ON or OFF
Response:	OK if command accepted, INVALID if rejected.
Example:	
From computer: From controller:	IG1 ON CRLF OKCRLF

- The IG1 ON command will be rejected as INVALID if the Ion gauge is already ON, and IG1 OFF will be rejected if the Ion gauge is already OFF.
- A response to the IG1 ON command of OK indicates only that a signal requesting that the ion gauge be turned ON has been sent to the electrometer. The tube may fail to come on, e.g., if the system pressure is too high or if the tube is disconnected. If the tube is OFF (or in its first few seconds of operation after being turned ON), a pressure of 9.99E+9 will be returned.

IG2

Identical to IG1 - performs the same functions as IG1

PCS

Definition:	Display process control channel status.
Modifiers:	1 or 2 or 3 or 4 or 5 or 6 or B or none.
Response:	Depends on modifier:
	Single digit (1 through 6); response = single ASCII digit, 0 if the corresponding relay is inactive, 1 if active. See Example 1.
	B; response = a byte of data with bits 0 through 5 set/clear according to whether the corresponding relay is active/inactive. Bit 6 will always be set to guarantee that the returned byte will not appear as a terminator byte. See Example 2.
	None or Absent; response will be a string of 6 ASCII zeroes and ones separated by commas, giving the status of all six channels. See Example 3.

Examples:

Assume that channels 1-3 are active, and 4-6 are inactive:

1. From computer: PCS 1 CRLF
   From controller: 1CRLF

2. From computer: PCS B CRLF
   From controller: GCRLF

(Note that ASCII "G" corresponds to the bit pattern 01000111 and represents the status of the PC channels in bits 0 through 5).

3. From computer: PCS CRLF
   From controller: 1,1,1,0,0,0 CRLF

5.14 RS-232 Error Messages

If an error is found in the incoming message, the following messages will be returned in place of the normal response:

OVERRUN ERROR

Returned if the incoming message overflows the controller's buffer. This may indicate a flaw in the host software.

PARITY ERROR

Returned if the parity of a byte in the incoming message does not match that programmed by the switches.

SYNTAX ERROR

Returned if the message fails to parse as a valid controller command. Could also result from failure to assert DCD during transmission to the controller.

5.15 Preparing to Use RS-485 Computer Interface

Consult the user's manual for the host computer to be sure the protocol used is in accord with that established via the switch configuration you have chosen for the RS-485 module.

Communication is via ASCII strings. A message to consists of a start character "#", an address, a command, and a command modifier, followed by a terminator. The message may contain leading spaces, and the command and modifier may optionally be separated by spaces or commas. No spaces may appear within the command or the modifier, only between them.

The address expected is programmed via the switch settings on the rear of the module and the internal switches. The syntax is "#AA" where AA is an ASCII representation of the hex address of the VGC.

The terminator expected is an ASCII carriage return denoted here by CR. Note that the terminator is sometimes appended automatically, by the host computer's interface software, to the message string supplied by the user. If extra characters are found in the message after it has been successfully interpreted but before the terminator, they will be ignored.

All messages will receive a reply, consisting of an ASCII string terminated with CR. Numbers will be returned in the format X.XXE±XX.

Messages may use upper or lower case alpha characters. The VGC will always respond with upper case characters.

Command Syntax for RS-485 Computer Interface

DG

Definition: Turn degas ON or OFF.

Modifiers: ON or OFF.

Response: OK if command accepted, or INVALID if rejected.

Example:
From computer: #AADG ON CR
From controller: OKCR

- Command is INVALID if the Ion gauge is OFF.
- A response to the DG ON command of OK indicates only that a signal requesting degas has been sent to the electrometer. Degas may fail to activate, e.g., if the pressure is above 5 x 10^{-5} Torr. Use the DGS command (see below) to verify that degas has been successfully initiated.

DGS

Definition: Display degas status.

Modifiers: None.

Response: ASCII 1 if degas is ON, 0 if degas is OFF.

Example:

From computer: #AADGSCR (Spaces may be omitted.)
From controller: 1CR (Indicating degas is ON)

DS

Definition: Display pressure reading.

Modifiers: IG or CG1 or CG2

Response: ASCII string representing the pressure for the selected gauge.

Example:

From computer: #AADS CG1 CR
From controller: 1.20E–03CR

- The DS CG1 and DS CG2 commands are used to display the pressures from the second and third display lines.
- If the ion gauge is turned OFF, or is in its first few seconds of operation, the controller will return 9.90E+09.
- The DS IG command will return pressure if the gauge is ON, and 9.90E+09 if it is OFF.

IG1

Definition:	Turn the Ion gauge ON or OFF.
Modifiers:	ON or OFF
Response:	OK is command accepted, INVALID if rejected.
Example:	
From computer:	#AAIG1 ON CR
From controller:	OKCR

- The IG ON command will be rejected as INVALID if the Ion gauge is already ON, and IG OFF will be rejected if the Ion gauge is already OFF.
- A response to the IG1 ON command of OK indicates only that a signal requesting that the Ion gauge be turned ON has been sent to the electrometer. The tube may fail to come on, e.g., if the system pressure is too high or if the tube is disconnected. To verify that the Ion gauge is ON, use the DS IG1 command. If the tube is OFF (or in its first few seconds of operation after being turned ON) a pressure of 9.90E+9 will be returned.

IG2

Identical to IG1 - performs the same functions as IG1

PCS

Definition:	Display process control channel status
Modifiers:	1 or 2 or 3 or 4 or 5 or 6 or B or none.
Response:	Depends on modifier:
	Single digit (1 through 6); response = single ASCII digit, 0 if the corresponding relay is inactive, 1 if active.
	B; response = a byte of data with bit 0 through 5 set/clear according to whether the corresponding relay is active/inactive. Bit 6 will always be set to guarantee that the returned byte will not appear as a terminator byte.
	None or Absent; response will be a string of 6 ASCII zeroes and ones separated by commas, giving the status of all six channels.

Examples:

Assume that channels 1through 3 are active, and 4 through 6 are inactive:

From computer: #AAPCS 1 CR
From controller: 1CR

From computer: #AAPCS B CR
From controller: GCR

The ASCII "G" corresponds to the bit pattern 01000111 and represents the status of the PC channels).

From computer: #AAPCS CR
From controller: 1,1,1,0,0,0CR

5.16 RS-485 Error Messages

If an error is found in the incoming message, the following messages will be returned in place of the normal response:

OVERRUN ERROR

Returned if the incoming message overflows the buffer. This may indicate a flaw in the host software.

PARITY ERROR

Returned if the parity of a byte in the incoming message does not match that programmed by the switches.

SYNTAX ERROR

Returned if the message fails to parse as a valid command.

Chapter 6 Operation

The instructions in this chapter assume the instructions for Setup, Installation, and Preparing for Operation have been completed. See *Chapter 2*, *Chapter 3*, and *Chapter 4*.

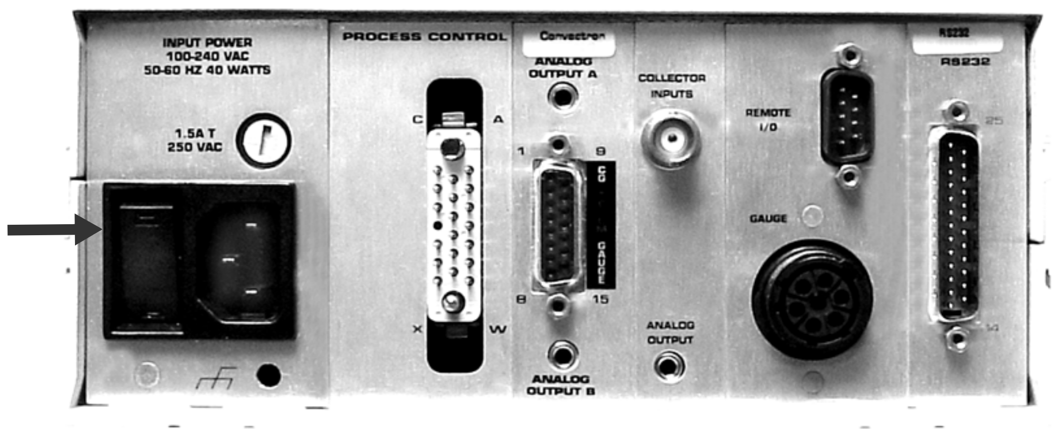
For theories of operation for the Micro-Ion Gauge, Convectron Gauge, electrometer, capacitance manometer, and process control modules, see *Chapter 7*.

6.1 Controller Operation

Turning the Controller ON

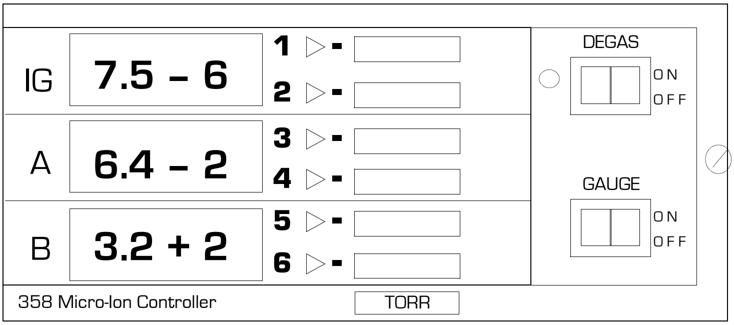
1. Press the top half of the power ON switch on the rear panel of the Controller (see Figure 6-1).

Figure 6-1 Power ON Switch



2. When the power switch is ON, the Micro-Ion Gauge pressure is displayed on line Micro-Ion Gauge and Convectron Gauge pressures are displayed on lines A and B of the display on the front panel of the Controller (see Figure 6-2). Display formats for the Convectron Gauge pressures are given in Table 6-1.

Figure 6-2 Controller Front Panel



3. If you have Convectron Gauge capability installed and have prepared your system for automatic operation of the Micro-Ion Gauge per *Micro-Ion Gauge Auto ON/OFF* on page 80, the Micro-Ion Gauge will turn ON and OFF automatically.
4. For manual operation, press the front panel GAUGE momentary rocker switch. See Figure 6-2. The pressure in the Micro-Ion gauge will be displayed on the Micro-Ion gauge line of the display in the chosen pressure units.
5. To degas the Micro-Ion Gauge (the gauge must be ON and the pressure within the Micro-Ion Gauge must be below 5 x 10^{-5} Torr), depress the DEGAS momentary rocker switch on the Controller.
6. When the filament is nearing the end of its useful lifetime or is badly contaminated, the LED indicator next to the DEGAS switch on the front panel will blink during degassing. This is an indication that the filament emission properties have deteriorated. This may be due to contamination which has temporarily "poisoned" the filament coating, or to long term permanent erosion of the coating.

   If this condition does not disappear after a few days of operation at clean high vacuum or UHV, it is an indication that the filament is approaching its end of life.

7. Stable pressure measurement requires that all the environmental parameters in, on, and around the vacuum gauge and vacuum system remain unchanged during measurement. Therefore, never attempt meaningful measurements immediately after turning on the Micro-Ion Gauge or immediately after degassing the gauge. Permit sufficient time for the environmental parameters to stabilize.

Table 6-1 Convectron Gauge Display Formats

Units	Display Format	Pressure	Example
Torr	scientific	< 1 Torr	3.2–3 Torr
	floating point	> 1 Torr	7.1 Torr
mbar	scientific	< 1 mbar	5.1–2 mbar
	scientific	> 1 mbar	8.8+1 mbar
	scientific	> 999 mbar	1.2+3 mbar
pascal	scientific	< 1 pascal	7.2–1 pascal
	scientific	> 1 pascal	7.8+1 pascal
	scientific	> 999 pascal	1.2+4 pascal

6.2 Micro-Ion Gauge ON/OFF

The Micro-Ion Gauge can be turned ON or OFF by the front panel GAUGE “momentary” rocker switch or by the remote input, the Convectron Gauge set point, or the computer interface command.

To turn ON the Micro-Ion Gauge from the front panel, press the GAUGE momentary rocker switch. See Figure 6-2. To turn it OFF, press the GAUGE rocker switch again. After a 3-second delay, the Micro-Ion Gauge pressure will be displayed.

6.3 Degas ON/OFF

The EB (electron bombardment) degas may be turned ON or OFF by the front panel DEGAS “momentary” rocker switch, (see Figure 6-2), or the remote input. To turn degas ON, press the DEGAS momentary rocker switch. To turn it OFF, press the DEGAS momentary rocker switch again. Degas automatically turns OFF and returns to normal emission in 2 minutes.

Degas “ON” indication is by the degas LED adjacent to the DEGAS rocker switch on the front panel (see Figure 6-2). Degas cannot be activated unless the Micro-Ion Gauge has been turned ON and indicated system pressure is below 5 x 10^{-5} Torr. This prevents degas turn-on at pressures where emission can not be established or where degas is of no practical use. Micro-Ion Gauge pressure measurement is displayed during degas, but it is not an accurate measurement during the degas cycle.

6.4 Special Considerations for Use Below 10^{-3} Torr

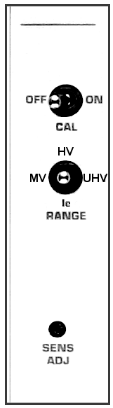
During a fast pumpdown from atmosphere, thermal effects will prevent the Convectron gauge from tracking pressure accurately below 1 x 10^{-3} Torr. After about 15 minutes, indications in the 1 x 10^{-4} range will be valid and response will be rapid.

In the 1 x 10^{-4} Torr range, the indication is accurate to about ± 0.1 milliTorr provided the instrument has been carefully zeroed at vacuum. See *Gauge Zero and Atmospheric Pressure Adjustment* on page 81 for vacuum and atmosphere calibration procedures. For accurate use in the 1 x 10^{-4} range, zeroing should be repeated frequently.

Convectron pressure readings in the 1 x 10^{-4} Torr range may differ from those of the ion gauge, since ion gauges usually lose sensitivity near their upper pressure limits.

6.5 Gauge Electrometer Operation

Figure 6-3 Electrometer Module Front Panel



Displaying Sensitivity with Calibration Switch

The CAL switch is used for displaying pressure or gauge sensitivity. It is activated by setting to the ON position. The data displayed will depend on the state of the Micro-Ion Gauge tube:

If the Micro-Ion Gauge is OFF, setting the switch ON displays the Micro-Ion Gauge sensitivity in the display. This will be in scientific notation. If the Micro-Ion Gauge is ON, the switch has no effect and pressure will be displayed.

NOTE: Do NOT leave the calibration switch in the ON position after viewing the sensitivity - otherwise, the displayed reading might be mistaken for the actual pressure reading.

Emission Range Switch

The emission range switch selects between three emission ranges; 20 microamperes (MV), 1 milliampere (HV), or 4 milliamperes (UHV).

In general, higher emissions are used at lower pressures. If you are measuring very low pressures the 4 mA range is best. Lower emissions will increase tube life.

The overpressure shutdown point will change inversely proportional to the emission range. See Table 3-1 on page 30.

Sensitivity Adjustment

The sensitivity adjustment (see Figure 6-3) on the electrometer module is used to match gauges of different sensitivities. The Calibration switch on the electrometer module must be ON with the Micro-Ion Gauge OFF to view sensitivity during the adjustment.

The controller is preset for a tube sensitivity of 20/Torr which is typical for the Micro-Ion Gauge. The approximate range of the adjustment is 3 to 50/Torr.

Relative Gas Sensitivities

Sensitivity depends on the gas being measured as well as the type of Micro-Ion Gauge tube. Table 6-2 on page 99 lists the relative gauge sensitivities for common gases. These values are from NASA Technical Note TND 5285, *Micro-Ion Gauge Sensitivities as Reported in the Literature*, by Robert L. Summers, Lewis Research Center, National Aeronautics and Space Administration. Refer to this technical note for further definition of these average values and for the gauge sensitivities of other gases.

To adjust the controller to direct reading for gases other than air or N_2 during Micro-Ion Gauge operation, calculate the sensitivity K_x for gas type x as follows:

$$K_x = (R_x)(KN_2)$$

Where KN_2 is the gauge sensitivity for N_2 and R_x is found from Table 6-2 on page 99.

Table 6-2 Relative Gas Sensitivities

Gas	R_x	Gas	R_x
He	0.18	H_20	1.12
Ne	0.30	NO	1.16
D_2	0.35	Ar	1.29
H_2	0.46	CO_2	1.42
N_2	1.00	Kr	1.94
Air	1.00	SF	2.50
O_2	1.01	Xe	2.87

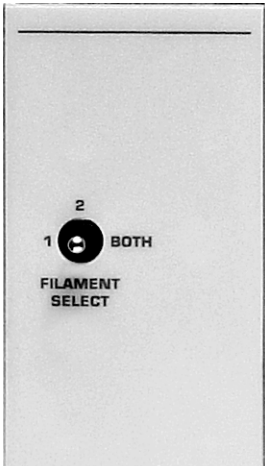
6.6 Filament Selection for Electrometer Module

The Filament Select switch (see Figure 6-4) is used to operate each filament individually or both in series.

Normally only one filament should be selected.

During degas, selecting the BOTH position will clean up the tube more satisfactorily allowing for a lower ultimate pressure reading.

Figure 6-4 Filament Select Switch



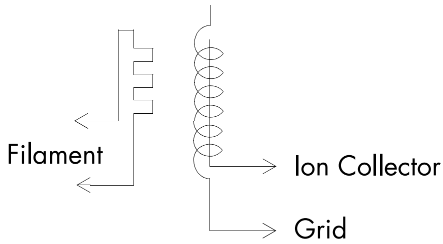
Chapter 7 Theory of Operation

7.1 Micro-Ion Gauge Theory of Operation

The functional parts of a typical Micro-Ion Gauge are the filament (cathode), grid (anode) and ion collector, which are shown schematically in Figure 7-1. These electrodes are maintained by the gauge Controller at +30, +180, and 0 V, relative to ground, respectively.

The filament is heated to such a temperature that electrons are emitted, and accelerated toward the grid by the potential difference between the grid and filament. Most of the electrons eventually collide with the grid, but many first traverse the region inside the grid one or more times.

Figure 7-1 Micro-Ion Gauge Schematic



When an energetic electron collides with a gas molecule an electron may be dislodged from the molecule leaving it with a positive charge. Most ions are then accelerated to the collector. The rate at which electron collisions with molecules occur is proportional to the density of gas molecules, and hence the ion current is proportional to the gas density (or pressure, at constant temperature).

The amount of ion current for a given emission current and pressure depends on the Micro-Ion Gauge design. This gives rise to the definition of Micro-Ion Gauge "sensitivity," frequently denoted by "K."

$$K = \frac{\text{Ion current}}{\text{Emission current} \times \text{Pressure}}$$

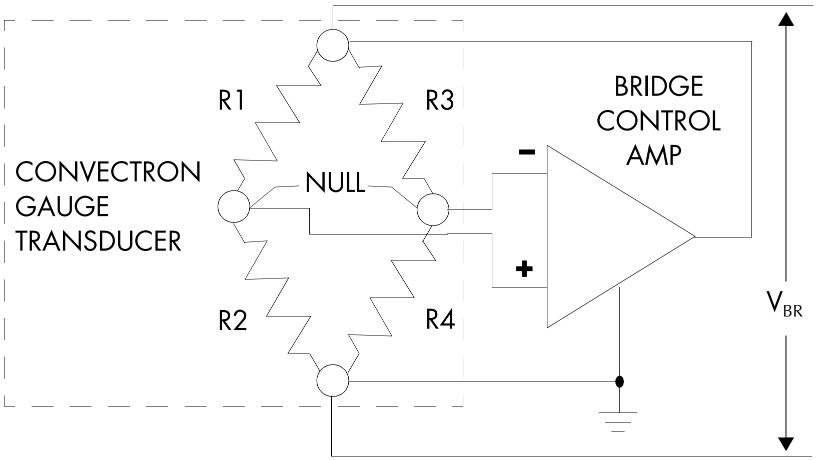
The Series 355 Micro-Ion Gauge has a sensitivity of 20/Torr when used with nitrogen or air. Sensitivities for other gases are given in *Relative Gas Sensitivities* on page 99.

The Micro-Ion Gauge Controller varies the heating current to the filament to maintain a constant electron emission, and measures the ion current to the collector. The pressure is then calculated from these data.

7.2 Convectron Gauge Theory of Operation

The Convectron Gauge transducer is represented in Figure 7-2 as R1, R2, R3, and R4. These four resistances form the legs of a bridge circuit, with R1 designating the sensor wire of the transducer. R2 is a resistive network in the tube that compensates for changes in the ambient temperature. At bridge null, R1=R2xR3/R4. If there are no changes in ambient temperature, the value of R1 is a constant and the bridge is balanced.

Figure 7-2 Convectron Gauge Schematic



As the vacuum system pressure is decreased, there are fewer molecules in the system to conduct the heat away from the sensor wire causing the temperature and resistance of R1 to increase. The increased resistance of R1 causes the bridge to unbalance and a voltage is developed across the null terminals. The bridge control circuit senses the null voltage and decreases the voltage across the bridge until the null voltage is again zero. When the bridge voltage is decreased, the power dissipated in the sensor wire is decreased causing the resistance of R1 to decrease to its previous value. The opposite events happen for a pressure increase. The bridge voltage is a nonlinear function of pressure.

All materials have been chosen for ultra high vacuum service, corrosion resistance and bakeability to 150 °C. The gauge tube envelope is type 304 stainless steel. All metallic joints in the envelope are TIG welded. No solder is used within the envelope. The following materials are exposed to the vacuum. Type 304 stainless steel, Carpenter Alloy 52, Kovar®, Kapton®, gold-plated tungsten, borosilicate glass and Dow-Corning® 9015 glass. The blue trim cover is molded of Ultem® polyetherimide resin suitable for service to 150 °C.

7.3 Microcontrollers and Bus Structure

The electrometer module in the controller has a dedicated microcontroller with internal ROM, RAM, timing, and interrupt management functions. This architecture provides high performance at low cost with greater reliability and noise immunity than more complicated microprocessor systems using external buses and memory hardware.

The microcontroller is equipped with a watchdog timer, which automatically generates a reset if the processor fails to fulfill timing “checkpoints” within its code. Interprocessor communication is accomplished via the display bus. These lines carry BCD-format pressure data that is used to generate the controller display.

7.4 Capacitance Manometer Theory of Operation

Within the capacitance manometer, a diaphragm is distorted by the pressure of the gas in the system under measurement. This diaphragm forms part of a capacitor, and its deflection causes changes in capacitance. Thus, the electrically measured capacitance is a measure of pressure. The device is very sensitive to the elastic properties of the metal of the diaphragm. For this reason, large pressure excursions, such as occur when the system is raised to atmospheric pressure, can cause offsets to the pressure reading. The diaphragm is also extremely sensitive to temperature effects, and although it may be held in a temperature controlled chamber, this temperature control is never perfect, resulting in further perturbations to the devices theoretical accuracy.

Note that these perturbations are inherent in the capacitance manometer design and are not a property of the electronic module used to operate the transducer.

Capacitance manometers are capable of exceptional accuracy, and read pressure independent of gas type, but are also subject to zero point drift, and must be calibrated at vacuum frequently if high accuracy is to be obtained. Refer to the manual for your transducer for instructions.

7.5 Process Control Theory of Operation

The process control module contains a dedicated microcontroller and a non-volatile memory chip for storage of the setpoints. The microcontroller compares the setpoints with the pressure display data on the display bus and makes a decision as to whether or not to activate a channel's relay.

Chapter 8 Service

8.1 Service Guidelines

Some minor difficulties are readily corrected in the field. Each module in the controller has fault indicator LEDs which help localize failures.

If a qualified service person makes repairs at the component level, repairs properly made with equivalent electronic parts and rosin core solder do not void the warranty.

Because the controller contains static-sensitive electronic parts, the following precautions must be followed when troubleshooting:

- Use a grounded, conductive work surface. Wear a high impedance ground strap for personal protection.
- Use conductive or static dissipative envelopes to store or ship static sensitive devices or printed circuit boards.
- Do not operate the product with static sensitive devices or other components removed from the product.
- Do not handle static sensitive devices more than absolutely necessary, and only when wearing a ground strap.
- Do not use an ohmmeter for troubleshooting MOS circuits. Rely on voltage measurements.
- Use a grounded, electrostatic discharge safe soldering iron.

This product was designed and tested to offer reasonably safe service provided it is installed, operated, and serviced in strict accordance with these safety instructions.

⚠ WARNING

Substitution or modifying parts can result in product damage or personal injury due to electrical shock or fire.

- Install only those replacement parts that are specified by Granville-Phillips.
- Do not install substitute parts or perform any unauthorized modification to the controller.
- Do not use the controller if unauthorized modifications have been made.

8.2 Customer service

For customer service:

- Phone **1-303-652-4400** or **1-800-776-6543** within the USA.
- Phone **1-800-367-4887** 24 hours per day, 7 days per week within the USA.
- Email *co-csr@brooks.com*
- For Global Customer Support, go to www.brooks.com, click on Contact Us, then click on Global Offices to locate the Brooks Automation office nearest you.

8.3 Damage Requiring Service

Disconnect this product from the power source and refer servicing to qualified service personnel if any the following conditions exist:

- A gauge cable or plug is damaged.
- Liquid has been spilled onto, or objects have fallen into, the product.
- The product has been exposed to rain or water.
- The product does not operate normally even if you have followed the Operation Instructions. Adjust only those controls that are covered in the instruction manual. Improper adjustment of other controls may result in damage and require extensive work by a qualified technician to restore the product to its normal operation.
- The product has been dropped or the enclosure has been damaged.
- The product exhibits a distinct change in performance. This may indicate a need for service.

⚠ WARNING

Failure to perform a safety check after the controller has been repaired can result in product damage or personal injury due to electrical shock or fire.

If the controller has been repaired, before putting it back into operation, make sure qualified service personnel perform a safety check.

8.4 Returning a Damaged Product

If a product must be returned for service, request a Return Authorization (RA) from Brooks Automation / Granville-Phillips. Do not return products without first obtaining an RA. In some cases a hazardous materials document may be required. The Brooks Automation / Granville-Phillips Customer Service Representative will advise you if the hazardous materials document is required.

When returning equipment to Brooks Automation / Granville-Phillips, be sure to package the products to prevent shipping damage. Circuit boards and modules separated from the controller chassis must be handled using proper anti-static protection methods and must be packaged in anti-static packaging. Brooks Automation / Granville-Phillips will supply return packaging materials at no charge upon request. Shipping damage on returned products as a result of inadequate packaging is the Buyer's responsibility. *Before you return the module*, obtain an RA number by contacting Granville-Phillips customer service:

- Phone **1-303-652-4400** or **1-800-776-6543** within the USA.
- Phone **1-800-367-4887** 24 hours per day, seven days per week within the USA.
- Email *co-csr@brooks.com*
- For Global Customer Support, go to www.brooks.com, click on Contact Us, then click on Global Offices to locate the Brooks Automation office nearest you.

8.5 Troubleshooting

If any of the conditions described above have occurred, troubleshooting is required to determine the repairs that are necessary.

Table 8-1 Symptoms and Possible Causes

Symptom	Possible Cause
Unit will not power-up, no response to power switch	Power fuse blown Wrong line voltage selection, see *Line Voltage* on page 53
Power fuse blows repeatedly	Wrong fuse rating Wrong line voltage selection, see *Line Voltage* on page 53
Micro-Ion gauge will not turn ON, or turns on briefly then shuts OFF	Micro-Ion gauge at too high pressure Auto turn ON/OFF circuit in Convectron gauge module is shutting OFF the Micro-Ion Gauge Emission current setting wrong for pressure in gauge Improper Micro-Ion Gauge connector hookup Badly contaminated Micro-Ion Gauge Damaged or contaminated cathode coating, will not sustain emission Short in Micro-Ion Gauge cable Short between Micro-Ion Gauge electrodes Open cathode in Micro-Ion Gauge
Micro-Ion gauge display shows a steady number when the Micro-Ion gauge is OFF	CAL switch is not in the OFF position
Convectron Gauge display reads a fixed (non changing) pressure	Micro-Ion Gauge IG AUTO switch is left in the set position or the Convectron option

Table 8-1 Symptoms and Possible Causes

Symptom	Possible Cause
Pressure reading is higher than expected	Micro-Ion Gauge contaminated UHV pressure range is not selected appropriately (pressure is below 1 x 10^{-7} Torr) Interference from other ion source Poor conductance in gauge's vacuum connection to chamber Gas source in plumbing to gauge, such as leak or contamination Chamber pressure high because of leak, contamination, or pump failure Poor location selected for gauge Faulty gauge or power cable Faulty electrometer
Degas will not turn ON	System pressure above 5 x 10^{-5} Torr Micro-Ion Gauge not turned ON
Micro-Ion Gauge shuts OFF when degas is initiated	Degas fuse blown Badly contaminated Micro-Ion gauge.
Micro-Ion Gauge pressure reads extremely low	Collector unplugged Bad collector cable Faulty electrometer Collector is coated with material
Micro-Ion Gauge pressure readout very erratic	Micro-Ion Gauge badly contaminated Improper Micro-Ion Gauge or Controller grounding Bad collector cable Excessive electrical noise source causing offset Interference from other charged particle source in chamber Faulty electrometer
Green +18 LED out on control board	+18 V supply to relays faulty
Green +15 LED out	+15 V supply faulty (power to analog circuitry and RS-232 overloaded)
Green –15 LED out	–15 V supply faulty (power to analog circuitry and RS-232 overloaded)
Green +5 display LED out	+5 V supply to display LED's faulty or overloaded
Green +5 logic LED out	+5 V logic supply faulty or overloaded

8.6 Overpressure Shutdown

As pressure increases, the ion current to the collector increases until the high density of gas molecules begins to interfere with the ionization process. When some electrons cannot acquire sufficient energy to ionize the gas molecules, the collector current no longer increases with increasing pressure. This pressure is called the “turn around” pressure. Further pressure increases will result in a decreasing ion current.

The Controller is factory set so the ion gauge will shut down when the pressure rises above the overpressure setpoint pressures shown in Table 8-2.

For reliable operation in general applications, the overpressure shutdown point is factory set below the Micro-Ion Gauge turn around point at both emission currents. Although we recommend that you do not change the factory settings, the overpressure shutdown can be readjusted for specific applications according to the following procedure.

CAUTION

Adjusting the overpressure shutdown to a pressure that is higher than the factory setting can damage the gauge and vacuum system.

Before adjusting the overpressure shutdown to a pressure that is higher than the factory setting, phone a Granville-Phillips application engineer at 1-303-652-4400 or 1-800-776-6543 within the USA, or email co–csr@brooks.com.

Table 8-2 Overpressure Shutdown Factory Settings

Pressure Range Designation	MV (Medium Vacuum)	HV (High Vacuum)	UHV (Ultrahigh Vacuum)
Emission Current	20 µA	1 mA	4 mA
Recommended Upper Limit, Torr	5×10^{-2}	8×10^{-4}	2×10^{-4}
Recommended Lower Limit, Torr	1×10^{-6}	1×10^{-7}	Less than 1×10^{-9}

To adjust the overpressure shutoff point to a different level:

1. Maintain system pressure at the desired shutoff point.
2. Rotate the overpressure adjustment potentiometer fully counterclockwise.
3. Turn ON the ion gauge.
4. Rotate the adjustment potentiometer clockwise slowly until the ion gauge turns OFF.

8.7 Troubleshooting the Convectron Gauge Module

Table 8-3 Convectron Gauge Module Troubleshooting - See Figure 5-13 on page 82

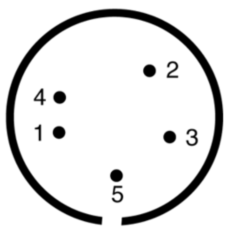
Symptom	Possible Cause
Pressure reading grossly in error	Controller out of calibration Unknown gas type Gauge not mounted horizontally (see Figure 4-2 on page 55) Sensor damaged (e.g., by reactive gas) or Gauge very dirty Extremes of temperature or mechanical vibration
CGA over current indicator lit	Cable short, pins 1-3
CGB over current indicator lit	Cable short, pins 1-3
Bridge circuit indicators lit	Circuit failure
CGA unplugged indicator lit	CGA unplugged; open sensor wire
CGB unplugged indicator lit	CGB unplugged; open sensor wire
Microprocessor reset LED lit or flashing	Microprocessor failure
A/D integration failure indicator lit or flashing	Circuit failure
Display reads blank or "–"	Gauge unplugged; open sensor wire

Convectron Gauge Test Procedure

The small diameter sensor wire can be damaged by small voltages. Do not perform electrical continuity tests with instruments applying in excess of 1 volt when the gauge is at vacuum, or 5 V when at atmospheric pressure.

The Convectron gauge should show the following resistances (pin numbers are embossed on the gauge connector):

Figure 8-1 Convectron Gauge Connector



- Pins 1 to 2: 19 to 22 ohms
- Pins 2 to 3: 50 to 60 ohms
- Pins 1 to 5: 180 to 185 ohms

If the resistance from pins 1 to 2 reads about 800 ohms, the sensor wire in the gauge is broken. Replace the gauge tube.

Note: If the resistance values shown here are correct, but you still think the gauge is not reading correctly, the gold plating on the sensor wire may be eroded and the gauge will have to be replaced.

Cleaning Contaminated Convectron Gauges

⚠ WARNING

Exposure to fumes from solvents in an improperly ventilated area can cause personal injury.

To avoid personal injury from inhaling fumes from solvents such as trichloroethylene, perchloroethylene, toluene, and acetone, use these solvents only in a well−ventilated area that exhausts to the outdoors.

⚠ WARNING

Use of flammable solvents near open flame or energized electrical equipment can cause an explosion or fire.

To avoid product damage or personal injury due to explosion or fire, use flammable solvents such as acetone and toluene only in a well−ventilated area that exhausts to the outdoors. Do not use such solvents near an open flame or energized electrical equipment.

The Convectron Gauge can be baked to 150 °C nonoperating while under vacuum with the Connector removed.

All materials were chosen for ultra high vacuum service, corrosion resistance and bakeability. The envelope is type 304 stainless steel. All metallic joints in the envelope are welded. No solder is used within the envelope. The following materials are exposed to the vacuum: Type 304 stainless steel, Carpenter Alloy 52, Kovar, Kapton, gold plated tungsten, borosilicate glass and Dow-Corning 9015 glass. The blue trim cover is rated at 150 °C.

When the small sensor wire is contaminated with oil or other films, its emissivity or its diameter may be appreciably altered and a change of calibration will result. Cleaning with trichloroethylene, perchloroethylene, toluene, or acetone is possible but it must be done very carefully so as not to damage the sensor.

Hold the gauge with the main body horizontal and the port projecting upward at an angle of 45degrees. Slowly fill it with solvent using a standard wash bottle with the spout inserted in the port to where it touches the screen. Let the solvent stand in the gauge for at least ten minutes. Do not shake the gauge. Shaking the gauge with liquid inside can damage the sensor wire. To drain the gauge, position it horizontally with the port facing downward. Slightly warming the gauge will help dry the gauge. Then allow the gauge to dry overnight with the port open and vertically downward.

8.8 Capacitance Manometer Troubleshooting

Refer to Figure 4-5 on page 60 to locate the LEDs on the capacitance manometer printed circuit board.

Table 8-4 Capacitance Manometer Troubleshooting Guide - See Figure 4-5 on page 60

Symptom	Possible Cause
Unstable reading	Mechanical vibration of capacitance manometer, faulty system ground or cable ground
Display always reads 0	Capacitance manometer cable unplugged, no ± 15 V power, faulty cable
-15V Overcurrent LED is ON	-15 V overcurrent. Defective cable, transducer, or circuit board
CG Unplugged LED is ON	The Convectron Gauge is unplugged
A/D Failure LED ON	A/D failure. Defective Normally Open converter circuit
+15V Overcurrent LED is ON	+ 15 V overcurrent. Defective cable, transducer, or circuit board
Convectron Bridge Out LED is ON	Defective PC board, Convectron bridge circuit
CG Overcurrent LED is ON	Convectron overcurrent. Defective gauge or cable
µP Failure LED is ON	Microprocessor failure

8.9 Process Control Troubleshooting

If the µP FAILURE LED is illuminated or flashing, there is a probable circuit failure. Return this product for repair at a service facility designated by Brooks Automation, Inc.

The setpoints are read from non-volatile memory into RAM when the unit powers up. On power up, a checksum is computed and stored in RAM, and is updated whenever a setpoint is changed. It is then periodically re-computed from the existing setpoints and checked against the pre-existing value. If for any reason (such as a power fluctuation or electrical transient in the system) a setpoint becomes corrupted, this method will trap the error.

If a setpoint is found to contain garbled data which cannot be interpreted as a valid setpoint, the setpoint presure will be set to 0.

8.10 RS-232 Troubleshooting

Because the RS-232 “standard” is found in an array of configurations, the first thing to do if trouble arises is check the following configuration options:

1. Check switch settings.

   Be sure the baud rate, character format and framing, and interface protocol are matched to your host computer or terminal's requirements. Note that there may be several mismatched parameters. Check to see if your computer requires the reversed-polarity RTS convention.

2. Check the interface wiring.

   The pin designations for the RS-232 connector are listed in Table 3-5 on page 38. Note that the “received” and “transmitted” data lines are defined as seen by the controller. Many companies supply “null modems” or switch boxes for the purpose of reconfiguring the control and communications lines for particular applications.

3. Check the command format.

   Be sure the strings you output to the controller are in accord with the syntax defined in *Preparing to use RS-232 Computer Interface* on page 87.

Table 8-5 RS-232 Troubleshooting Guide

Symptom	Possible Cause
Microcontroller reset LED lit or flashing. See Figure 3-12 on page 39	Microcontroller failure
No response or garbled output	Baud rate incorrect Character length incorrect or stop bit(s) incorrect Bad cable.
OVERRUN ERROR message	Stop bit(s) incorrect, host software failure
PARITY ERROR message	Parity incorrect
SYNTAX ERROR message	Message to controller not in accord with specified syntax or failure to assert DCD handshake line

8.11 RS-485 Troubleshooting

The first thing to do if trouble arises is check the following configuration options:

1. Check switching settings.

   Be sure the baud rate, character format and framing, and interface protocol are matched to your host computer or terminal's requirements. Note that there may be several mismatched parameters.

2. Check the command format.

   Be sure the strings you output to the controller are in accord with the syntax defined in *Preparing to Use RS-485 Computer Interface* on page 90.

Table 8-6 RS-485 Troubleshooting Guide

Symptom	Possible Cause
Microcontroller reset LED CR1 lit or flashing	Microcontroller failure
No response or garbled output	Baud rate incorrect. Character length incorrect or stop bit(s) incorrect Bad cable
Responds intermittently	Poor cable connections, ground fluctuations (the maximum common mode potential across the system is 7V) and EMI from other sources. The terminating resistor circuit is not installed, or is improperly installed. If the start character is not received properly, the controller may not interpret it as a start character and the controller will not respond. The Host software must be prepared to re-send a command if a response is not generated within a reasonable period of time.
OVERRUN ERROR message	Stop bit(s) incorrect, host software failure
PARITY ERROR message	Parity incorrect
SYNTAX ERROR message	Message to controller not in accord with specified syntax

8.12 Field Installation of a Module

1. Turn OFF power to the Controller.
2. With power OFF, remove any cables from the Controller rear panel.
3. Observe antistatic precautions to avoid damaging static sensitive components inside the chassis. Use a grounded, conductive work surface. Do not handle MOS devices more than absolutely necessary, and only when wearing a high impedance ground strap. Use conductive envelopes to store or ship MOS devices or printed circuit boards. Do not operate the Controller with MOS devices removed from the printed circuit boards.
4. See *Top Cover Removal* on page 27 for how to remove the top cover.
5. Locate correct position for module.
6. Carefully remove the bus ribbon cable from all modules located to the right (as you face the front panel) of the position where the module is to be installed. Remove connectors slowly using pull tabs.
7. Lift out the filler module at the position where the module is to be installed.
8. Install the module in its proper position making sure all ends lock together.
9. Carefully reconnect the bus ribbon connectors.
10. Select appropriate switch settings. See Chapter 2.
11. Replace the top cover as instructed in *Replacing the Controller Cover* on page 47.

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T

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Series 358

Granville-Phillips® Series 358 Micro-Ion® Vacuum Gauge Controller

BROOKS AUTOMATION

6450 Dry Creek Parkway
Longmont, CO 80503 USA
Phone: 1-303-652-4400

15 Elizabeth Drive
Chelmsford, MA 01824 USA
Phone: 1-978-262-2400

Worldwide Customer Service/Support - 24/7
Phone: 1-800-367-4887

To obtain a copy of this instruction manual online, visit our website at *www.brooks.com*
(Adobe® Reader® version 5.0 or higher required)

Instruction Manual

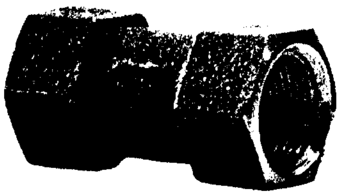
Instruction manual part number 358013
Revision 09 - June 2008

Hays fluid controls

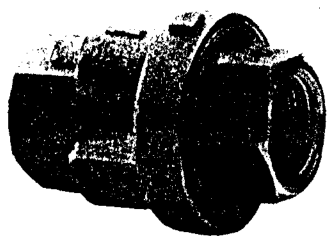
MESURFLO — Automatic Flow Controls

Series 2305 & Series 2307

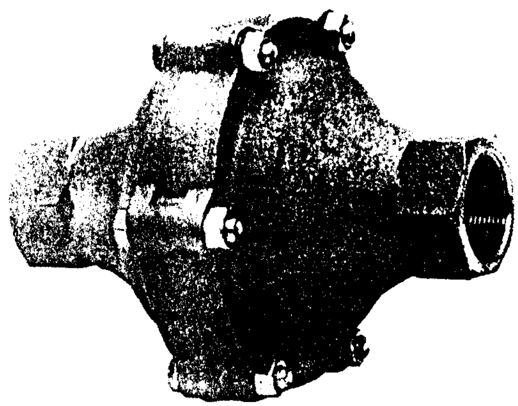
- Constant flow regardless of pressure fluctuation
- Quiet operation
- Pressure Differential Range 15 - 150 psid
- Temperature Range 32° to 160° F
- Accuracy ± 10%
- Suitable for Most Coolants
- Consult factory for differential pressures lower than 15 psid



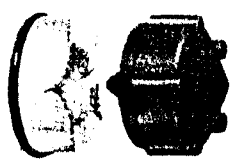
Series 2305 - ¼" ⅜", ½", ¾" IPS



Series 2307 - ¾", 1" IPS



Series 2307 - 1¼", 1½" IPS



Flow Control Assembly

SPECIAL FEATURES

Unique Hays design
Patented Flow Control Assembly provides a constant flow rate on a consistent basis.

Flexing diaphragm is self-cleaning
Maintains clear orifice by flexing action of patented diaphragm assembly which significantly reduces clogging.

Long-life means real savings
Mesurflo Controls will operate efficiently for many years which means little or no down time and loss of productivity.

Diaphragm area is proportioned to pressure
Each Mesurflo is designed specifically to deliver the prescribed flow rate.

Mesurflo can be used for large flow rates.
Mesurflo controls are placed parallel in a single housing providing the specified flow rate even on large flow rates.

Hays fluid controls

MESURFLO — Automatic Flow Controls

TYPICAL APPLICATIONS

- Irrigation and Crop Dusting
- Swimming Pool Filters
- Industrial Equipment Cooling Systems
- Electronic Power Tube Cooling Systems
- Welding Equipment Cooling Systems
- Pump, Compressor, & Vacuum Equipment Cooling Systems
- Industrial Time Fill & Meter Equipment
- Tankless Heater & Heat Transfer Systems
- Water Stream & Water Spray Control
- Film Process & Rinse Systems
- Industrial & Medical Stills
- Balancing Valve for Heating & Air Conditioning Systems
- Water Conservation Applications
- Water Table Drawdown
- Water Source Heat Pumps

CLEVELAND PARTS SPECIALISTS CO
37195-B BEN HUR AVE.
WILLOUGHBY OHIO 44094
PHONE 216-942-2244
FAX 216-942-1654
OUR NEW AREA CODE IS 440

TO ORDER MESURFLO

Specify: catalog number and pipe size

CATALOG NUMBERS

GPM	¼" I.P.S.	⅜" I.P.S.	½" I.P.S.	¾" I.P.S.
[illegible]	2305-0011			
¼	2305-1011			
3/10	2305-0031	2305-0031		
4/10	2305-0041	2305-0041		
½	2305-1021	2305-1021	2305-1021	
6/10	2305-0061	2305-0061	2305-1061	
[illegible]	2305-1031	2305-1031	2305-1031	
1	2305-1041	2305-1041	2305-1041	2305-1041
1¼	2305-1051	2305-1051	2305-1051	2305-1051
1½	2305-1061	2305-1061	2305-1061	2305-1061
1¾	2305-1071	2305-1071	2305-1071	2305-1071
2	2305-1081	2305-1081	2305-1081	2305-1081
2½			2305-1091	2305-1091
3			2305-1101	2305-1101
3½			2305-1111	2305-1111
4			2305-1121	2305-1121
4½				2305-1131
5				2305-1141
6				2305-1151
7				2305-1161
8				2305-1171
9				2305-1181
10				2305-1191

NOTE: Consult factory for fluids other than water.

CATALOG NUMBERS

GPM	¾" I.P.S.	1" I.P.S.	GPM	1-¼" I.P.S.	GPM	1-½" I.P.S.
8	2307-1171	2307-1171	18	2307-1271	50	2307-1451
9	2307-1811	2307-1181	19	2307-1281	55	2307-1461
10	2307-1191	2307-1191	20	2307-1291	60	2307-1471
11	2307-1201	2307-1201	21	2307-1301	65	2307-1481
12	2307-1211	2307-1211	22	2307-1311	70	2307-1491
13	2307-1221	2307-1221	24	2307-1321	75	2307-1501
14	2307-1231	2307-1231	26	2307-1331	80	2307-1511
15	2307-1241	2307-1241	28	2307-1341	85	2307-1521
16	2307-1251	2307-1251	30	2307-1351	90	2307-1531
17	2307-1261	2307-1261	32	2307-1361	95	2307-1541
18	2307-1271	2307-1271	34	2307-1371	100	2307-1551
19		2307-1281	36	2307-1381		
20		2307-1291	38	2307-1391		
21		2307-1301	40	2307-1401		
22		2307-1311	42	2307-1411		
			44	2307-1421		
			46	2307-1431		
			48	2307-1441		

Example: Mesurflo with ⅜, 6/10 GPM
Order: 2305-0061 ⅜"

TECHNICAL DATA

How the Mesurflo Controls the Flow

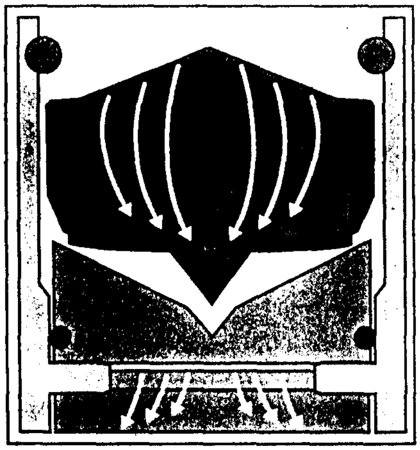


Figure 1 PSID-0
Diaphragm-original shape

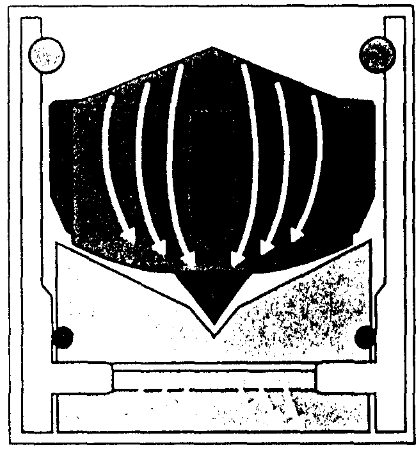


Figure 2 PSID-15
Diaphragm-starting to flex into contoured orifice plate

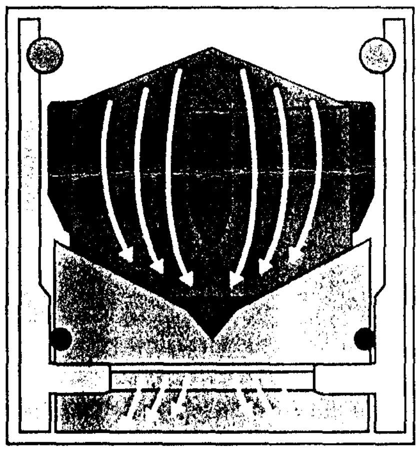


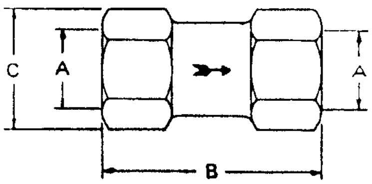
Figure 3 PSID-80
Diaphragm-is fully flexed into the orifice plate.

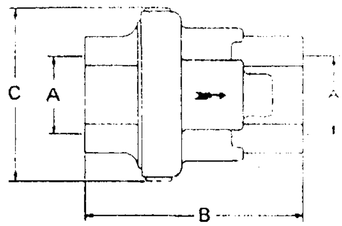
For a pressure differential range of 15 to 150 psi, the rubber diaphragm will flex into the contoured orifice plate to increase flow restriction as the pressure drop increases. Both the rubber diaphragm and the contoured orifice plate are rigidly controlled to provide a constant flow rate over the pressure differential range. This "flexing" of the rubber diaphragm against the fixed orifice plate makes the Mesurflo difficult to clog and will not damage due to cavitation. The "flexing" action actually chews up debris preventing clogging. Outside of the pressure drop window, the controller performs similiar to a fixed orifice.

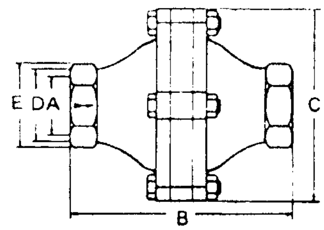
Note to piping system designers:
The HAYS Mesurflo is a constant flow rate device. Since it is a variable orifice that changes to govern the flow, it can not be described with a Cv or a pressure drop at a given flow for piping system design purposes. Conversely, the designer may assume a constant flow rate over the pressure differential range of 15 to 150 psid as one uses constant pressure in system design.

Hays fluid controls

MESURFLO — Automatic Flow Controls





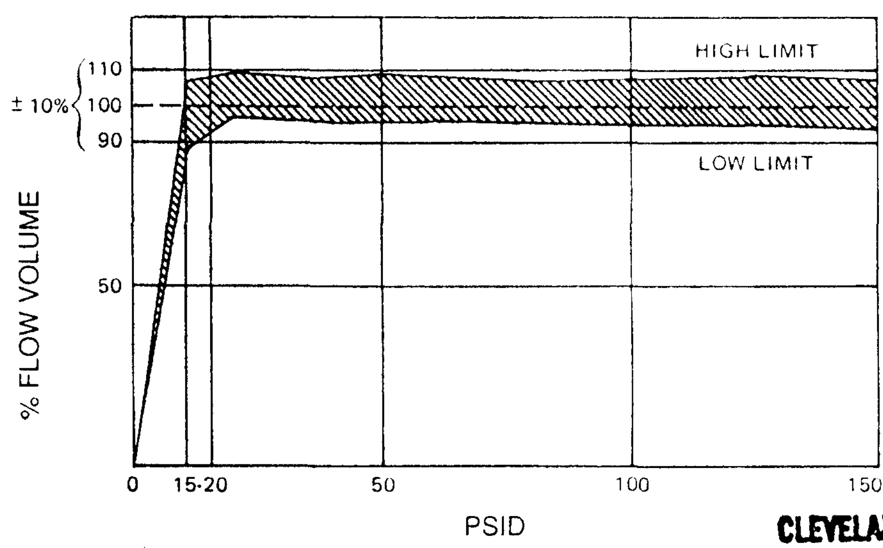


2305	2307	2307
¼", ⅜", ½", ¾"	¾", 1"	1¼", 1½"

DIMENSIONS

	2305				2307		2307	
A. Pipe Size	¼"	⅜"	½"	¾"	¾"	1"	1¼"	1½"
B. Overall Length	2"	1¾"	2 7/32"	2 9/16"	3 19/32"	3 19/32"	6 3/16"	8⅞"
C. Diameter Across Corners	1 1/16"	1 1/16"	1¼"	1 17/32"	2⅞"	2⅞"	2 5/16"	2¾"
D. Hex Flats							2"	2⅜"
E. Diameter							5¼"	7⅜"

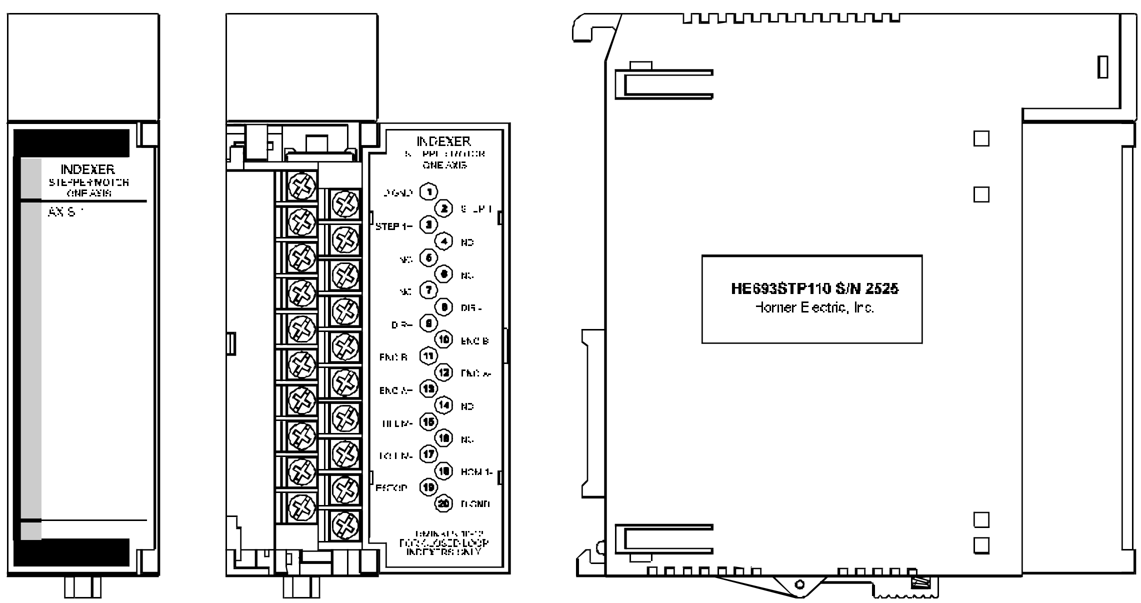
FLOW CAPACITY CHART



ATTENTION READER:
REVISION PAGES ATTACHED
AFTER PAGE 52 OF THIS MANUAL.

Horner Electric's Stepper Positioning Module

for models **HE693STPxx0 Revision G or later**
AND
models **HE693STPxx1 Revision A or later**
User's Manual



Horner Electric Advanced Products Group

12-11-97 **MAN0084-06**

LIMITED WARRANTY AND LIMITATION OF LIABILITY

Horner Electric, Inc. ("HE") warrants to the original purchaser that the Stepper Positioning Module manufactured by HE is free from defects in material and workmanship under normal use and service. The obligation of HE under this warranty shall be limited to the repair or exchange of any part or parts which may prove defective under normal use and service within two years from the date of manufacture or eighteen (18) months from the date of installation by the original purchaser, which ever occurs first. Such defect to be disclosed to the satisfaction of HE after examination by HE of the allegedly defective part or parts. THIS WARRANTY IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES EXPRESSED OR IMPLIED INCLUDING THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR USE AND OF ALL OTHER OBLIGATIONS OR LIABILITIES AND HE NEITHER ASSUMES, NOR AUTHORIZES ANY OTHER PERSON TO ASSUME FOR HE, ANY OTHER LIABILITY IN CONNECTION WITH THE SALE OF THIS STEPPER POSITIONING MODULE. THIS WARRANTY SHALL NOT APPLY TO THIS STEPPER POSITIONING MODULE OR ANY PART THEREOF WHICH HAS BEEN SUBJECT OT ACCIDENT, NEGLIGENCE, ALTERATION, ABUSE, OR MISUSE. HE MAKES NO WARRANTY WHATSOEVER IN RESPECT TO ACCESSORIES OR PARTS NOT SUPPLIED BY HE. THE TERM "ORIGINAL PURCHASER", AS USED IN THIS WARRANTY, SHALL BE DEEMED TO MEAN THAT PERSON FOR WHOM THE STEPPER POSITIONING MODULE IS ORIGINALLY INSTALLED. THIS WARRANTY SHALL APPLY ONLY WITHIN THE BOUNDARIES OF THE CONTINENTAL UNITED STATES.

In no event, whether as a result of breach of contract, warranty, tort (including negligence) or otherwise, shall HE or its suppliers be liable for any special, consequential, incidental or penal damages including, but not limited to, loss of profit or revenues, loss of use of the products or any associated equipment, damage to associated equipment, cost of capital, cost of substitute products, facilities, services or replacement power, down time costs, or claims of original purchaser's customers for such damages.

To obtain warranty service, return the product to your distributor after obtaining a "Return Material Authorization" (RMA) number. Send the module with a description of the problem, proof of purchase, post paid, insured, in a suitable package.

TABLE OF CONTENTS

PREFACE

This manual explains how to use the Horner Electric Stepper Positioning Modules, model numbers HE693STPxx0, revision G or later, and HE693STPxx1, revision A or later for use with GE Fanuc Series 90 and CEGELEC Alspa 8000 family of Programmable Logic Controllers

ABOUT THE PROGRAMMING EXAMPLES

Any example programs and program segments in this manual are included solely for illustrative purposes. Due to the many variables and requirements associated with any particular installation, Horner Electric cannot assume responsiblity or liability for actual use based on the examples and diagrams. It is the sole responsibility of the system designer utilizing the Stepper Positioning Module to appropriately design the end system, to appropriately integrate the Stepper Positioning Module and to make safety provisions for the end equipment as is usual and customary in industrial applications as defined in any codes or standards which apply.

COPYRIGHT

This manual is for use with the Horner Electric Stepper Indexer for GE Fanuc Series 90 and CEGELEC Alspa 8000 family of Programmable Logic Controllers.

TRADEMARK ACKNOWLEDGEMENTS

MODULE SPECIFICATIONS

I/O Connector Specifications

PARAMETER	MIN	MAX	UNITS
+5V Power Output (Step/Direction)	-	300	mA
Step Outputs Frequency	DC	245	KHz
Step Outputs High (-20mA)	2.5	-	Vdc
Step Outputs Low (+20mA)	-	0.5	Vdc
Direction Output Setup Time	2	-	mS
Direction Output High (-20mA)	2.5	-	Vdc
Direction Output Low (+20mA)	-	0.5	Vdc
Direction Output High (-60mA, Rev A)	2.5	-	Vdc
Direction Output Low (+60mA, Rev A)	-	0.5	Vdc
Encoder Input Frequency	DC	1.0	MHz
Encoder Single-Ended Threshold	1.2	1.6	Vdc
Encoder Differential Threshold High	-	0.2	Vdc
Encoder Differential Threshold Low	-.2	-	Vdc
Home Inputs Off	12	-	Vdc
Home Inputs On (+1mA)	-	9	Vdc
End Limits Inputs Off	12	-	Vdc
End Limits Inputs On (+1mA)	-	9	Vdc
Emergency Stop Input On	12	-	Vdc
Emergency Stop Input Off (+1mA)	-	9	Vdc

Power Load Specifications

PARAMETER	MIN	MAX	UNITS
+5Vdc (Logic)	200	500	mA
+24Vdc (Relay)	-	0	mA
+24Vdc (Isolated)	-	0	mA

Environmental Specifications

PARAMETER	MIN	MAX	UNITS
Operating Temperature	0	60	°C
Storage Temperature	-40	85	°C
Humidity	5	95	%RH

SECTION 1: INTRODUCTION

Congratulations on your purchase of a Horner Electric Stepper Positioning Module (SPM30)! The SPM30 is an intelligent, programmable motion control option module for the GE Fanuc Series 90-30 Programmable Logic Controller (PLC).

Within a stepper motor control system, the SPM30 acts as a programmable indexer which is capable of interfacing to a wide variety of stepper motor translator drives, limit switches and encoder feedback devices.

In addition, its high maximum step rate and wide dynamic range position control make the SPM30 compatible with microstepping translator drives, for smooth, quiet operation.

1.1 Stepper Positioning Module (SPM30) Features

The Stepper Positioning Module offers a variety of features, including:

- ☑ One and Three Axis (multiplexed) models
- ☑ Up to 245,730 steps (or microsteps) per second
- ☑ Motion may be completely controlled by ladder program
- ☑ Non-volatile memory storage
- ☑ Auto "find home" and manual jogging
- ☑ Moves to relative and/or absolute positions
- ☑ Home and Overtravel inputs
- ☑ Power-up/watchdog timer safety interlock
- ☑ Emergency Stop input
- ☑ Incremental Encoder input (some models)
- ☑ Programmable position, velocity, and acceleration
- ☑ Automatic ramp-down deceleration calculation
- ☑ Trapezoidal and Triangular velocity profiles

SECTION 2: INSTALLATION

2.1 Module Placement

The Stepper Positioning Module may be placed in any I/O module slot of the GE Fanuc Series 90-30 model 311, 321 or 331. The user should **NEVER** insert or remove the Stepper Positioning Module while power is applied to the host PLC. Follow the guidelines defined in the Series 90-30 literature for proper module insertion and removal.

2.2 Terminal Wiring

The Stepper Positioning Module is equipped with a 20 contact removable terminal block. The pinout of the removable terminal block is illustrated on the following page.

Terminals are provided for interfacing the Stepper Positioning Module with a variety of devices, including:

a) Stepper Motor Drives (Translators),
b) Incremental encoders (quadrature or up/down)
c) Mechanical and Proximity type limit switches
d) E-stop pushbuttons.

The sign (+ or -) after each signal name indicates what state the signal is in when it is active. Active-high is indicated by +, while active-low is indicated by -.

The motor outputs may be connected to translator drives with either differential or single-ended inputs. For single-ended drives, select the motor output whose active signal state (+/-) matches the drive's input.

The encoder inputs may be connected to an encoder with either differential or single-ended outputs. For single-ended encoders, use the active high encoder inputs (ENCODERA+ and ENCODERB+).

The emergency stop input should be connected to terminal 20 via a normally-closed ESTOP switch for normal operation.

PIN	SIGNAL	UNITS	Type
1	D GND	Digital Ground	Diff
2	STEP1-	Axis 1 motor step outputs	Diff
3	STEP1+		Diff
4	STEP2-	Axis 2 motor step outputs	Diff
5	STEP2+		Diff
6	STEP3-	Axis 3 motor step outputs	Diff
7	STEP3+		Diff
8	DIR-	Motor direction outputs	Diff
9	DIR+		Diff
10	ENC B-	Phase B incremental encoder inputs	Diff
11	ENC B+		Diff
12	ENC A-	Phase A incremental encoder inputs	Diff
13	ENC A+		Diff
14	HOM 3-	Axis 3 home input	S.E./Isol
15	HI LIM-	Upper end limit input	S.E./Isol
16	HOM 2-	Axis 2 home input	S.E./Isol
17	LO LIM-	Lower end limit input	S.E./Isol
18	HOM 1-	Axis 1 home input	S.E./Isol
19	ESTOP+	Emergency stop input	S.E./Isol
20	D GND / I GND	Digital Ground or Isolated Ground	S.E./Isol

Figure 2-1. Stepper Positioning Module Terminal Strip Pinout.
(Type: Diff=Differential, S.E./Isol.=Single Ended or Isolated)

2.3 LED Indicators

INDICATOR	COLOR	DESCRIPTION
STOP	Red	Stopped
RAMP	Yellow	Accelerating or decelerating
CNST	Green	Moving at constant velocity

Figure 2-2. Stepper Positioning Module LED Indicators.

2.4 Configuring the Series 90-30

Before any I/O module can be accessed by the Series 90-30, the "makeup" of I/O modules must be defined inside the Series 90-30 CPU. This process is called "configuration". Stepper Positioning Module configuration is supported by Logicmaster 90, version 2.01 or later . Alternatively, the user may configure the Series 90-30 using the Hand-Held Programmer.

2.4.1 Configuration with Logicmaster

The Stepper Positioning Module is programmed in the Logicmaster 90-30 Configuration program as a foreign module. From the main configuration menu, select *I/O Configuration* **(F1)**, cursor over to the slot containing the module and select *Other* **(F8)**, and *Foreign* **(F3)**. The foreign module screen appears (see below).

```
                          SOFTWARE  CONFIGURATION
 SLOT   Catalog #: FOREIGN                FOREIGN MODULE
   2

FRGN
        Module ID   :    3
        %I Ref Adr :   %I0001   Byte 1      : 00000001   Byte 9     : 00
        %I Size     :     16    Byte 2      : 00000000   Byte 10    : 00
        %Q Ref Adr :   %Q0001   Byte 3      : 00         Byte 11    : 00
        %Q Size     :     16    Byte 4      : 00         Byte 12    : 00
        %AI Ref Adr:   %AI001   Byte 5      : 00         Byte 13    : 00
        %AI Size    :      2    Byte 6      : 00         Byte 14    : 00
        %AQ Ref Adr:   %AQ001   Byte 7      : 00         Byte 15    : 00
        %AQ Size    :      6    Byte 8      : 00         Byte 16    : 00
```

Figure 2-3. Logicmaster 90-30 Configuration Foreign Module Screen.

The foreign module screen contains many different parameters. The first column of parameters configures the I/O references allocated to the module. The amount of I/O references required by the module will depend upon its model number. See the following chart:

<table>
<tr><th>MODEL</th><th>%I</th><th>%Q</th><th>%AI</th><th>%AQ</th><th>Byte 1</th><th>Byte 2</th><th>Byte 3</th></tr>
<tr><td>HE693STP100</td><td rowspan="8">16</td><td rowspan="8">16</td><td rowspan="2">2</td><td>6</td><td rowspan="8">1</td><td rowspan="8">0</td><td rowspan="8">0</td></tr>
<tr><td>7HE693STP101</td><td>7</td></tr>
<tr><td>HE693STP110</td><td rowspan="2">4</td><td>6</td></tr>
<tr><td>HE693STP111</td><td>7</td></tr>
<tr><td>HE693STP300</td><td rowspan="2">2</td><td>6</td></tr>
<tr><td>HE693STP301</td><td>7</td></tr>
<tr><td>HE693STP310</td><td rowspan="2">4</td><td>6</td></tr>
<tr><td>HE693STP311</td><td>7</td></tr>
</table>

Figure 2-4. I/O Reference and Bytes 1-3 configuration parameters.

The second column of configuration parameters contains a number of additional configuration bytes. The stepper module requires that Byte 1 through Byte 7 be configured. For these parameters, see the chart above for Bytes 1-3, and the chart below for Bytes 4-7.

<table>
<tr><th>MODEL</th><th>Byte 4</th><th>Byte 5</th><th>Byte 6</th><th>Byte 7</th></tr>
<tr><td>HE693STP100</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td></tr>
<tr><td>7HE693STP101</td></tr>
<tr><td>HE693STP110</td><td rowspan="2">Encoder
Type</td><td rowspan="2">Encdr. Multiplier
(01-FF)H</td><td rowspan="2">Encoder Divisor
(01-0F)H</td><td rowspan="2">Encdr. Tolerance
(00-FF)H</td></tr>
<tr><td>HE693STP111</td></tr>
<tr><td>HE693STP300</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td></tr>
<tr><td>HE693STP301</td></tr>
<tr><td>HE693STP310</td><td rowspan="2">Encoder
Type</td><td rowspan="2">Encoder
Multiplier</td><td rowspan="2">Encoder
Divisor</td><td rowspan="2">Encoder
Tolerance</td></tr>
<tr><td>HE693STP311</td></tr>
</table>

Figure 2-5. Bytes 4-7 configuration parameters.

Bytes 4-7 are utilized by those indexer models which feature encoder feedback capability. Byte 4 configures the type of encoder used (see Figure 2-6), Byte 5 and 6 set the encoder multiplier and divisor, and Byte 7 sets the encoder tolerance. For details on encoder feedback operation, see Chapter 5.

BYTE 4 VALUE	ENCODER TYPE
0	NONE
1	QUADRATURE
2	UP/DOWN
3	QUAD NO MARKER

Figure 2-6. Bytes 4 values for different encoder types.

2.5.2 Configuration Using the Hand Held Programmer

When utilizing the Hand Held Programmer, select configuration mode. Press the DOWN arrow until the slot containing the stepper module is selected. Press READ, then the ENTER button. One by one, configure the starting %I, %Q, %AI, and %AQ addresses allocated to the module with the numeric and ENTER keys. After completing I/O address configuration, press the RIGHT arrow key to display additional configuration parameters. The first two parameters, "baud rate" and "parity", will not affect module operation; these are for future use only. The "encoder type" parameter is configured using the +/- key and ENTER. The "encoder multiplier", "encoder divisor", and "encoder tolerance" parameters are set using the numeric keys and ENTER.

For additional information on Hand Held Programmer operation, see the *Hand Held Programmer User's Manual* from GE Fanuc, or contact Horner Electric.

CHAPTER 3: CONTROLLING MOTION

The Stepper Positioning Module communicates with the 90-30 CPU via a seriesof bit type (%I and %Q) and integer type (%AI and %AQ) I/O registers. These registers are assigned to the SPM30 during rack configuration (see Chapter 2). Executing motion control with the 90-30 and the SPM30 is accomplished by properly monitoring and manipulating these bits and words.

These I/O registers can be divided up into four different types; **Status Bits, Command Bits, Status Words,** and **Command Words**. These registers and their role in the control and monitoring of the SPM30 is described in detail below.

3.1 Status Bit Inputs

The Status Bits are the 16 digital inputs (%I) assigned to the SPM30. The CPU uses the %I status bits to determine what the SPM30 is doing and whether or not an error has occurred. These status bits are summarized in the table below:

POINT	DESCRIPTION
%I1	Emergency Stop Error
%I2	Lower End Limit Error
%I3	Upper End Limit Error
%I4	Illegal Move Error
%I5	Motor Stalled Error
%I6	Future Use
%I7	Future Use
%I8	Power-up/Watchdog Error
%I9	Current Position Valid
%I10	Pre-empted Move Resumable
%I11	Axis 2 Selected
%I12	Axis 3 Selected
%I13	At Home
%I14	Accelerating
%I15	Decelerating
%I16	Moving

Note that the I/O addresses of the bits are listed in the table starting with %I1, but the bits may reside in any 16 consecutive legal %I addresses.

At power-up or after a watchdog timer reset, all status bits will be OFF, except the POWER-UP/WATCHDOG ERROR (%I8) will be ON.

If any of the lower eight bits (%I1 to %I8) is ON, the SPM30 has detected an error condition. These bits will be latched ON until the CLEAR ERROR command (%Q14) is issued. No other commands will be obeyed by the SPM30 while an error bit is ON.

The upper eight bits (%I9 to %I16) reflect various other SPM30 status conditions and are not affected by the CLEAR ERROR command.

3.2 Command Bit Outputs

The Command Bits are the 16 digital outputs (%Q) assigned to the SPM30. The CPU uses the %I status bits to trigger action in the SPM30. These command bits are summarized in the table below:

POINT	DESCRIPTION
%Q1	Select Axis 1
%Q2	Select Axis 2
%Q3	Select Axis 3
%Q4	Find Home Up
%Q5	Find Home Down
%Q6	Jog Up
%Q7	Jog Down
%Q8	Move Relative
%Q9	Move Absolute
%Q10	Resume Move
%Q11	Future Use
%Q12	Future Use
%Q13	Set Current Position
%Q14	Clear Error(s)
%Q15	Decelerate and Stop
%Q16	Immediate Stop

All %Q command bits are OFF to ON edge sensitive. This means that the command will be obeyed only when the SPM30 sees it go from OFF to ON. The SPM30 will always detect this transition in less than one CPU sweep time, thus allowing the use of "one-shots" to trigger commands.

The JOG UP and JOG DOWN commands (%Q6 and %Q7) are unique in that they are also ON to OFF edge sensitive.

Note that since the POWER-UP/WATCHDOG ERROR status bit (%I8) is ON at power-up or after a watchdog timer reset, the CLEAR ERROR command (%Q14) must be issued before any other command may be executed. This is an important safety interlock.

Also, some command bits are ignored depending on the state of other status bits. For example, if the MOVING status bit (%I16) is ON, the only legal command bits are DECELERATE AND STOP (%Q15) and IMMEDIATE STOP (%Q16).

Finally, in the event that more than one legal %Q goes from OFF to ON in the same CPU sweep, the one with the highest %Q number will be obeyed and the others will be ignored. Note that this gives the Immediate Stop command (%Q16) the highest priority.

3.3 Status Word Inputs

SPM30 modules use either two or four %AI status words. All models use %AI1 and %AI2, but %AI3 and %AI4 are used only by SPM30 models which support encoder feedback. These words are described in the table below:

POINT	DESCRIPTION	MINIMUM	MAXIMUM
%AI1	Motor Position (Low Word)	-8,388,608	+8,388,607
%AI2	Motor Position (High Word)		
%AI3	Encoder Position (Low Word)	-8,388,608	+8,388,607
%AI4	Encoder Position (High Word)		

3.3.1 Motor Position

The first two status words (%AI1 and %AI2) are treated as a single 32-bit signed integer value representing the MOTOR POSITION for the selected axis.

MOTOR POSITION is continuously updated (up or down) based on step pulses sent by the SPM30 to the stepper motor translator drive.

Note that at power-up or after a watchdog timer reset, this value will be set to zero and is considered invalid. This is reflected by the fact that the CURRENT POSITION VALID status bit is OFF.

The MOTOR POSITION will continue to be invalid until a FIND HOME UP (%Q4), FIND HOME DOWN (%Q5) or SET CURRENT POSITION (%Q13) command is executed successfully. Until this happens, the SPM30 will not obey the MOVE ABSOLUTE command (%Q9).

Note also, that MOTOR POSITION may become invalid again if motion stops suddenly, as a result of EMERGENCY STOP ERROR (%I1), LOWER END LIMIT ERROR (%I2), UPPER END LIMIT ERROR (%I3), MOTOR STALLED ERROR (%I5) or IMMEDIATE STOP command (%Q16).

3.3.2 Encoder Position

For SPM30 models which support encoder feedback, the %AI3 and %AI4 status words are treated as a single 32-bit signed integer value representing the ENCODER POSITION for Axis 1.

ENCODER POSITION is continuously updated (up or down) based on feedback pulses sent by the encoder to the SPM30, regardless of which axis is currently selected.

Note that at power-up or after a watchdog timer reset, this value will be set to zero and is considered invalid. This is reflected by the fact that the CURRENT POSITION VALID status bit is OFF.

If the SPM30 is properly configured (see Chapter 5), ENCODER POSITION will track Axis 1's MOTOR POSITION.

Note that when ENCODER POSITION doesn't match MOTOR POSITION exactly, a position validation error has been detected. There are several possible causes for this error (see Chapter 5).

Some position validation errors can't be avoided, which is why the SPM30 supports an error tolerance configuration parameter (ENCODER TOL).

3.4 Command Word Outputs

The %AQ command words are qualifiers for the %Q command bits. The words and their minimum and maximum values are detailed in the chart below:

POINT	DESCRIPTION	MINIMUM	MAXIMUM
%AQ1	Destination Position (Low Word)	-8,388,608	+8,388,607
%AQ2	Destination Position (High Word)		
%AQ3	Velocity Resolution	20	65,535
%AQ4	Base Velocity	1	8,190
%AQ5	Running Velocity	2	8191
%AQ6	Acceleration Time (mS)	1	27300
%AQ7	Deceleration Time (mS)	0	27,300

Typically, the %AQ command words are set to appropriate values and then one of the %Q command bits is changed from OFF to ON.

On the CPU sweep following the one in which the %Q was transitioned from OFF to ON, the %AQ command words may be changed to prepare for the next move without affecting the move in progress.

The exception to this rule is, that the DESTINATION POSITION must not be disturbed during a FIND HOME UP or a FIND HOME DOWN command, until either an error occurs or the CURRENT POSITION VALID status bit goes ON.

3.4.1 Destination Position

The first two command words (%AQ1 and %AQ2) are treated as a single 32-bit signed integer value representing the DESTINATION POSITION for the selected axis.

For the FIND HOME UP, FIND HOME DOWN and SET CURRENT POSITION commands, the DESTINATION POSITION is the value to be loaded into MOTOR POSITION when the command completes sucessfully.

For the MOVE ABSOLUTE command, the DESTINATION POSITION is the absolute position to move to.

For the MOVE RELATIVE command, the DESTINATION POSITION is the relative distance to move above or below "wherever we are now".

3.4.2 Velocity Resolution

This command word determines the resolution of the BASE VELOCITY (%AQ4) and the RUNNING VELOCITY (%AQ5) command words.

The selectable resolutions range from .01 pulses per second to 30 pulses per second according to the following formula:

$$\textbf{VELOCITY RESOLUTION} = \frac{\textbf{600}}{\textbf{\%AQ3}} \qquad \textbf{[pulses per second]}$$

The following table shows some useful %AQ3 settings along with the resulting velocity resolution and maximum velocity:

%AQ3	Velocity Resolution	Maximum Velocity
20	30.0 pulses per second	245,730.0 pulses per second
60	10.0 pulses per second	81,910.0 pulses per second
120	5.0 pulses per second	40,995.0 pulses per second
300	2.0 pulses per second	16,382.0 pulses per second
600	1.0 pulses per second	8,191.0 pulses per second
1200	0.5 pulses per second	4,095.5 pulses per second

3.4.3 Base Velocity

This command word determines the velocity the SPM30 starts at when executing one of the motion commands (%Q4 through %Q10).

A typical move will start at the BASE VELOCITY and accelerate to the RUNNING VELOCITY. Then, if the move ends normally, it will decelerate from RUNNING VELOCITY to BASE VELOCITY, and then stop.

Also, near the end of a FIND HOME UP or FIND HOME DOWN command, the motor will move at a constant BASE VELOCITY while searching for the exact home position.

BASE VELOCITY depends on VELOCITY RESOLUTION (%AQ3) and is calculated according to the following formula:

$$\textbf{BASE VELOCITY} = \%AQ4 \times \frac{600}{\%AQ3} \quad \text{[pulses per second]}$$

3.4.4 Running Velocity

This command word determines the maximum velocity the motor will be moving after the SPM30 finishes accelerating.

The RUNNING VELOCITY must be greater than the BASE VELOCITY.

RUNNING VELOCITY depends on VELOCITY RESOLUTION (%AQ3) and is calculated according to the following formula:

$$\textbf{RUNNING VELOCITY} = \%AQ5 \times \frac{600}{\%AQ3} \quad \text{[pulses per second]}$$

3.4.5 Acceleration Time

This command word determines the maximum time spent accelerating from the BASE VELOCITY to the RUNNING VELOCITY during a move.

If the move ends normally, this same amount of time is spent decelerating from the RUNNING VELOCITY to the BASE VELOCITY before stopping.

Note that if the move is halfway done before acceleration to the RUNNING VELOCITY is complete, the SPM30 will start decelerating right away. In this case, the acceleration and deceleration times are decreased and the velocity profile becomes triangular.

Also note that the maximum useful value for ACCELERATION TIME is dependent on the BASE VELOCITY (%AQ4) and RUNNING VELOCITY (%AQ5) according to the following formula:

$$\textbf{MAXIMUM USEFUL \%AQ6} = \frac{\%AQ5 - \%AQ4}{0.3} \quad \text{[milliseconds]}$$

3.4.6 Deceleration Time

This command word determines the maximum time spent decelerating from the RUNNING VELOCITY to the BASE VELOCITY during a move.

Also note that the maximum useful value for DECELERATION TIME is dependent on the BASE VELOCITY (%AQ4) and RUNNING VELOCITY (%AQ5) according to the same formula as used with acceleration.

Note that only models HE693STPxx1 allow for independent control of acceleration time and deceleration time.

If the deceleration time is set to 0, the module will automatically set the actual deceleration time equal to the acceleration time.

CHAPTER 4: COMMAND DESCRIPTIONS

COMMAND DESCRIPTIONS

These pages describe the commands in more detail. Each command description includes the following information:

(1) Command Name
(2) Command Bit(s)
(3) Status Bits Required
(4) Status Bits Affected
(5) Status Words Required
(6) Status Words Affected
(7) Command Words Required
(8) Command Description

SELECT AXIS

Command Numbers:	%Q1, %Q2, %Q3
Status Bits Required:	%I1 thru %I8 and %I16 must be OFF
Status Bits Affected:	%I9 and %I13
Status Words Required:	%AI1, %AI2
Status Words Affected:	%AI1, %AI2
Command Words Required:	None

Command Description:

These commands are used to select a new axis to be acted upon by the other commands as follows:

%Q1	Selects axis 1 to be the new current axis
%Q2	Selects axis 2 to be the new current axis
%Q3	Selects axis 3 to be the new current axis

At power-up or after a watchdog timer reset, axis 1 is selected by default. %Q2 and %Q3 are illegal commands for the STP100 and STP110 (1 axis models).

When a new axis is selected, the following sequence takes place:

(1) If requested new axis is the same as the old axis or is illegal, do nothing.

(2) Otherwise, save old axis' MOTOR POSITION, CURRENT POSITION VALID and AT HOME status,

(3) Set axis multiplexer for the new axis,

(4) Restore last known MOTOR POSITION, CURRENT POSITION VALID and AT HOME status for the new axis,

(5) If the new axis' AT HOME status has changed since the last time it was selected, its CURRENT POSITION VALID status is turned OFF.

FIND HOME UP and FIND HOME DOWN

Command Numbers: %Q4, %Q5

Status Bits Required: %I1 thru %I8 and %I16 must be OFF
Status Bits Affected: %I1 thru %I5, %I9, %I13 thru %I16
Status Words Required: None
Status Words Affected: %AI1 thru %AI4
Command Words Required: %AQ1 thru %AQ6

Command Description:

These commands are used to start a search for the current axis' home reference position as follows:

%Q4 Searches for home in the UP direction
%Q5 Searches for home in the DOWN direction

When searching for home, the following sequence takes place:

(1) CURRENT POSITION VALID status is turned OFF,

(2) The current axis is moved normally (starts at BASE VELOCITY and accelerates to RUNNING VELOCITY) in the selected direction,

(3) When the axis' home input becomes active, motion is stopped immediately,

(4) Then, just in case we shot right past home, the axis is run at the BASE VELOCITY in the opposite direction till the home input becomes active again,

(5) Motion then continues in the same direction as step (4) above, (still at the BASE VELOCITY), till the home input is inactive for 50 mS,

(6) Then the direction is reversed again, and the axis is moved at the BASE VELOCITY till the home input is active at which time the axis stops precisely AT HOME,

(7) DESTINATION POSITION is copied into MOTOR POSITION (and into EN CODER POSITION if axis 1 is selected) and CURRENT POSITION VALID status bit is turned ON.

FIND HOME UP and FIND HOME DOWN (cont'd)

Command Description - (cont'd):

If the current axis is axis 1, and the ENCODER configuration parameter is set to QUAD, there is a slight variation in step (3) of the above sequence as follows:

(3) When the axis' End Limit input for the current direction becomes active, motion is stopped immediately,

This variation assumes the encoder's marker output is to be used as axis 1's home input (see later chapter for more information on the use of encoder feedback devices).

Since the marker output on a rotary encoder typically occurs several times during a full stroke move, this technique allows the marker which occurs closest to the limit switch to be used as the home position.

For best results, the marker to limit switch relationship should be mechanically adjusted such that the marker occurs at appoximately half of an encoder revolution away from the limit switch.

JOG UP and JOG DOWN

Command Numbers: %Q6, %Q7

Status Bits Required:	%I1 thru %I8 and %I16 must be OFF
Status Bits Affected:	%I1 thru %I5, %I13 thru %I16
Status Words Required:	None
Status Words Affected:	%AI1 thru %AI4
Command Words Required:	%AQ3 thru %AQ6

Command Description:

These commands are used to perform manual jogging on the current axis as follows:

%Q6	Starts a manual jog move in the UP direction
%Q7	Starts a manual jog move in the DOWN direction

When one of the jog command bits goes ON, the current axis starts in the selected direction at the BASE VELOCITY and accelerates to the RUNNING VELOCITY.

The axis will continue moving at the RUNNING VELOCITY until the jog command bit goes OFF. At that time, the axis will decelerate to the BASE VELOCITY and then stop.

If the jog command bit goes OFF before the axis has reached RUNNING VELOCITY, acceleration and deceleration times will be decreased and the velocity profile becomes triangular.

MOVE RELATIVE and MOVE ABSOLUTE

Command Numbers:	%Q8, %Q9
Status Bits Required:	%I1 thru %I8 and %I16 must be OFF; %I9 must be ON for %Q9 command
Status Bits Affected:	%I1 thru %I5, %I10, %I13 thru %I16
Status Words Required:	%AI1, %AI2 required for %Q9 command
Status Words Affected:	%AI1 thru %AI4
Command Words Required:	%AQ1 thru %AQ6

Command Description:

These commands are used to perform relative or absolute moves on the current axis as follows:

%Q8	Performs a relative move
%Q9	Performs an absolute move

These commands perform a programmed move up or down to a relative target position.

If doing a relative move, the relative target position is taken directly from DESTINATION POSITION and it IS NOT necessary for CURRENT POSITION VALID to be ON.

If doing an absolute move, the relative target position is calculated as the difference between the DESTINATION POSITION and the MOTOR POSITION and therefore it IS necessary for CURRENT POSITION VALID to be ON.

Normally the move will start at the BASE VELOCITY and accelerate to the RUNNING VELOCITY until it is time to decelerate back down to the BASE VELOCITY and then stop. This type of move is said to have a trapezoidal velocity profile.

If the move gets halfway to its relative target position before accelerating to the RUNNING VELOCITY, the SPM3030 will start decelerating at that point. In this case, the accel- eration and
deceleration times are decreased and the velocity profile becomes triangular.

RESUME MOVE

Command Number: %Q10

Status Bits Required: %I1 thru %I8 and %I16 must be OFF; %I10 must be ON
Status Bits Affected: %I1 thru %I5, %I10, %I13 thru %I16
Status Words Required: None
Status Words Affected: %AI1 thru %AI4
Command Words Required: None

Command Description:

This command resumes a previously pre-empted relative or absolute move.

If a MOVE RELATIVE or MOVE ABSOLUTE command was previously pre-empted by a DECELERATE AND STOP command, and no other commands have been issued since then, the PRE-EMPTED MOVE RESUMABLE status bit will be ON.

In this case, the RESUME MOVE command can be issued to restart the pre-empted move from where it left off. Of course, this action will turn the PRE-EMPTED MOVE RESUMABLE status bit back OFF.

Note that the resume logic is such that a move may be pre-empted and resumed any number of times until one of the following occurs:

(1) The move reaches its originally programmed relative target position,
(2) An error occurs (such as end limit or emergency stop),
(3) Some command other than %Q10 is issued after the move is pre-empted.

The RESUME MOVE command is especially useful for "manually assisted programmed moves". For example, the machine operator may trigger a MOVE ABSOLUTE command by pressing a footswitch. If he continues to press the footswitch, the move will continue until it reaches its programmed target position.

However, at the operator's option, he may release the footswitch causing a DECELERATE AND STOP command to be issued. There are a number of reasons why he might decide to do this, such as to make a mechanical adjustment or to manually reposition the material being moved.

Then, when he's ready, he may press the footswitch again sending a RESUME MOVE command to the SPM30 to complete the motion.

SET CURRENT POSITION

Command Number: %Q13

Status Bits Required: %I1 thru %I8 and %I16 must be OFF
Status Bits Affected: %I9
Status Words Required: None
Status Words Affected: %AI1 thru %AI4
Command Words Required: %AQ1, %AQ2

Command Description:

This command is used to manually set the current position for the current axis.

When this command is issued, DESTINATION POSITION is copied into MOTOR POSITION (and into ENCODER POSITION if axis 1 is selected) and CURRENT POSITION VALID status bit is turned ON.

This command can be used in conjunction with the JOG UP and JOG DOWN commands as an alternative to the FIND HOME UP and FIND HOME DOWN commands for finding and setting a reference position.

CLEAR ERROR(S)

Command Number: %Q14

Status Bits Required:	None
Status Bits Affected:	%I1 thru %I8
Status Words Required:	None
Status Words Affected:	None
Command Words Required:	None

Command Description:

This command is used to clear errors previously detected by the SPM30.

When this command is issued, all error status bits (%I1 thru %I8) are turned OFF.

Note that when an error status bit is ON, the SPM30 will not obey any other commands till the error is cleared via the CLEAR ERROR(S) command.

This logic also acts as a safety interlock, since the POWER-UP/WATCHDOG error status bit is always set after the SPM30 is reset due to power-up or watchdog timer reset.

DECELERATE AND STOP

Command Number: %Q15

Status Bits Required: None
Status Bits Affected: %I10, %I13 thru %I16
Status Words Required: None
Status Words Affected: %AI1 thru %AI4
Command Words Required: None

Command Description:

This command is used to cause the current axis to decelerate and stop.

When this command is issued, the current axis will decelerate until it reaches the BASE VELOCITY and then it will stop.

If this command pre-empts a MOVE RELATIVE or MOVE ABSOLUTE command, the PRE-EMPTED MOVE RESUMABLE status bit is turned ON unless an error occurred.

In this case, the original move may be resumed from where it left off via the RESUME command.

IMMEDIATE STOP

Command Number: %Q16

Status Bits Required:	None
Status Bits Affected:	%I9, %I13 thru %I16
Status Words Required:	None
Status Words Affected:	%AI1 thru %AI4
Command Words Required:	None

Command Description:

This command is used to cause the current axis to stop immediately.

When this command is issued, the current axis will stop as quickly as possible.

If the axis was moving, the CURRENT POSITION VALID status bit is turned OFF.

CHAPTER 5:ENCODER FEEDBACK

SPM30 models which support encoder feedback, may be configured for a variety of incremental encoder feedback options for axis 1.

The type of encoder used and the relationship of the SPM30 step pulses to the encoder feedback pulses are set via the encoder type, encoder multiplier, encoder divisor, and encoder tolerance configuration parameters.

5.1 Encoder Type

First of all, the type of encoder used is determined by the ENCODER configuration parameter as follows:

ENCODER	**Description**
NONE	No encoder feedback
QUAD	Incremental quadrature encoder feedback with marker as home input
U/D	Incremental up/down encoder feedback
QUAD N/M	Incremental quadrature encoder feedback without marker as home input

If the encoder type is configured to NONE, the ENCODER POSITION status registers (%AI3 and %AI4) will always match axis 1's MOTOR POSITION and the MOTOR STALLED ERROR (%I5) will never go ON.

Otherwise, if the encoder type is configured for QUAD (or QUAD N/M) or U/D, the ENCODER POSITION status registers are updated as a result of feedback pulses from the encoder to the SPM30, thus allowing MOTOR POSITION validation and motor stall detection.

The quadrature encoder is the most common position feedback device used in motion control. This type of encoder outputs two square wave signals (A and B) which are 90 degrees out of phase from each other. The SPM30 determines the direction of motion based on which signal lags behind the other.

A third signal, called a marker, is also provided by some quadrature encoders. This signal occurs once per revolution and is used as a "reference location" which may be connected to the SPM30's Home 1- input. If the marker signal is to be connected to the home input, the encoder type should be QUAD, *and* an marker signal converter must be used (contact Horner Electric). See Chapter 4 for a description of the FIND HOME UP and FIND HOME DOWN commands.

Also, a quadrature encoder's resolution can be effectively doubled or quadrupled by the SPM30's quadrature decoding hardware.

If the ENCODER type is configured for U/D, the SPM30's phase A input becomes a "count up" input and phase B becomes a "count down" input.

The U/D mode is especially useful for unidirectional motion control in which some mechanical event provides the feedback, such as a proximity detector monitoring gear teeth.

5.2 Step Pulse to Feedback Pulse Ratio

In order to use encoder feedback for MOTOR POSITION validation, it is necessary to know the ratio of SPM30 step pulses to encoder feedback pulses.

STEP RESOLUTION, specified in microsteps per revolution, indicates the number of step pulses which must be sent by the SPM30 to the translator drive, to move the stepper motor one revolution. This value is determined by the translator drive and is switch or jumper selectable on some drives.

ENCODER RESOLUTION, specified in lines per revolution, indicates the number of feedback pulses the encoder sends to the SPM30 during one revolution of motion. This value is determined by the encoder itself.

For a given STEP RESOLUTION and ENCODER RESOLUTION, the following formula may be used to determine the proper settings for the ENCODER MLT and ENCODER DIV configuration parameters:

$$\frac{\textbf{ENCODER MLT}}{\textbf{ENCODER DIV}} = \frac{\textbf{STEP RESOLUTION}}{\textbf{ENCODER RESOLUTION}}$$

Where: ENCODER MLT is any value from 1 to 255
ENCODER DIV is any value from 1 to 16

If more than one combination of ENCODER MLT and ENCODER DIV will satisfy the formula, choose the combination with the lowest values for ENCODER MLT and ENCODER DIV (reduce the fraction).

5.3 Example Ratio Configurations

Lets assume we have a two-phase quadrature, incremental rotary encoder, with an ENCODER RESOLUTION of 1000 lines per revolution.

Lets further assume the encoder is mechanically connected to the stepper motor shaft, and is electrically connected to the SPM30's Phase A and B incremental encoder inputs.

The following table shows the proper configuration settings for ENCODER MLT and ENCODER DIV for 16 typical STEP RESOLUTIONS:

STEP RESOLUTION	ENCODER MLT	ENCODER DIV	STEP RESOLUTION	ENCODER MLT	ENCODER DIV
200	1	5	20000	20	1
400	2	5	21600	108	5
1000	1	1	25000	25	1
2000	2	1	25400	127	5
5000	5	1	25600	128	5
10000	10	1	36000	36	1
12800	64	5	50000	50	1
18000	18	1	50800	254	5

5.4 Setting Encoder Tolerance

When an encoder feedback device is connected to the SPM30, it can be used to verify successful execution of axis 1 motion commands.

In an ideal control loop, ENCODER POSITION and MOTOR POSITION would always match exactly.

However, when ENCODER POSITION and MOTOR POSITION become skewed, it means that one or more of the following errors have occurred:

1. A change in direction produced a "backlash error" caused by the mechanical linkage between the motor and the encoder.

2. A "resolution error" has occurred because the encoder is less precise than the microstep rate (STEP RESOLUTION is higher than the ENCODER RESOLUTION).

3. The STEP RESOLUTION exceeds the motor's ability to accurately position its rotor. (Most motors have an absolute step accuracy of about 1 part in 2000 which means a STEP RESOLUTION higher than 2000 only contributes to motor smoothness.)

4. The motor missed some step pulses, or stalled, because of low or mid-frequency resonance.

5. The motor missed some step pulses, or stalled, because the programmed ACCELERATION TIME was too low for the inertial load.

6. Some external force changed the motor's position.

The SPM30 can be configured to use encoder feedback pulses, to automatically detect position errors, and motor stalling. This is accomplished via the encoder tolerance configuration parameter.

If encoder tolerance is zero, automatic position error detection is disabled and the MOTOR STALLED ERROR will never go ON.

Otherwise, encoder tolerance may be set to a number between 1 and 255 indicating the position error magnitude which will cause CURRENT POSITION VALID to be turned OFF.

In this case, when the absolute value of the difference between MOTOR POSITION and ENCODER POSITION reaches encoder tolerance, the CURRENT POSITION VALID status bit will be turned OFF.

Also, when ENCODER TOL is non-zero, the SPM30 uses the encoder feedback pulses to verify motor velocity during motion. This allows the SPM30 to detect a stalled motor regardless of how fast the motor is "supposed" to be moving.

When the SPM30 detects a stalled motor, the MOTOR STALLED ERROR is turned ON and motion is stopped immediately.

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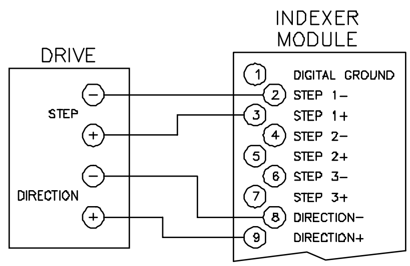
APPENDIX A: SAMPLE WIRING DIAGRAMS

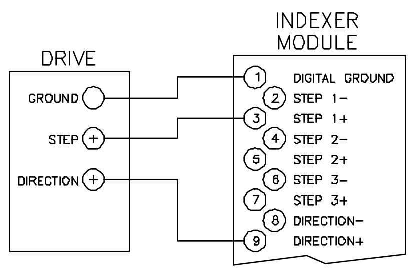
A1 TRANSLATOR DRIVE CONNECTION

The Stepper Indexer Module is compatible with translator drives which accept signal levels of 5V. These include TTL level signals (5V single-ended, negative or positive active) and Line driver signals (5V, differential). The following three diagrams illustrate the connection of the stepper indexer module to translator drives of the abovementioned types. These diagrams illustrate connection for the "step" (pulse) and "direction" (forward/reverse) signals.

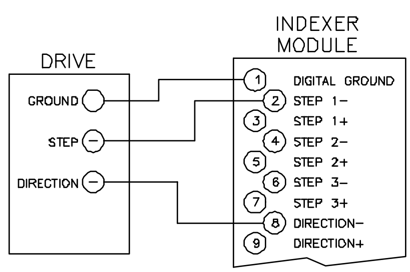
5V Line Driver



5V Positive Active



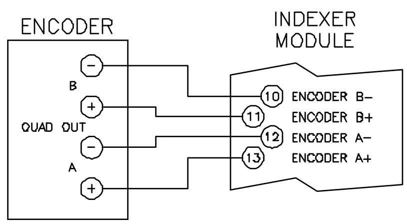
5V Negative Active



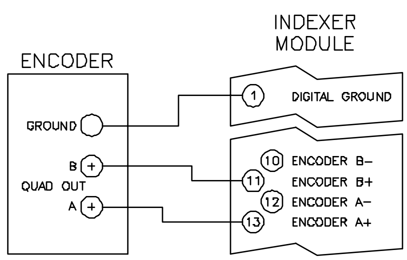
A2. ENCODER FEEDBACK CONNECTION

The Stepper Indexer Module is compatible with incremental encoders which output either a 5V line driver (differential) or 5V positive active (single-ended) signal. Some encoders feature a "marker" pulse. This signal may be used as a "home" input if a signal converter is used. This signal converter is available from Horner Electric. It converts the Home 1- input terminal from negative active to positive active.

5V Line Driver



5V Positive Active



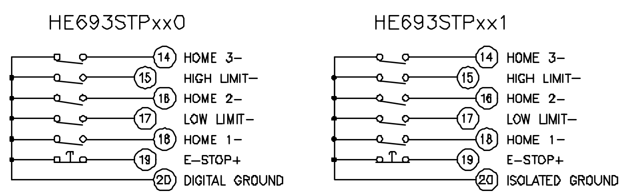
A3 HOME, END LIMIT AND EMERGENCY STOP INPUTS (SWITCH INPUTS)

The Stepper Indexer Module allows real world switches (limit, proximity, mechanical, etc.) to be connected to the module. This enhances the ability of the overall stepper control system to find home position accurately and to quickly stop motion in the event of an emergency situation.

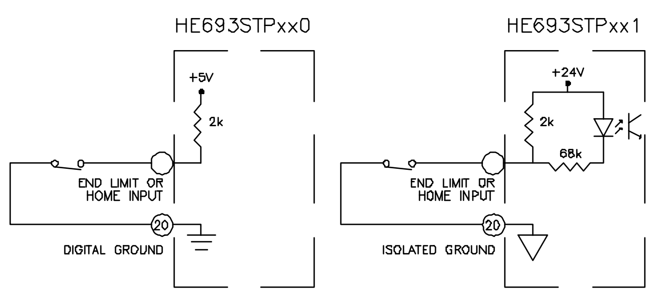
The Stepper Models HE693STPxx0 allow mechanical switches, proximity switches, limit switches, etc. to be connected to the module. Optical isolation is *not* provided, thus the common for these switch inputs (terminal 20 on the terminal strip) is designated "digital ground", electrically equivalent to the common for the step and direction outputs of the module. For these non isolated models, switches must be selected which are compatible with 5V signal levels, and great care must be taken to ensure that noise is not picked up by the wiring run from these switches to the module terminal strip. Preventative steps may include seperate conduit, and/or shielded wiring. If the switches selected require power, this must be provided externally.

The Stepper Indexer models HE693STPxx1 provide optical isolation for the switch inputs. Optical isolation is provided, thus the common for the switch inputs is designated "isolated ground", isolated from the common for the step and direction outputs. Switches may be selected which are compatible with 12 or 24V signal levels. If proximity type switches are used, they must be of the NPN type. The voltage required to power the switches (if needed) must be provided externally.

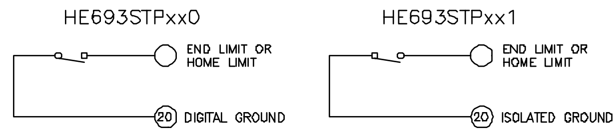
Home, End Limit, and Emergency Stop Inputs



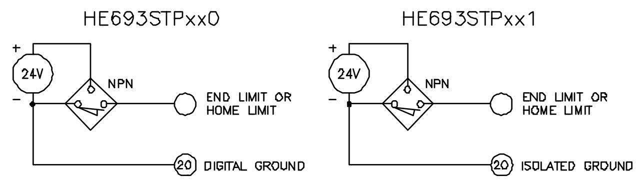
Equivalent Circuit (circuitry within dotted lines internal to module)



Electrical Connection for Mechanical Switches



Electrical Connection for Proximity Switches



APPENDIX B: STEPPER CALCULATOR

B1.1 STPCALC

In addition to the LogicMaster™ 90 example folder, the STEPEXAM disk contains the STPCALC.EXE executable file.

STPCALC.EXE can be used to predict motion profiles which will result from particular sets of HE693STPXXX %AQ parameter values loaded by the user's ladder program.

B1.2 Entering Parameters

When STPCALC is started, it prompts for the entry of 6 parameters. These parameters correspond to the values which would be loaded in the stepper module's %AQ registers to define a move.

B1.2.1 Enter total pulses (0 to 16777215) :

This parameter corresponds to the module's %AQ1 and %AQ2 double-word register (destination position) and is the total number of step pulses for a particular move. Since some moves (e.g. jog up / jog down) have no specific destination, this parameter is optional.

If this parameter is entered, it should be unsigned, since all calculations performed by STPCALC are independant of the move's direction.

Note that "legal" values accepted by the module for this parameter range from -8,388,608 to +8,388,607. Therefore, the maximum "relative move" would be 8,388,608 pulses, while the maximum "absolute move" would be 16,777,215 pulses. Note that this value is input without commas.

B1.2.2 Enter velocity resolution (20 to 65535) :

This parameter corresponds to the module's %AQ3 register and determines the value (in pulses per second) of each count of the base velocity and running velocity parameters.

This parameter is actually a "velocity divisor" which results in selectable velocity resolutions ranging from .01 pulses per second to 30 pulses per second. The following table shows some useful %AQ settings along with the resulting velocity resolution and maximum velocity.

%AQ3	Velocity Resolution	Maximum Velocity
20	30.0 pulses per second	245,730.0 pulses per second
60	10.0 pulses per second	81,910.0 pulses per second
120	5.0 pulses per second	40,995.0 pulses per second
300	2.0 pulses per second	16,382.0 pulses per second
600	1.0 pulses per second	8,191.0 pulses per second
1200	0.5 pulses per second	4,095.5 pulses per second

B1.2.3 Enter base velocity (1 to 8190) :

This parameter corresponds to the module's %AQ4 register and determines the velocity (in pulses per second) the module starts at when a move begins.

B1.2.4 Enter running velocity (X to 8191) :

This parameter corresponds to the module's %AQ5 register and determines the maximum velocity (in pulses per second) the motor will be moving after accelerating.

The running velocity must be greater than the base velocity.

B1.2.5 Enter acceleration mS (X to YYYYY) :

This parameter corresponds to the module's %AQ6 register and determines the maximum time spent accelerating from the base velocity to the running velocity at the start of a move.

This parameter will always be in the range 1 to 27300 but its actual minimum and maximum values depend on the values previously entered for velocity resolution, base velocity and running velocity.

B1.2.6 Enter deceleration mS (X to YYYYY) :

This parameter corresponds to the module's %AQ7 register and determines the maximum time spent decelerating from the running velocity to the base velocity at the end of a move.

This parameter will always be in the range 1 to 27300 but its actual minimum and maximum values depend on the values previously entered for velocity resolution, base velocity and running velocity.

When using STPCALC for a module which does not support seperate deceleration control, enter the same value as was entered for acceleration time.

B1.3 Calculated Values

After the 6 motion parameters have been entered, STPCALC performs calculations to determine the corresponding motion profile and then displays the results.

These results help the system designer determine the expected motions for specific sets of %AQ parameters. The calculated results are described in the following sections.

B1.3.1 Actual acceleration rate =

This value is the actual acceleration rate ($Rate_A$) in pulses per second² and is calculated in two steps as follows:

$$Z_A = \frac{AQ6 \times 24576}{(AQ5 - AQ4) \times 5}$$ (Rounded up to the nearest integer)

$$Rate_A = \frac{4915200 \times 600}{Z_A \times AQ3}$$ (pulses per second²)

B1.3.2 Actual deceleration rate =

This value is the actual deceleration rate ($Rate_D$) in pulses per second² and is calculated in two steps as follows:

$$Z_D = \frac{AQ7 \times 24576}{(AQ5 - AQ4) \times 5} \quad \text{(Rounded up to the nearest integer)}$$

$$Rate_D = \frac{4915200 \times 600}{Z_D \times AQ3} \quad \text{(pulses per second}^2\text{)}$$

B1.3.3 Actual velocity resolution =

This value is the actual velocity resolution (Vel_Res) in pulses per second and is calculated as follows:

$$Vel\_Res = \frac{600}{AQ3} \quad \text{(pulses per second)}$$

The table in section B1.2.2 shows some useful %AQ settings along with the resulting velocity resolution and maximum velocity:

B1.3.4 Actual base velocity =

This value is the actual base velocity (Vel_B) in pulses per second and is calculated as follows:

$$Vel_B = AQ4 \times \frac{600}{AQ3} \quad \text{(pulses per second)}$$

B1.3.5 Actual running velocity =

This value is the actual running velocity (Vel_R) in pulses per second and is calculated as follows:

$$Vel_R = AQ4 \times \frac{600}{AQ3} \quad \text{(pulses per second)}$$

Note that if the total pulses parameter is too short to accomodate the acceleration time and deceleration time parameters, the motor will never reach the running velocity and the move will become triangular. When this happens, actual peak velocity is calculated and displayed instead of running velocity.

B1.3.6 Actual peak velocity =

For triangular moves, this value is the actual peak velocity (Vel_P) in pulses per second and is calculated as follows:

$$Vel_P = \frac{Rate_A \times Time_A}{1000} + Vel_B \quad \text{(pulses per second)}$$

For the definitions of $Rate_A$, $Time_A$ and Vel_B see sections B1.3.1, B1.3.11 and B1.3.4 respectively.

B1.3.7 Actual acceleration pulses =

This value is the actual number of acceleration pulses ($Pulse_A$) and is calculated as follows for trapezoidal moves:

$$Pulse_A = \frac{(AQ5 - AQ4) \times (AQ5 + AQ4 + 1) \times Z_A}{16384 \times AQ3} \quad \text{(pulses)}$$

For the definition of Z_A see section B1.3.1.

For a triangular move, $Pulse_A$ is multiplied by the ratio R_T before being displayed, as described in the next section.

B1.3.8 Actual running pulses = (pulses at full speed)

If a value was entered for total pulses ($Pulse_{TOT}$ section 1.2.1), this value is displayed as the actual number of running pulses ($Pulse_R$) and is calculated as follows for trapezoidal moves:

$$Pulse_R = Pulse_{TOT} - Pulse_A - Pulse_D \quad \text{(pulses)}$$

$Pulse_{TOT}$ is the total pulses parameter as described in B1.2.1. For the definitions of $Pulse_A$ and $Puse_D$ see section B1.3.7 and B1.3.9 respectively.

If the resulting value for $Pulse_R$ is negative, running velocity is never reached and the move is triangular. In this case, $Pulse_R$ is displayed as zero and $Pulse_A$ and $Pulse_D$ are multiplied by the following ratio (R_T) before being displayed.

$$R_T = \frac{Pulse_{TOT}}{Pulse_A + Pulse_D}$$

B1.3.9 Actual deceleration pulses =

This value is the actual number of deceleration pulses ($Pulse_D$) and is calculated as follows for trapezoidal moves:

$$Pulse_D = \frac{(AQ5 - AQ4) \times (AQ5 + AQ4 + 1) \times Z_D}{16384 \times AQ3} \quad \text{(pulses)}$$

For the definition of Z_D see section B1.3.2.

For a triangular move, $Pulse_D$ is multiplied by the ratio R_T before being displayed, as descibed in the previous section.

B1.3.10 Actual total acc/dec pulses =

If a value was not entered for total pulses (section B1.2.1), this value is displayed as the total number of acc/dec pulses ($Pulse_{A+D}$) and is calculated as follows:

$$Pulse_{A+D} = Pulse_A + Pulse_D \quad \text{(pulses)}$$

B1.3.11 Actual acceleration time =

This value is the actual acceleration time ($Time_A$) and is calculated as follows for trapezoidal moves:

$$Time_A = \frac{(AQ5 - AQ4) \times Z_A \times 5}{24576} \quad \text{(mS)}$$

For the definition of Z_A see section B1.3.1.

For a triangular move, $Time_A$ is multiplied by the ratio R_T (described in section B1.3.8) before being displayed and before being used to calculate peak velocity (section B1.3.6).

B1.3.12 Actual running time = (time at full speed)

This value is the actual running time ($Time_R$) and is displayed only if a value was entered for total pulses (section B1.2.1). This value is calculated as follows for trapezoidal moves:

$$Time_R = \frac{Pulse_R \times 1000}{Vel\_Res} \qquad (mS)$$

For the definitions of $Pulse_R$ and Vel_Res see sections B1.3.8 and B1.3.5 respectively.

For a triangular move, $Time_R$ will be zero.

B1.3.13 Actual deceleration time =

This value is the actual deceleration time ($Time_D$) and is calculated as follows for trapezoidal moves:

$$Time_D = \frac{(AQ5 - AQ4) \times Z_D \times 5}{24576} \qquad (mS)$$

For the definition of Z_D see section B1.3.2.

For a triangular move, $Time_D$ is multiplied by the ratio R_T (described in section B1.3.8) before being displayed.

B1.3.14 Actual total acc/dec time =

If a value was not entered for total pulses (section B1.2.1), this value is displayed as the total time spent accelerating and decelerating ($Time_{A+D}$) and is calculated as follows:

$$Time_{A+D} = Time_A + Time_D$$

For the definitions of $Time_A$ and $Time_D$ see section B1.3.11 and B1.3.13.

B1.3.15 Actual total move time =

If a value was entered for total pulses (section B1.2.1), this value is displayed as the total time required for the entire move ($Time_{TOT}$) and is calculated as follows:

$$Time_{TOT} = Time_A + Time_R + Time_D$$

For the definitions of $Time_A$, $Time_R$ and $Time_D$ see sections B1.3.11, B1.3.12 and B1.3.13 respectively.

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APPENDIX C: INDEXED MOVES

This appendix details the added functionality of model number HE693STP113 Stepper Indexer Module for the Series 90-30 PLC. The user of this product should have an understanding of the standard functionality of the stepper indexer modules in addition to the information contained in this document.

C1.1 Wiring

The pinout of the HE693STP113 is identical to any of the isolated Stepper Indexer Modules, with the exception of the HOME3 input. The STP113 utilizes this input (pin 14 on the 20 pin terminal strip) as its INDEX input. The INDEX input is wired with the same electrical considerations as the HOME3 input. The INDEX + is connected at pin 14 of the terminal block while the negative connection is attached to pin 20, digital groiund. *See page A-3 of Appendix A for more details.*

PIN	SIGNAL	UNITS	Type
1	D GND	Digital Ground	Diff
2	STEP1-	Axis 1 motor step outputs	Diff
3	STEP1+		Diff
4	STEP2-	Axis 2 motor step outputs	Diff
5	STEP2+		Diff
6	STEP3-	Axis 3 motor step outputs	Diff
7	STEP3+		Diff
8	DIR-	Motor direction outputs	Diff
9	DIR+		Diff
10	ENC B-	Phase B incremental encoder inputs	Diff
11	ENC B+		Diff
12	ENC A-	Phase A incremental encoder inputs	Diff
13	ENC A+		Diff
14	INDEX +	Indexed move input	S.E./Isol
15	HI LIM-	Upper end limit input	S.E./Isol
16	HOM 2-	Axis 2 home input	S.E./Isol
17	LO LIM-	Lower end limit input	S.E./Isol
18	HOM 1-	Axis 1 home input	S.E./Isol
19	ESTOP+	Emergency stop input	S.E./Isol
20	D GND / I GND	Digital Ground or Isolated Ground	S.E./Isol

Table C1-1. I/O wiring for the HE693STP113.

C1.2 Configuration

Due to the information required to perform an indexed move, the STP113 requires additional I/O to be allocated to the module as compared to a standard isolated module. Configuration of the STP113 is identical to configuration of a HE693STP110, with the exception of the number of %AQ registers assigned to the module. The configuration parameters for the STP113 are shown in Table C1-1 below. For further details on the configuration parameters, see pages 2-3 through 2-5 of Chapter 2.

C1.2.1 Find Home

Byte 2 of the configuration has been redefined. Previously, this byte was used to define the parity for serial communications. Since serial communication is not supported, this byte is now used to select the "Find Home" algorithm. A "**0**" entered for this parameter indicates the Normal (or default) algorithm. A "**1**" entered for this setting configures the module for the Simplified algorithm. The Simplified algorithm assumes that the home command will be run at a slow enough step rate that there is no possibility of loss of motor synchronization or overshoot.

Byte 3 has been redefined as a spare byte and is not used. This configuration byte was previously used for the serial communications baud rate.

MODEL	%I	%Q	%AI	%AQ	Byte 1	Byte 2	Byte 3
HE693STP113	16	16	4	14	1	1 or 0	0

MODEL	Byte 4	Byte 5	Byte 6	Byte 7
HE693STP113	Encoder Type	Encdr. Multiplier (01-FF)H	Encoder Divisor (01-0F)H	Encdr. Tolerance (00-FF)H

BYTE 4 VALUE	ENCODER TYPE
0	NONE
1	QUADRATURE
2	UP/DOWN
3	QUAD NO MARKER

Table C1-2. Configuration parameters of HE693STP113.

C1.3 Controlling Motion

C1.3.1 Status Bit Inputs (%I)

The status bit inputs of the STP113 are identical to those detailed in Section 3.1 on Page 3-1.

C1.3.2 Command Outputs (%Q)

The command bit outputs of the STP113 are identical to those detailed in Section 3.2 on Page 3-2 **EXCEPT** for %Q11, which is defined in the STP113 as the "index move" command. An index move command causes the stepper module to execute a special relative move. If a valid index signal (pin 14 on the terminal strip) is not received, the module executes a standard relative move. If a valid index signal is received, the stepper module moves a predetermined number of steps from that point.

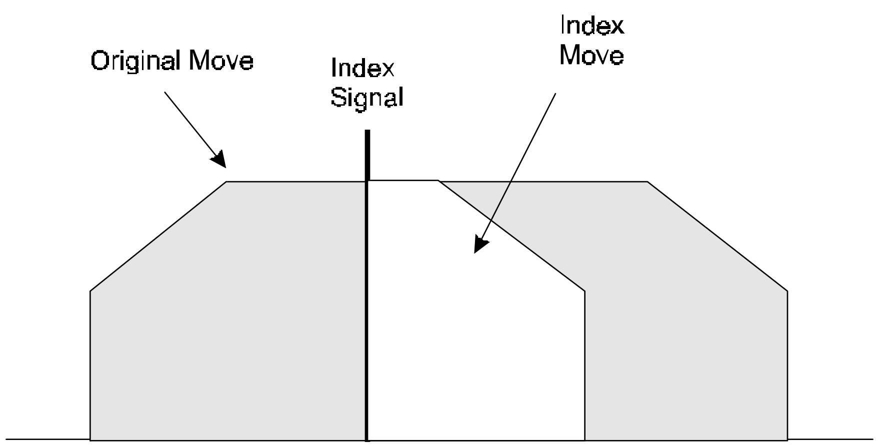

Figure C1-1. Index move

C1.3.3 Status Word Inputs (%AI)

The status word inputs of the STP113 are identical to those detailed in Section 3.3 on Page 3-3.

C1.3.4 Command Word Outputs (%AQ)

The STP113 contains several command word outputs in addition to those detailed in Section 3.4 on Page 3-4. **Table C1-3** below lists the additional %AQ command word outputs.

POINT	DESCRIPTION	MINIMUM	MAXIMUM
%AQ8	Index Destination Position (Low Word)	0	+8,388,607
%AQ9	Index Destination Position (High Word)		
%AQ10	Index Deceleration	0	27300
%AQ11	Index Window Open (Low Word)	0	+8,388,607
%AQ12	Index Window Open (High Word)		
%AQ13	Index Window Closed (Low Word)	0	+8,388,607
%AQ14	Index Window Closed (High Word)		

Table C1-3. Additional Command Word Outputs (%AQ) for STP113.

Index Destination Position. This is a double integer value which establishes the length of the index move. The index move is executed starting at the point in which a valid index input is asserted. If a valid index input is not received during the index move, the destination position defined in %AQ1 is utilized instead.

Index Deceleration. This is the deceleration time (in mS) to be used during an index move. It is only used during an index move when a valid index signal is received. If a valid index signal is not received during the index move, the deceleration time defined in %AQ7 is utilized instead.

Index Window Open. This is the starting point (in steps) in which a index signal is considered valid. An index signal received before this point is ignored. The Index Window Open point must be defined as a point which occurs after the full acceleration point.

Index Window Closed. This is the ending point (in steps) in which an index signal is considered valid. An index signal received before this point is ignored. The Index Window Closed point must be defined as a point which occurs no later than 1mS before the deceleration point.

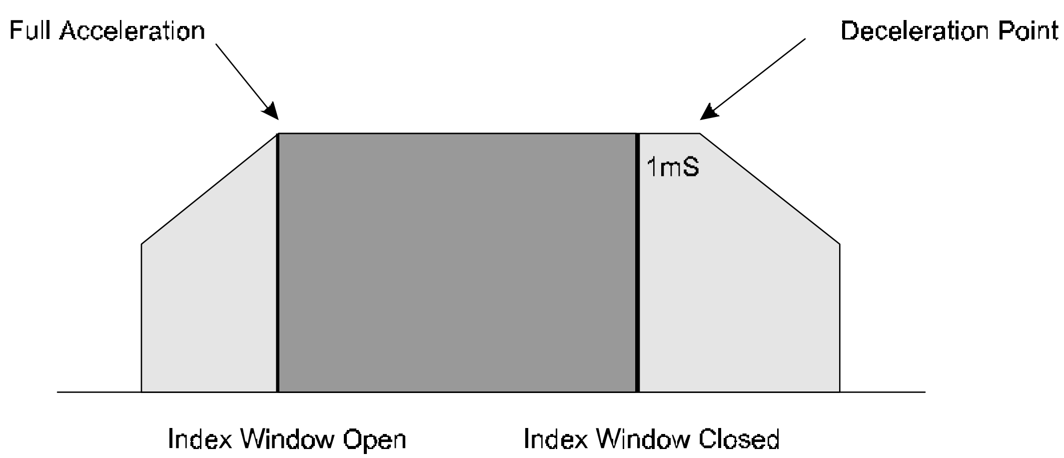

Figure C1-2. Restrictions on Index Window Open and Index Window Closed Parameters.

29 September 1999

Revision pages for

Horner APG's Stepper Positioning Module User Manual, Sixth Edition

for Models
HE693STPxx0 Revision G or later AND
HE693STPxx1 Revision A or later AND
HE693STP104 Revision A or later

Attached to this cover page are revisions for the Stepper Positioning Module User Manual dated 12-11-97, MAN0084-06.

THESE REVISED REQUIREMENTS ARE NOW IN EFFECT.

New and revised pages may be issued periodically. For user manual updates, please contact Horner APG, Technical Support Division, at (317) 916-4274 or visit our website at www.heapg.com.

Revision Key
Changes to text, tables or graphics contained in the attached revision are indicated as follows:

1. **Added text is underlined.**
2. **~~Deleted text is lined through.~~**
3. **New, revised, or deleted items are specified as such in ( ).**

List of Effective Pages

The most current user manual consists of the following list of effective pages including the attached revision pages: * Denotes new or revised pages

Page	Date
***Title Page**	**Revision Page dated 29 September 1999**
***iii**	**Revision Page dated 29 September 1999**
iv – v	Contained in MAN0084-06 dated 12-11-97
***vi**	**Revision Page dated 29 September 1999**
***vii**	**Revision Page dated 29 September 1999**
viii	Contained in MAN0084-06 dated 12-11-97
1-1	Contained in MAN0084-06 dated 12-11-97
2-1	Contained in MAN0084-06 dated 12-11-97
***2-2**	**Revision Page dated 29 September 1999**
2-3	Contained in MAN0084-06 dated 12-11-97
***2-4**	**Revision Page dated 29 September 1999**
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List of Effective Pages continued

(Revised Logo)

User Manual for the
HE693STPxx0 Revision G or later AND
HE693STPxx1 Revision A or later AND
HE693STP104 Revision A or later

Stepper Positioning Module

Sixth Edition
12-11-1997

MAN0084-06

(REVISED. Reflects name change from Horner Electric, Inc. to Horner APG, LLC.)

LIMITED WARRANTY AND LIMITATION OF LIABILITY

Horner APG,LLC ("HE-APG") warrants to the original purchaser that Stepper Positioning Module manufactured by HE-APG is free from defects in material and workmanship under normal use and service. The obligation of HE-APG under this warranty shall be limited to the repair or exchange of any part or parts which may prove defective under normal use and service within two (2) years from the date of manufacture or eighteen (18) months from the date of installation by the original purchaser whichever occurs first, such defect to be disclosed to the satisfaction of HE-APG after examination by HE-APG of the allegedly defective part or parts. THIS WARRANTY IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES EXPRESSED OR IMPLIED INCLUDING THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR USE AND OF ALL OTHER OBLIGATIONS OR LIABILITIES AND HE-APG NEITHER ASSUMES, NOR AUTHORIZES ANY OTHER PERSON TO ASSUME FOR HE-APG, ANY OTHER LIABILITY IN CONNECTION WITH THE SALE OF THIS Stepper Positioning Module. THIS WARRANTY SHALL NOT APPLY TO THIS Stepper Positioning Module OR ANY PART THEREOF WHICH HAS BEEN SUBJECT TO ACCIDENT, NEGLIGENCE, ALTERATION, ABUSE, OR MISUSE. HE-APG MAKES NO WARRANTY WHATSOEVER IN RESPECT TO ACCESSORIES OR PARTS NOT SUPPLIED BY HE-APG. THE TERM "ORIGINAL PURCHASER", AS USED IN THIS WARRANTY, SHALL BE DEEMED TO MEAN THAT PERSON FOR WHOM THE Stepper Positioning Module IS ORIGINALLY INSTALLED. THIS WARRANTY SHALL APPLY ONLY WITHIN THE BOUNDARIES OF THE CONTINENTAL UNITED STATES.

In no event, whether as a result of breach of contract, warranty, tort (including negligence) or otherwise, shall HE-APG or its suppliers be liable of any special, consequential, incidental or penal damages including, but not limited to, loss of profit or revenues, loss of use of the products or any associated equipment, damage to associated equipment, cost of capital, cost of substitute products, facilities, services or replacement power, down time costs, or claims of original purchaser's customers for such damages.

ABOUT PROGRAMMING EXAMPLES

Any example programs and program segments in this manual or provided on accompanying diskettes are included solely for illustrative purposes. Due to the many variables and requirements associated with any particular installation, Horner APG cannot assume responsibility or liability for actual use based on examples and diagrams. It is the sole responsibility of the system designer utilizing Stepper Positioning Module to appropriately design the end system, to appropriately integrate the Stepper Positioning Module and to make safety provisions for the end equipment as is usual and customary in industrial applications as defined in any codes or standards which apply.

Note: The programming examples shown in this manual are for illustrative purposes only. Proper machine operation is the sole responsibility of the system integrator.

(REVISED. Reflects name change from Horner Electric, Inc. to Horner APG, LLC.)

PREFACE

This manual explains how to use the Horner APG's Stepper Positioning Modules.

For user manual updates, contact Horner APG, LLC., Technical Support Division, at (317) 916-4274 or visit our website at www.heapg.com.

MODULE SPECIFICATIONS

I/O Connector Specifications

(REVISED)

PARAMETER	MIN	MAX	UNITS
+5V Power Output (Step/Direction)	-	300	mA
Step Outputs Frequency	DC	245	KHz
Step Outputs High (-20mA)	2.5	-	VDC
Step Outputs Low (+20mA)	-	0.5	VDC
Direction Output Setup Time	2	-	mS
Direction Output High (-20mA)	2.5	-	VDC
Direction Output Low (+20mA)	-	0.5	VDC
Direction Output High (-60mA, Rev A)	2.5	-	VDC
Direction Output Low (+60mA, Rev A)	-	0.5	VDC
Encoder Input Frequency	DC	1.0	MHz
Encoder Single-Ended Threshold	1.2	1.6	VDC
Encoder Differential Threshold High	-	0.2	VDC
Encoder Differential Threshold Low	-0.2	-	VDC
Home Inputs Off	12	-	VDC
Home Inputs On (+1mA)	-	9	VDC
End Limits Inputs Off (all models except STP104)	12	-	VDC
End Limits Inputs On (+1mA) (all models except STP104)	-	9	VDC
End Limits Inputs Off (+1mA) (covers STP104 only)	-	9	VDC
End Limits Inputs On (covers STP104 only)	12	-	VDC
Emergency Stop Input On	12	-	VDC
Emergency Stop Input Off (+1mA)	-	9	VDC

(Figure revised 29 SEP 1999.)

(REVISED)

PIN	SIGNAL	UNITS	TYPE
1	D GND	Digital Ground	Diff
2	STEP1-	Axis 1 motor step outputs	Diff
3	STEP1+		Diff
4	STEP2-	Axis 2 motor step outputs	Diff
5	STEP2+		Diff
6	STEP3-	Axis 3 motor step outputs	Diff
7	STEP3+		Diff
8	DIR-	Motor direction outputs	Diff
9	DIR+		Diff
10	ENC B-	Phase B incremental Encoder inputs	Diff
11	ENC B+		Diff
12	ENC A-	Phase A incremental Encoder inputs	Diff
13	ENC A+		Diff
14	HOM3-	Axis 3 home input	S.E./Isol
15	~~HI LIM~~ HI LIM + (STP104 only) HI LIM - (All models except STP104)	~~Upper end limit input~~ Upper end limit input	S.E./Isol
16	HOM 2-	Axis 2 home input	S.E./Isol
17	~~LO LIM~~ LO LIM + (STP104 only) LO LIM - (All models except STP104)	~~Lower end limit input~~ Lower end limit input	S.E./Isol
18	HOM 1-	Axis 1 home input	S.E./Isol
19	ESTOP+	Emergency stop input	S.E./Isol
20	D GND / I GND	Digital Ground or Isolated Ground	S.E./Isol

Figure 2-1 Stepper Positioning Module Terminal Strip Pin-out.
(Type: Diff=Differential, S.E./Isol.-Single Ended or Isolated)

(Figure 2.1 revised 29 SEP 1999.)

(REVISED)

<table>
<tr><th>MODEL</th><th>%I</th><th>%Q</th><th>%AI</th><th>%AQ</th><th>BYTE 1</th><th>BYTE 2</th><th>BYTE3</th></tr>
<tr><td>HE693STP100</td><td rowspan="9">16</td><td rowspan="9">16</td><td rowspan="2">2</td><td>6</td><td rowspan="9">1</td><td rowspan="9">0</td><td rowspan="9">0</td></tr>
<tr><td>HE693STP101</td><td>7</td></tr>
<tr><td>HE693STP110</td><td rowspan="2">4</td><td>6</td></tr>
<tr><td>HE693STP111</td><td>7</td></tr>
<tr><td>HE693STP300</td><td rowspan="2">2</td><td>6</td></tr>
<tr><td>HE693STP301</td><td>7</td></tr>
<tr><td>HE693STP310</td><td rowspan="2">4</td><td>6</td></tr>
<tr><td>HE693STP311</td><td rowspan="2">7</td></tr>
<tr><td>HE693STP104</td><td>2</td></tr>
</table>

Figure 2-4 I/O Reference and Bytes 1-3 Configuration Parameters
(Figure 2-4 revised 29 SEP 1999.)

The second column of configuration parameters contains a number of additional configuration bytes. The stepper module requires that Byte 1 through Byte 7 be configured. For these parameters, see the chart for Bytes 1-3, and the chart below for Bytes 4-7.

(REVISED)

<table>
<tr><th>MODEL</th><th>BYTE 4</th><th>BYTE 5</th><th>BYTE 6</th><th>BYTE 7</th></tr>
<tr><td>HE693STP100</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td></tr>
<tr><td>HE693STP101</td></tr>
<tr><td>HE693STP110</td><td rowspan="2">Encoder Type</td><td rowspan="2">Encdr. Multiplier (01-FF)H</td><td rowspan="2">Encoder Divisor (01-0F)H</td><td rowspan="2">Encdr. Tolerance (00-FF)H</td></tr>
<tr><td>HE693STP111</td></tr>
<tr><td>HE693STP300</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td></tr>
<tr><td>HE693STP301</td></tr>
<tr><td>HE693STP310</td><td rowspan="2">Encoder Type</td><td rowspan="2">Encoder Multiplier</td><td rowspan="2">Encoder Divisor</td><td rowspan="2">Encdr. Tolerance</td></tr>
<tr><td>HE693STP311</td></tr>
<tr><td>HE693STP104</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>

Figure 2-5 Bytes 4-7 Configuration Parameters
(Figure 2-5 revised 29 SEP 1999.)

Bytes 4-7 are utilized by those indexer models, which feature encoder feedback capability. Byte 4 configures the type of encoder used (see Figure 2-6), Byte 5 and 6 set the encoder multiplier and divisor, and Byte 7 sets the encoder tolerance. For details on encoder feedback operation, see Chapter 5.

(REVISED)

The Stepper Indexer Module allows real world switches (limit, proximity, mechanical, etc.) to be connected to the module. This enhances the ability of the overall stepper control system to find home position accurately and to quickly stop motion in the event of an emergency situation.

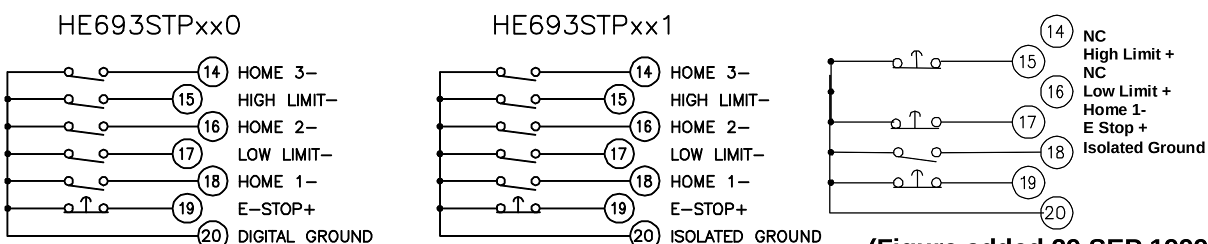
The Stepper Models HE693STPxx0 allow mechanical switches, proximity switches, limit switches, etc. to be connected to the module. Optical isolation is *not* provided, thus the common for these switch inputs (terminal 20 on the terminal strip) is designated "digital ground", electrically equivalent to the common for the step and direction outputs of the module. For these non isolated models, switches must be selected which are compatible with 5V signal levels, and great care must be taken to ensure that noise is not picked up by the wiring run from these switches to the module terminal strip. Preventative steps may include seperate conduit, and/or shielded wiring. If the switches selected require power, this must be provided externally.

The Stepper Indexer models HE693STPxx1 and HE693STP104 provide optical isolation for the switch inputs. Optical isolation is provided, thus the common for the switch inputs is designated "isolated ground", isolated from the common for the step and direction outputs. Switches may be selected which are compatible with 12 or 24V signal levels. If proximity type switches are used, they must be of the NPN type. The voltage required to power the switches (if needed) must be provided externally.

(Paragraph revised 29 SEP 1999.)

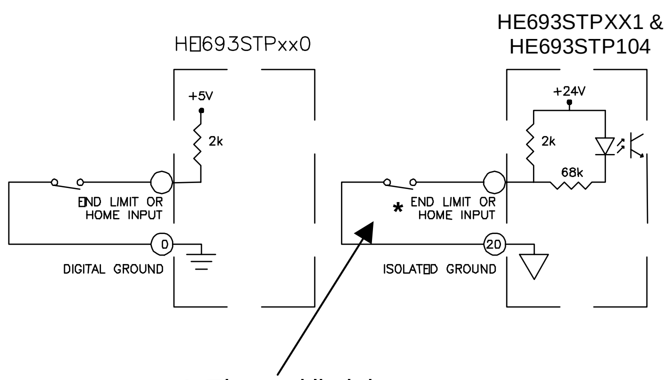
Home, End Limit, and Emergency Stop Inputs

(NEW) HE693STP104



(Figure added 29 SEP 1999)

(REVISED)

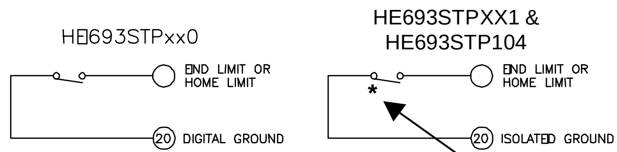


* The end limit inputs on an HE693STP104 are active high for compatibility with normally closed switches.

(Added note to Figure 29 SEP 1999)

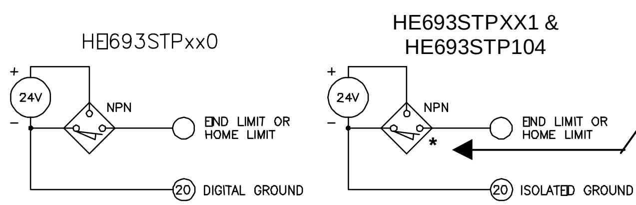
(REVISED)

Electrical Connection for Mechanical Switches



***** The end limit inputs on an HE693STP104 are active high for compatibility with normally closed switches.

Electrical Connection for Proximity Switches



(Added note to figures 29 SEP 1999.)

HIGH VACUUM APPARATUS Mfg. Inc.
1763 SABRE ST., HAYWARD, CA 94545; TEL: (510)785-2744 FAX: (510)732-9853

IMPORTANT NOTICE

FOR NON-MECHANICALLY LOCKED OVER CENTER GATE VALVES

(SIZES 8" I.D. AND LARGER, ALL MILLION CYCLE VALVES OR CUSTOMER SPECIFIED)

This gate valve is shipped in the closed position by pressurizing the top chamber of the air cylinder.

- This pressure is held by a check-valve that is mounted on the input of the solenoid valve. This is done to prevent or dampen the motion of the valve's carriage during transit. The check-valve **must be kept at the input of the 4-Way driving solenoid valve during operation.** This will insure that the valve will maintain its sealing integrity in the event of pressure loss in the air supply line, provided all air lines and fittings have been checked and are leak tight.

NOTE : **Smaller valves or valves that do not ship with a solenoid.** A check valve is installed at the top inlet of the air cylinder. In this case, the check valve must be removed prior to operating the gate valve and placed at the input of the driving solenoid. Failing to do so would prevent the air from venting from the top inlet of the air cylinder due to the check-valve. **This will prevent proper valve operation.**

Vibration during transit may cause the pressure to drop in the air cylinder. This would cause the carriage to position itself in the mid open position. However, this should not merit any concern. The check-valve will prevent the carriage from moving back-and-forth too freely, even in the absence of air pressure in the cylinder. This would fulfill its purpose during transit.

Example of how to calculate fill/exhaust times:

Model 310, 24VDC — One Air Line (0.125 I.D. x 36-inch long)

100 psig supply — Air Cylinder (1.062-inch bore x 4-inch stroke)

Volume = 0.785 x Diameter squared x stroke or length

Cylinder Volume	= 3.54 cubic inches
Air Line Volume	= 0.44 cubic inches
Total Circuit Volume	= 3.98 or 4 cubic inches

T1 Time to Energize Valve	= 0.010 sec.
Time to fill 4 cubic inches 40% of 0.2 sec. for 10 cubic inches	= 0.080 sec.
T3 Time to De-energize Valve	= 0.005 sec.
Time to Exhaust 4 cubic inches 40% of .32 sec. for 10 cubic inches	= 0.128 sec.
Total Cycle Time	= 0.223 sec.*

*Although this result is not exact, it is sufficient for most application needs and provides a simple, straight forward system.

Plumbing 310/410 valves are direct acting. When used with vacuum or low pressure, use largest possible tubing size and minimum tubing length for optimum performance.

Before connecting fittings and tubing, blow all foreign material from these components. If using a sealant, take extra care the sealant does not enter valve causing malfunction and/or leaks.

CAUTION: Compressed air is powerful and may be dangerous. Before attempting to remove a component from an air line or system, always disconnect the supply air and thoroughly exhaust the line or system. Never attempt to construct, operate, or service anything using compressed air unless you have been properly trained to do so. *Failure to heed this warning could result in SERIOUS, EVEN FATAL, PERSONAL INJURY.*

METRIC PORTS/DIMENSIONS

Although these valves are produced using the inch system, all drawings show the metric equivalent in millimeters (indicated by slanted numbers).

All port connections are available in metric sizes. The 1/8-27 NPSF pipe ports are available in 1/8 BSP taper.

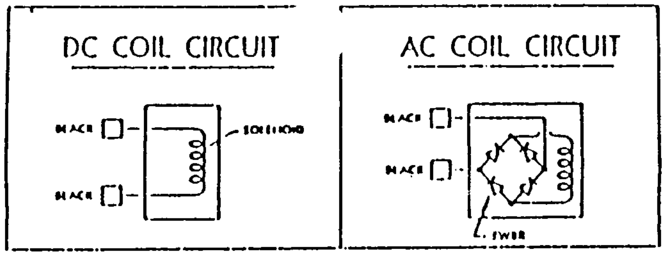
Specify metric port threads by using letter *E* as a model number prefix. Example: *E410* has metric size ports.

ELECTRICAL SPECIFICATION CHART

Voltage	Resistance (Ohms)	Current (Milliamps)
12VDC	36	333
24VDC	144	167
24VAC	100	200
100VAC	2100	44
120VAC	3025	36
200VAC	8400	22
240VAC	12100	18

- All coils are standard with 24-inch black lead wires. Optional 72-inch lead wires are available.
- All AC coils are rated for 50/60 Hertz.
- All coils conform to Class B insulation systems.
- Resistance and current are nominal values.
- Valve assemblies are "Hi-pot" tested at 1750 VAC for one second.
- Ensure proper voltage supply per voltage label rating, +10%, −15% for AC or DC systems.

SOLENOID CIRCUIT SCHEMATICS

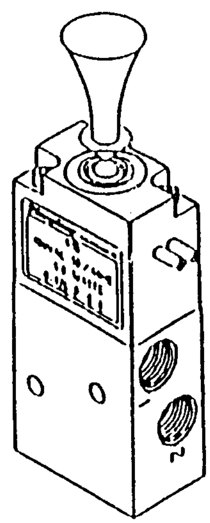


MANUAL OVERRIDE

Push button/spring return manual override is standard. Manual override is located on top of coil.

Pushing red button shifts armature which actuates the main stem of valve. Release of manual force permits valve spring to return valve to normal position.

310/410 valves are available without manual override by specifying Code 87 (example is 310-87 24VDC). On valves without manual override, a solid disk is installed on the coil. This replaces the punched disk which is used on valves with manual override.



TROUBLESHOOTING

If valve fails to function when electrical power is supplied:

1. Check valve function using manual override. If valve functions by manual actuation, proceed to steps 2 and 3. If valve does not function, proceed to step 4.

   For valves without manual override, proceed to steps 2 and 3.

2. Check line voltage to determine compliance with valve electrical rating.

3. Check valve for inoperable (open) coil, measuring milliamps per Electrical Specification Chart.

4. Check that air supply has been delivered in adequate volume and pressure for proper functioning of the device. Ensure that there are no blockages due to air line contamination or defective/blocked fittings.

WARRANTY

All valves have a one year warranty from date of manufacture. This warranty includes repair and/or replacement at no charge should the product be deemed defective due to workmanship and/or material. (See detailed Product Warranty in Humphrey's General Valve Catalog.)

SPECIFICATIONS

	310/410 Models
Media	Air, vacuum or inert gases
Pressure Range	28" Hg. (vacuum) to 125 psig (8.5 bar)
Ambient Temperature Range	32 to 125°F (0 to 50°C)
Coil Temperature Rise (any voltage)	81°F (45°C)
Power Consumption (AC/DC)	4.0 watts
Response Time (on/off)	.012/.010 (DC), .012/.020 (AC) sec.
Voltage Tolerance	Plus 10%, minus 15% of rated voltage
Coil Voltages	12VDC, 24VDC, 24VAC, 100VAC, 120VAC, 200VAC, 240VAC
SCFM @ 100 psig	>10
Cv	.167
Fill/Exhaust Time @ 100 psig (7.0 bar)	1 cu. in. .020/ .032 sec. 10 cu. in. .20 / .32 sec. 100 cu. in. 2.00/3.20 sec.
Leak Rate (max. allowed)	4cc/minute @ 100 psig
Type of Operation	Direct solenoid
Effective Area	Model 310 .0069-inch² Model 410 .0064-inch²
Stroke	.015-inch
Maximum Cycle Rate (cycles/min)	2700 (DC), 1875 (AC)
Lubrication	None required, factory pre-lubed
Filtration	40 Micron recommended
Weight	Model 310 .26 lbs. (118 gms) Model 410 .28 lbs. (128 gms) Model 410-70 .28 lbs. (128 gms)
Materials	Brass, Buna N, Aluminum, Stainless Steel, Acetal

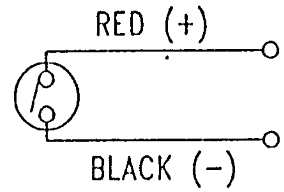
Humphrey

HUMPHREY PRODUCTS • P.O. Box 2008, Kalamazoo, MI 49003, U.S.A. • Telephone (616) 381-5500 • Fax (616) 381-4113

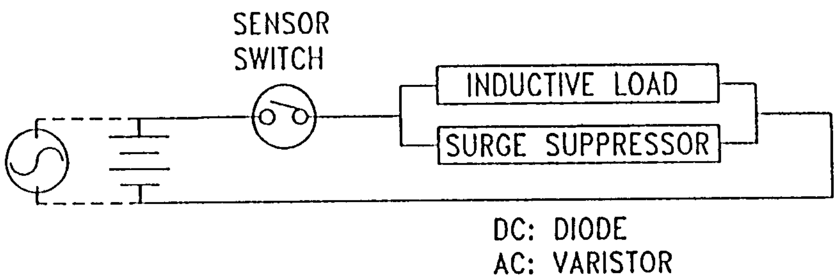
P012950

REV	ECO NU'	DESCRIPTION OF REVISION	BY	DATE	CHK

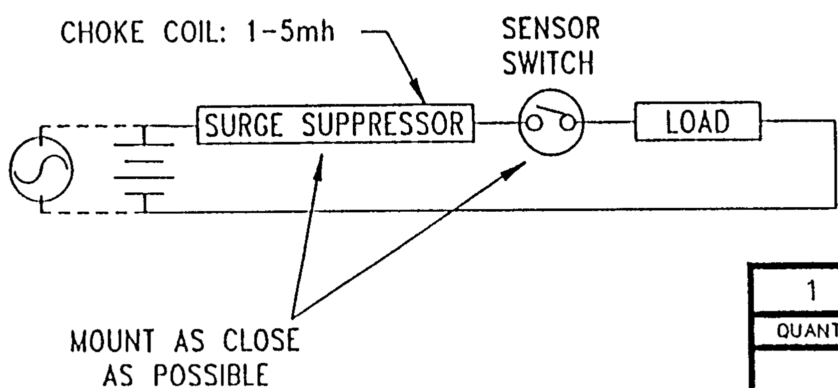
RECOMMENDED PROTECTION
FOR REED SWITCH SENSORS



USE IN THE PRESENCE OF INDUCTIVE LOADS (MAGNETIC RELAYS, ETC.):



USE WHEN LONG LEAD WIRES (>39 ft or 10 m) ARE NECESSARY BETWEEN SENSOR AND LOAD:



SENSOR TYPE:	TWO WIRE MAGNETIC SENSING
POWER SUPPLY:	115 VAC MAX or 28VDC MAX
LOAD CURRENT:	20 mA MAX
DELAY TIME:	1.2 mSEC MAX
SHOCK RESISTANCE:	30G NON-REPEATED SHOCK
VIBRATION RESISTANCE:	9G (TOTAL AMPL. 1.5mm,10-55 Hz. RESONANCE FREQUENCY 2750 ± 250 Hz
ENVIRONMENTAL PROTECTION:	IP66 (IEC STANDARD)
LEAD WIRE:	PVC INSULATED 2 X 24 AWG
CYCLE LIFE:	5 MILLION MIN.
TEMP.RANGE:	40-140°F (5-60°C)
STORAGE TEMP:	-14 to 158°F (-10 to 60°C)

QUANT	PART NUMBER	DESCRIPTION OR MATERIAL	ITEM
1	21-076	MAGNETIC SENSOR D-90A	1

HVA
1763 SABRE ST, HAYWARD, CA 94545
TEL (510)785-2744 FAX (510)732-9853

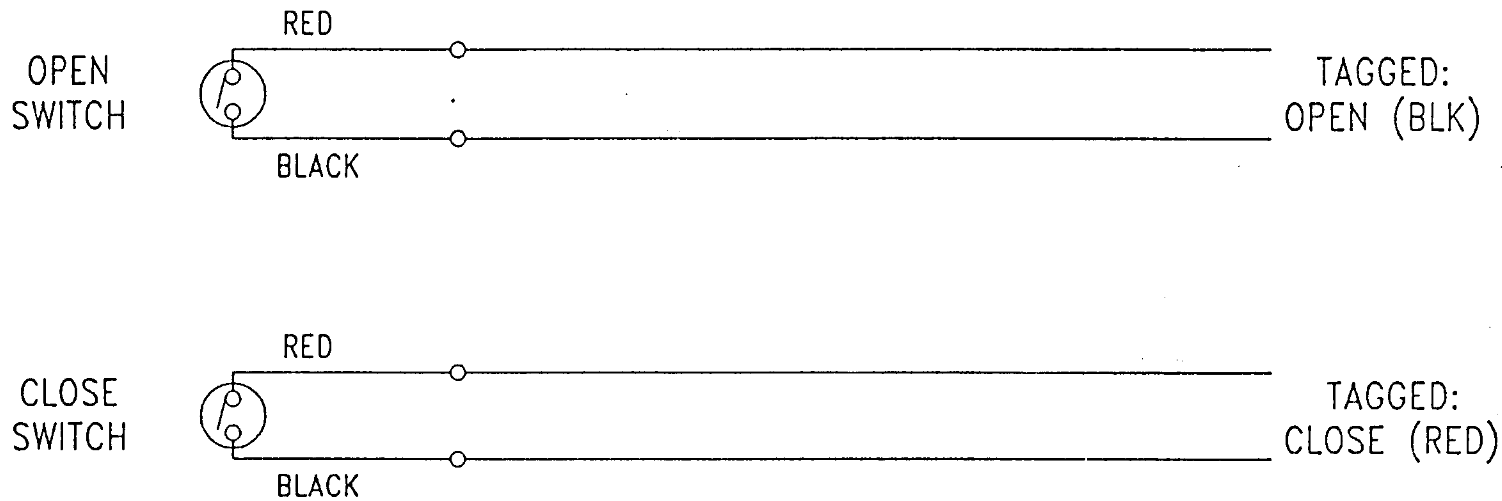
DRAWING TITLE
ELECTRICAL SPECIFICATION
MAGNETIC REED SWITCH

DRAWN BY	DATE	SCALE
RC	02-08-94	NONE

SIZE	DRAWING NUMBER	REV
A	06679	B

UNLESS OTHERWISE SPECIFIED, ALL TOLERANCES ARE IN INCHES [MILLIMETERS]
.XX = ±0.01 [0.3]
.XXX = ±0.005 [0.13]
ANGLES = ±0° 30'
BREAK ALL EDGES 0.02 [0.5] X 45°
0.32 [0.8]

REV	ECO NUMBER	DESCRIPTION OF REVISION	BY	DATE	CHK



FOR REED SWITCH ELECTRICAL
RATINGS SEE DRAWING # 06679

QUANT	PART NUMBER	DESCRIPTION OR MATERIAL	ITEM
		SENSOR NUMBERS 21-076 (D-90A)	1

HVA
1763 SABRE ST, HAYWARD, CA 94545
TEL (510)785-2744 FAX (510)732-9853

DRAWING TITLE: POSITION INDICATOR WIRING

DRAWN BY	DATE	SCALE
RC	03-08-94	NONE

SIZE	DRAWING NUMBER	REV
A	06873	A

UNLESS OTHERWISE SPECIFIED, ALL TOLERANCES ARE IN INCHES [MILLIMETERS]
.XX = ±0.01 [0.3]
.XXX = ±0.005 [0.13]
ANGLES = ±0° 30'
BREAK ALL EDGES 0.02 [0.5] × 45°
0.32 [0.8]

STAINLESS STEEL VACUUM VALVE

SERIES 100

MANUAL

KEY HIGH VACUUM PRODUCTS, INC.
36 SOUTHERN BOULEVARD
NESCONSET, NY 11767
631-360-3970 - Fax 631-360-3973
http://www.keyhigh.com

GENERAL SPECIFICATIONS:

KEY HIGH VACUUM PRODUCTS, INC.'s SERIES 100 STAINLESS STEEL HIGH VACUUM VALVES, are designed and manufactured to produce a highly reliable valve at a reasonable cost. Construction of the **SERIES 100** is from high grade vacuum compatible materials. Body is made from type 304 stainless steel, which is electropolished for optimum surface cleanliness. All O-rings are made of viton.

All **SERIES 100 STAINLESS STEEL HIGH VACUUM VALVES** are leak tested on a Helium Mass Spectrometer at a sensitivity of 3.0x10-8 or better on both ports.

The bellows is a stainless steel welded nested bellows, which gives a lower compressed height, thus providing higher conductance, greater extended length, as well as a longer cycle life.

SERIES 100 valves have been reliability tested for over 500,000 cycles without a single failure.

Because of the design of the welded bellows assembly, assemblies can be overpressured. Consult the factory before using in the application!!!

SERIES 100 pneumatic valves are spring loaded (normally closed).

Typical response time is 20 to 30 milliseconds.

SERIES 100 pneumatic valves are available with an option for mechanical position indicators. Two micro switches are internally mounted and are actuated by the same shaft which actuates the sealing mechanism, thus giving the host a positive valve position.

SWITCH RATINGS: 5 amp at 110 vac

TERMINATION: Spade terminals

MOUNTING:
KEY HIGH's SERIES 100 VALVES will operate in any mounted position. Hovever the preferred method is to mount the lower port towards the vacuum source, as this will allow for optimum performance

KEY HIGH's stainless steel valves can be equipped with a wide variety of options, such as flanges on one or both ports. Standard fittings include KF-25 fittings, MET-SEAL flanges, ASA flanges, quick seals or any type of connection required can be fabricated.

ASSEMBLY PROCEDURE MANUAL VALVES:

1. Turn handle completely counterclockwise
2. Remove four (4) each 8-32x1/2" slotted pan head screws
3. **Carefully remove bellows/top cap assembly. (Note: use caution as to not damage the bellows.)**
4. Assesmble in reverse order

ASSEMBLY PROCEDURE PNEUMATIC VALVES:

CAUTION: Air cylinder is springloaded. Use caution when removing.

1. Remove four (4) each 8-32x1" long socket head cap screws, carefully while holding pressure on the air cylinder can assembly.
2. Relax pressure on the can assembly so the spring is at a relaxed state.
3. Remove can assembly.

4. Carefully slide the intermediate cap/bellows assembly out. **(Note: Use caution not to damage the bellows.)** When re-assembling make certain that both can assembly and the bellows assembly O-rings are properly seating in their location.

WELDING INSTRUCTIONS FOR TUBE END VALVES:

Manual valves:

Before T.I.G. welding, open the valve fully. This is to protect the bellows assembly and O-rings during welding.

Pneumatic valves:

Connect the compressed air supply to the solenoid via the 1/8" NPT. Air supply should be filtered, dry and oil free. Air supply should be no less than 60 psi and no greater than 100 psi. Energize solenoid with correct voltage to open valve. This will protect the bellows assembly and O-rings during welding.

CAUTION:

After welding, inspect welds for pits,cracks, etc.. Allow valve to cool before operation.

WARRANTY

All products manufactured by **KEY HIGH VACUUM PRODUCTS, INC**. are warranted to be free of defects in materials and workmanship for a period of one (1) year from the shipment to the purchaser. All workmanship and materials are consistent with good common high vacuum practice. Liability under this warranty is limited to repair or replacement only, at **KEY HIGH VACUUM PRODUCTS, INC**. shall be received prepaid. Expendable items such as ion tubes, heaters, bellows, etc., may have a service life of less than one (1) year in normal usage. If such items fail to give reasonable service for a reasonable period of time, as determined by **KEY HIGH VACUUM PRODUCTS, INC**., the item will be repaired or replaced at **KEY HIGH VACUUM PRODUCTS, INC.'s** election.,

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LET.	REVIS	DATE	BY
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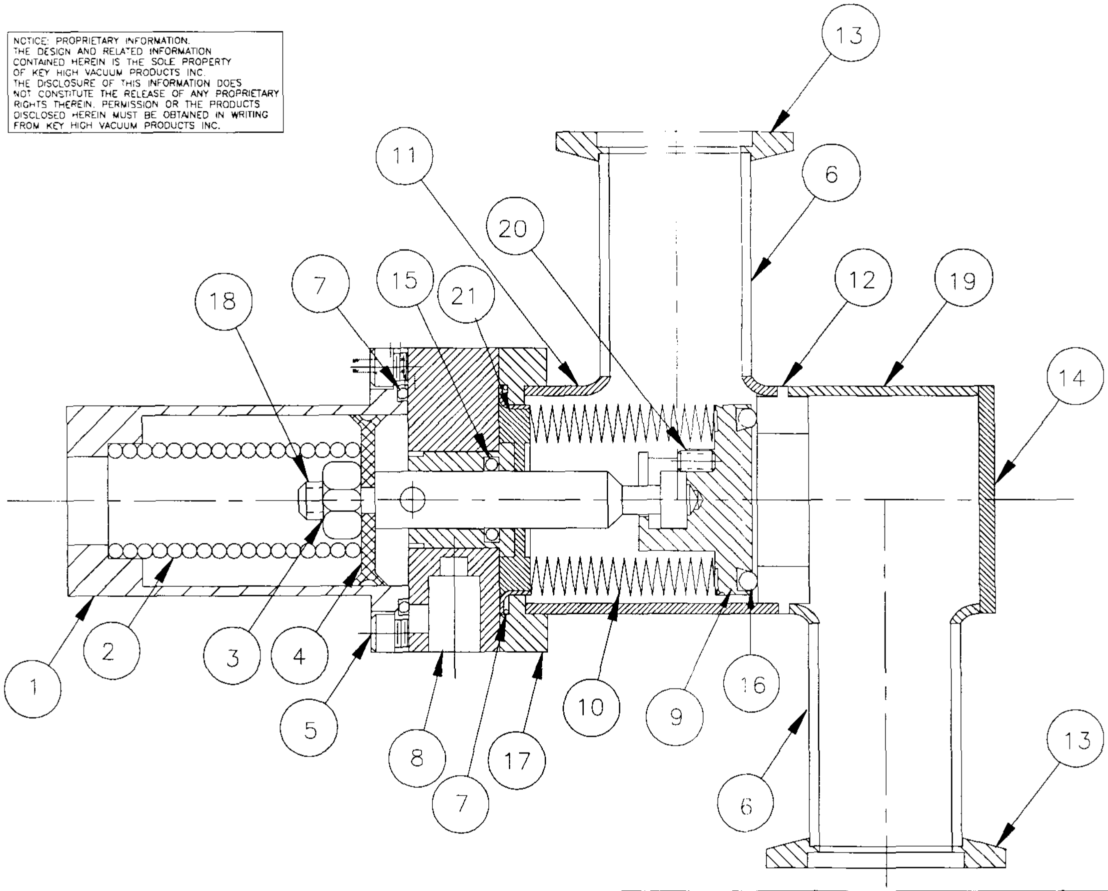

ITEM	QTY	DESCRIPTION	P/N	MAT'L
21	1	BELLOW TO FLANGE	21128	SS
20	1	SOC SET SCR #6 32 X 1/4 LG	SS-SHC632-25	SS
19	1	BODY BOTTOM	50025	SS
18	1	PNEUMATIC STEM	21127	SS
17	1	TOP FLANGE	11034	SS
16	1	O-RING BROWN / PARKER	VOR213	VITON
15	1	O-RING	VOR110	VITON
14	1	END CAP	10029	SS
13	2	KF-25	KSF-9825-3	SS
12	1	SEAT	50026	SS
11	1	BODY	21123	SS
10	1	BELLOWS ASSY	RS-B-100-N	SS
9	1	PLUNGER DISC	50059	SS
8	1	CAP ASSY	52516	
7	2	O-RING	VOR125	VITON
6	2	SIDE TUBE	21125	SS
5	4	SOC HD CAP SCR	SS-SHC832-100	SS
4	1	WIPER	CB-28118	1
3	1	HEX NUT 1/4-20	SS-HN2520-NYLOC	SS
2	1	SPRING	MC0910051	M&R
1	1	CAN	21113	ALUM

DRAWN: SC	KEY HIGH VACUUM PRODUCTS, INC. 36 SOUTHERN BLVD. NESCONSET, NEW YORK 11767	SCALE: 1 1/4 /1
CHECKED:		DATE: 2/4/95
TOLERANCES FRACTIONS ± 1/64 DECIMALS 2 PL. ± .01 3 PL. ± .005 ANGLE ± 1/2°	1" STAINLESS STEEL. PNEUMATIC INLINE VALVE	DWG. NO. PSL-100-K-N-NS REV. A

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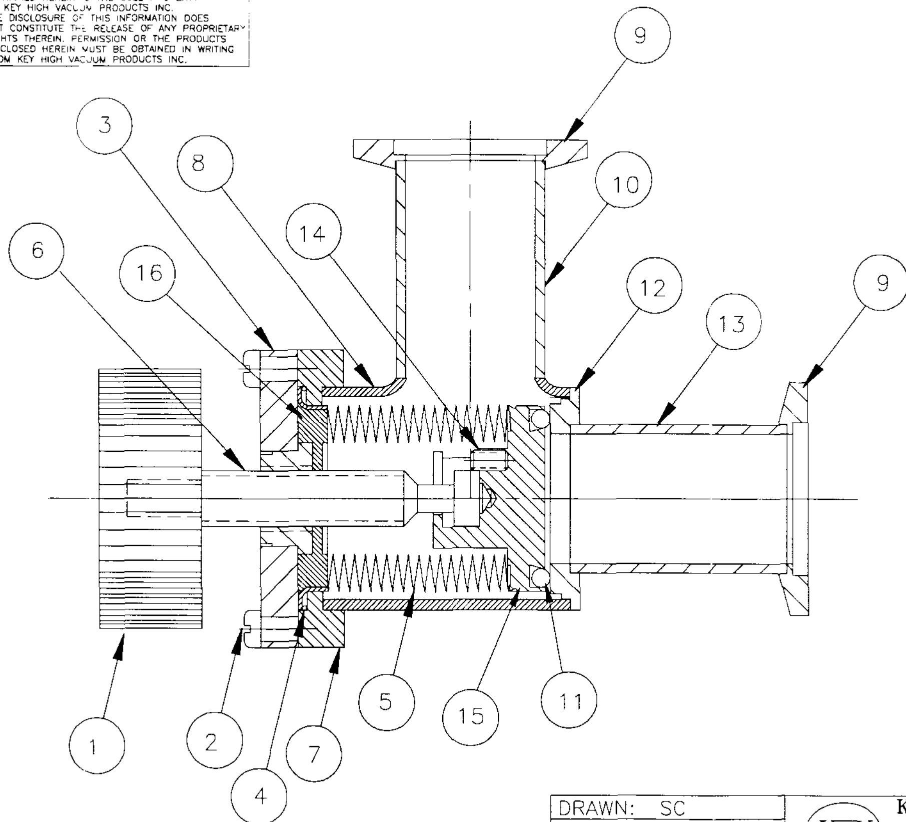
LTT.	REVISION	DATE	BY



ITEM	QTY	DESCRIPTION	P/N	MAT'L.
16	1	BELLOWS TOP FLANGE	21128	SS
15	1	PLUNGER DISC	50059	SS
14	1	SOCKET SET SCR #6-32X 1/4	SS-SHC632 25	SS
13	1	SEAT TUBE	21124	SS
12	1	SEAT	21126	SS
11	1	O-RING BROWN/PARKER	VOR213	VITON
10	1	SIDE TUBE	21125	SS
9	2	LOW PROFILE KF-25	KSF-9825-3	SS
8	1	BODY	21123	SS
7	1	TOP FLANGE	11034	SS
6	1	SHAFT	50037	SS
5	4	BELLOWS ASSY.	RS-B-100-N	SS
4	1	O-RING	VOR125	VITON
3	1	TOP CAP ASSY.	51213	ALUM
2	4	SCREW, SLOTTED PAN #8-32 X 1/2 LG	SS-SLPH-832-50	SS
1	1	HANDLE	RB-67-4A-M	

DRAWN: SC CHECKED: TOLERANCES FRACTIONS ± 1/64 DECIMALS 2 PL. ± .01 3 PL. ± .005 ANGLE ± 1/2°	KEY HIGH VACUUM PRODUCTS, INC. 36 SOUTHERN BLVD. NESCONSET, NEW YORK 11767 1" STAINLESS STEEL MANUAL ANGLE VALVE	SCALE: 1 1/4 / 1 DATE: 2/4/95 DWG. NO. SA-100-N-K REV.

Vakuum-Lösungen

Applikations-
Unterstützung

Service

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TURBOVAC

Turbo-Molekularpumpen
mit fettgeschmierten Lagern

Turbomolecular pumps with
grease-lubricated bearings

Gebrauchsanleitung

Operating instructions

Inhalt

The English Operating Instructions start on page 20

Erläuterungen

Abbildungen

Abbildungshinweise, z. B. (2/10), geben mit der ersten Ziffer die Abbildungsnummer an und mit der zweiten Ziffer die Position in dieser Abbildung.

Vorsicht

Steht bei Arbeits- und Betriebsverfahren, die genau einzuhalten sind, um eine Gefährdung von Personen auszuschließen.

Achtung

Bezieht sich auf Arbeits- und Betriebsverfahren, die genau einzuhalten sind, um Beschädigungen und Zerstörungen des Gerätes zu vermeiden.

Eine Änderung der Konstruktion und der angegebenen Daten behalten wir uns vor.

Die Abbildungen sind unverbindlich.

1 Beschreibung

Die TURBOVAC 50 bis 1000 sind Turbo-Molekularpumpen mit fettgeschmierten Lagern. Sie sind vorgesehen zum Abpumpen von Vakuumbehältern auf Druckwerte im Hochvakuumbereich. Zum Betrieb der TURBOVAC sind ein Frequenzwandler TURBOTRONIK und eine Vorvakuumpumpe erforderlich.

Die Pumpen sind **nicht** geeignet zum Betrieb ohne Vorvakuumpumpe.

Medienverträglichkeit

Turbo-Molekularpumpen sind **nicht** geeignet zum Fördern von Flüssigkeiten oder staubhaltigen Gasen.

Turbo-Molekularpumpen ohne Sperrgas-Einrichtung sind nur geeignet zum Pumpen von Luft oder von inerten Gasen. Sie sind **nicht** geignet zum Pumpen von aggressiven oder reaktiven Gasen.

TURBOVAC mit einem „C“ in der Typenbezeichnung haben eine Sperrgas-Einrichtung. Das Sperrgas schützt nur den Lager-Bereich und den Motor der TURBOVAC.

Einige Medien (z.B. Aluminiumtrichlorid) können in der Pumpe sublimieren und Beläge bilden. Dicke Beläge führen zu Spielaufzehrung und damit zum Blockieren der Pumpe. Bei einigen Prozessen kann die Belagbildung durch Erwärmen der Pumpe verhindert werden. Dazu erbitten wir Ihre Anfrage.

Ätzende Gase (z.B. Chlor) können die Rotoren zersetzen.

Bei Betrieb der TURBOVAC ist der Druck in der Pumpe so gering, daß keine Zündgefahr besteht (bei Drücken unter ca. 100 mbar). Gefahr besteht, wenn zündfähige Gemische über 100 mbar Druck in die heiße Pumpe gelangen. Die Pumpentemperatur bei Betrieb beträgt bis zu 120 °C. Zündfunken sind im Schadensfall möglich und können zur Explosion zündfähiger Gemische führen.

Lassen Sie sich bitte von uns beraten, welche Medien mit oder ohne Sperrgas gepumpt werden können.

Vorsicht

Keine Körperteile dem Vakuum aussetzen.

1.1 Lieferumfang

Die TURBOVAC wird in einem verschlossenen PE-Beutel mit Trockenmittel ausgeliefert.

Wirkungsdauer des Trockenmittels max. 1 Jahr.

bei Hochvakuum-Anschluß mit ISO-K-Flansch
Splitterschutz,
Zentrierring mit FPM-Dichtring, Außenring.

bei Hochvakuum-Anschluß mit CF-Flansch
Splitterschutz.

bei Hochvakuum-Anschluß mit KF-Flansch
Splitterschutz, Zentrierring mit FPM-O-Ring und Spannring.

bei Hochvakuum-Anschluß mit ANSI-Flansch
Splitterschutz.

Vorvakuum-Anschluß
Zentrierring mit O-Ring und Spannring.

Der Sperrgas- und der Belüftungs-Anschluß sind blindgeflanscht.

Außerdem gehören bei den TURBOVAC 151, 361 und 600 Schwenkverschraubungen für den Kühlwasseranschluß zum Lieferumfang, die bei Bedarf gegen die eingebauten Schlauchtüllen ausgetauscht werden können.

Der zum Betrieb notwendige elektronische Frequenzwandler und die Verbindungsleitungen sind nicht im Lieferumfang der Pumpe enthalten.

PE=Polyethylen
FPM=Fluor-Kautschuk, temperaturbeständig bis 150°C

1.2 Bestelldaten

TURBOVAC	50	50 D	50 D2	151	151 C	361	361 C	600 C	1000 C
Hochvakuum-Flansch									
DN 40 KF	854 00	856 61							
DN 40 CF	853 99	856 60							
DN 63 ISO-K	854 01	856 62	856 68	856 30	auf Anfrage				
DN 63 CF	854 02	856 63							
2" ANSI				894 13	auf Anfrage				
DN 100 ISO-K				856 31	856 35	856 70	856 75		
DN 100 CF				856 32	auf Anfrage	856 71	auf Anfrage		
DN 160 ISO-K						856 72	856 77	856 82	855 35 1) 855 38 2)
DN 160 CF						856 73	auf Anfrage	auf Anfrage	auf Anfrage
4" ANSI						894 23	auf Anfrage		
DN 200 CF									auf Anfrage
6" ANSI								894 25	894 89 1)
DN 250 ISO-K									855 36 1) 855 39 2)

1) Mit Vorvakuum-Flansch DN 40 KF
2) Mit Vorvakuum-Flansch DN 63 ISO-K

1.3 Technische Daten

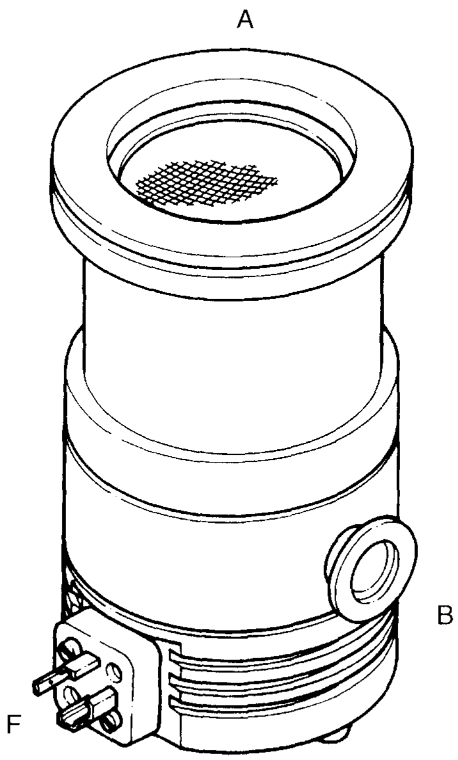
TURBOVAC		**50**	**50**	**50**	**50**	**50 D**	**50 D**	**50 D**	**50 D**	**50 D2**
Hochvakuum-Anschluß	DN	40 KF	40 CF	63 ISO-K	63 CF	40 KF	40 CF	63 ISO-K	63 CF	63 ISO-K
Saugvermögen für N_2	$l \cdot s^{-1}$	33	29	55	55	35	35	55	55	55
Enddruck	mbar	$8 \cdot 10^{-9}$	$< 8 \cdot 10^{-9}$	$8 \cdot 10^{-9}$	$< 8 \cdot 10^{-9}$	$8 \cdot 10^{-9}$	$< 10^{-9}$	$8 \cdot 10^{-9}$	$< 10^{-9}$	$< 10^{-9}$
Vorvakuumdruck	mbar	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}	5	5	5	5	15
Empfohlene Vorvakuum-pumpe	TRIVAC	D 1,6 B	D 1,6 B	D 1,6 B	D 1,6 B	S 1,6 B	S 1,6 B	S 1,6 B	S 1,6 B	Membran-pumpe
Empfohlene Frequenz-wandler	NT	10/12/13	10/12/13	10/12/13	10/12/13	10/12/13	10/12/13	10/12/13	10/12/13	10/12/13
Drehzahl	min^{-1}	72 000	72 000	72 000	72 000	72 000	72 000	72 000	72 000	72 000
Hochlaufzeit	ca. min	2	2	2	2	3	3	3	3	3
Kühlwasser-Durch-flußmenge bei 15 °C*	$l \cdot h^{-1}$	20	20	20	20	20	20	20	20	20
Vorvakuum-Anschluß	DN	16 KF	16 KF	16 KF	16 KF	16 KF	16 KF	16 KF	16 KF	16 KF
Sperrgas-Anschluß	DN	-	-	-	-	-	-	-	-	-
Belüftungs-Anschluß	DN	-	10 KF	-	10 KF	-	10 KF	-	10 KF	-
Gewicht, ca.	kg	2	2	2	2	2	2	2	2	2
Max. Ausheiztemperatur am CF-Flansch	°C	-	80	-	80	-	80	-	80	-

TURBOVAC		**151**	**151**	**151 C**	**361**	**361**	**361 C**	**361 C**
Hochvakuum-Anschluß	DN	63 ISO-K 2“ ANSI	100 ISO-K 100 CF	100 ISO-K	100 ISO-K 100 CF	160 ISO-K 160 CF 4“ ANSI	100 ISO-K	160 ISO-K
Saugvermögen für N_2	$l \cdot s^{-1}$	115	145	145	345	400	345	400
Enddruck	mbar	$< 10^{-10}$	$< 10^{-10}$	$< 10^{-10}$	$< 10^{-10}$	$< 10^{-10}$	$< 10^{-10}$	$< 10^{-10}$
Vorvakuumdruck	mbar	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}
Empfohlene Vorvakuum-pumpe	TRIVAC	D 4 B	D 4 B	D 16 B	D 16 B	D 16 B	D 25 B	D 25 B
Empfohlene Frequenz-wandler oder	NT NT	151/361 20	151/361 20	151/361 20	151/361 20	151/361 20	151/361 20	151/361 20
Drehzahl	min^{-1}	50 000	50 000	50 000	45 000	45 000	45 000	45 000
Hochlaufzeit	ca. min	2	2	2	2	2	2	2
Kühlwasser-Anschluß Schlauchtülle	mm	10	10	10	10	10	10	10
Kühlwasser-Temperatur	°C	10 - 25	10 - 25	10 - 25	10 - 25	10 - 25	10 - 25	10 - 25
Kühlwasser-Durch-flußmenge bei 15 °C	$l \cdot h^{-1}$	20	20	20	20	20	20	20
Vorvakuum-Anschluß	DN	25 KF	25 KF	25 KF	25 KF	25 KF	25 KF	25 KF
Sperrgas-Anschluß	DN	-	-	10 KF	-	-	10 KF	10 KF
Belüftungs-Anschluß	DN	10 KF	10 KF	10 KF	10 KF	10 KF	10 KF	10 KF
Gewicht, ca.	kg	8	8	8	12	12	12	12
Max. Ausheiztemperatur am CF-Flansch	°C	-	100	-	100	100	-	-

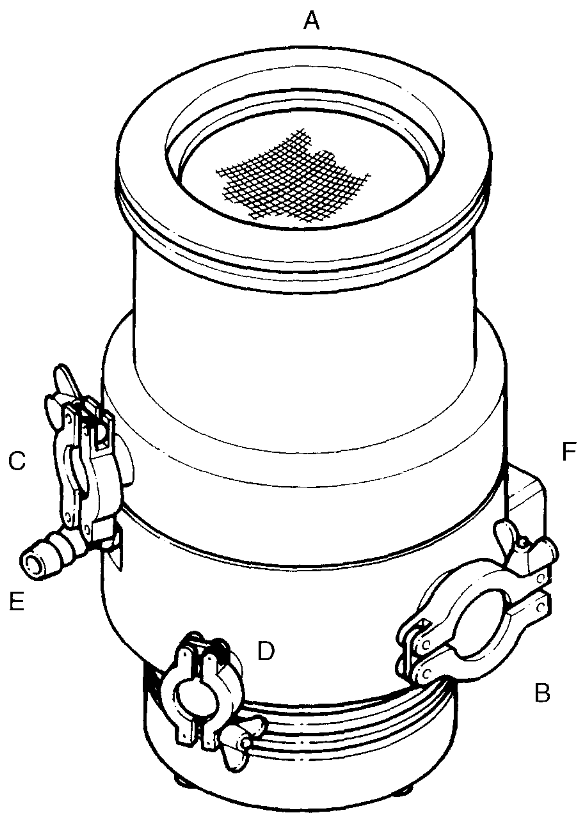
* Bei Verwendung der Option Wasserkühlung, Kat.-Nr. 854 08

TURBOVAC		600 C	600 C	1000 C	1000 C	1000 C
Hochvakuum-Anschluß	DN	160 ISO-K 160 CF	6" ANSI	160 ISO-K 160 CF	6" ANSI 200 CF	250 ISO-K
Saugvermögen für N_2	$l \cdot s^{-1}$	560	620	850	1100	1150
Enddruck	mbar	$< 10^{-10}$	$< 10^{-10}$	$< 10^{-10}$	$< 10^{-10}$	$< 10^{-10}$
Vorvakuumdruck	mbar	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}
Empfohlene Vorvakuum-pumpe	TRIVAC	D 40 B	D 40 B	D 40 B	D 40 B	D 40 B
Empfohlene Frequenz-wandler oder	NT NT	1000/1500 20	1000/1500 20	1000/1500 VH 20	1000/1500 VH 20	1000/1500 VH 20
Drehzahl	min^{-1}	36 000	36 000	36 000	36 000	36 000
Hochlaufzeit	ca. min	3	3	4[1)]	4[1)]	4[1)]
Kühlwasser-Anschluß Schlauchtülle	mm	10	10	11 / 10[2)]	11	11 / 10[2)]
Kühlwasser-Temperatur	°C	10 - 30	10 - 30	10 - 30	10 - 30	10 - 30
Kühlwasser-Durch-flußmenge bei 15 °C	$l \cdot h^{-1}$	30	30	30	30	30
Vorvakuum-Anschluß	DN	40 KF	40 KF	40 KF/63 ISO-K	40 KF	40 KF/63 ISO-K
Sperrgas-Anschluß	DN	10 KF	10 KF	10 KF[3)]	10 KF[3)]	10 KF[3)]
Belüftungs-Anschluß	DN	10 KF	10 KF	10 KF[3)]	10 KF[3)]	10 KF[3)]
Gewicht, ca.	kg	17	17	25	25	25
Max. Ausheiztemperatur am CF-Flansch	°C	100	-	100	100	-

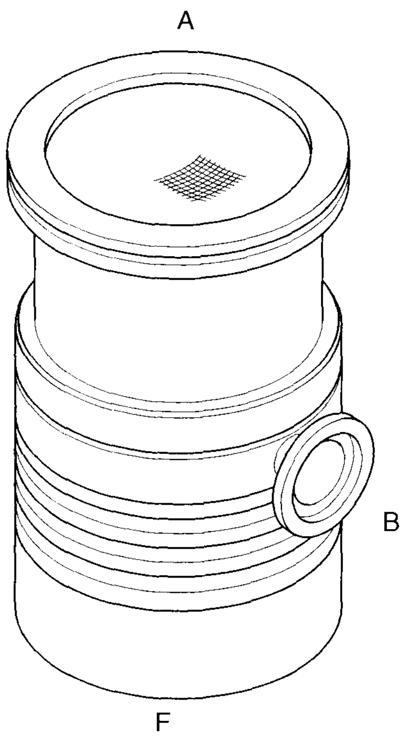
1) mit NT 20: 9 min
2) bei VV-Anschluß DN 40 KF 11 mm
bei VV-Anschluß DN 63 ISO-K 10 mm
3) ab 1995 zum Teil DN 16 KF



TURBOVAC 50 D/D2

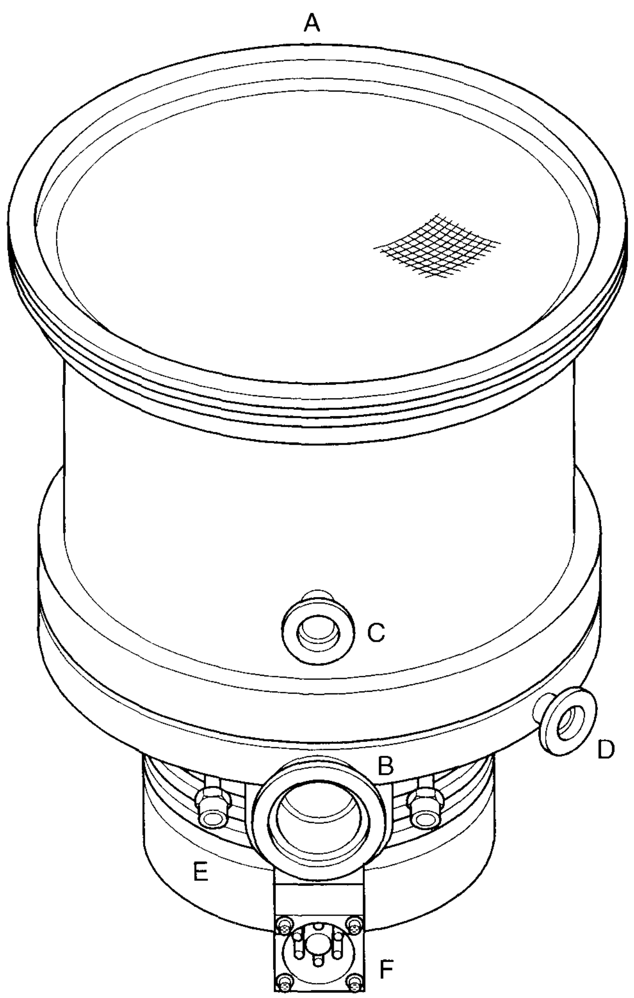


TURBOVAC 151 C; TURBOVAC 361 C ähnlich

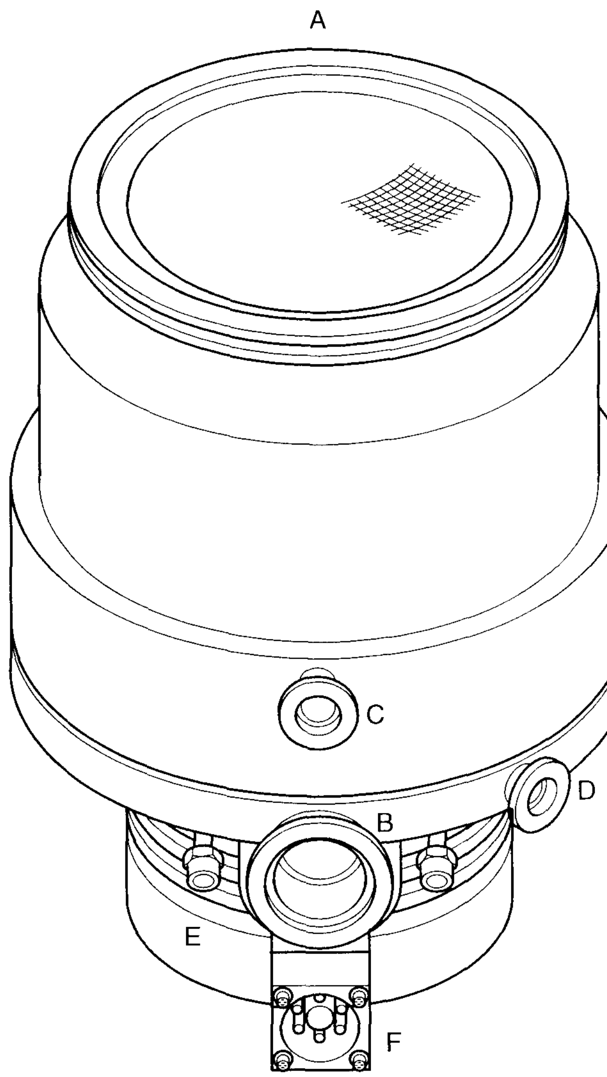


TURBOVAC 50

Abb. 1



TURBOVAC 600 C



TURBOVAC 1000 C

A Hochvakuum-Anschlußflansch
B Vorvakuum-Anschlußflansch
C Belüftungsflansch
D Sperrgasflansch
E Anschluß für Wasserkühlung
F Elektroanschluß

Abb. 2

Betriebsbedingungen und Kühlung

TURBOVAC	Keine zusätzliche Kühlung erforderlich, wenn alle diese Bedingungen erfüllt sind	Luft- oder Wasserkühlung erforderlich	Wasserkühlung erforderlich, wenn eine dieser Bedingungen erfüllt ist
50 D, 50 D2	Umgebungstemp. < 30 °C kein Ausheizbetrieb Hochvakuumdruck < 10^{-3} mbar Vorvakuumdruck < $5 \cdot 10^{-1}$ mbar	Umgebungstemp. 30 - 40 °C Ausheizbetrieb Hochvakuumdruck 10^{-3} - $5 \cdot 10^{-2}$ mbar Vorvakuumdruck $5 \cdot 10^{-1}$ - 2 mbar	Umgebungstemp. > 40 °C Ausheizbetrieb Hochvakuumdruck > $5 \cdot 10^{-2}$ mbar Vorvakuumdruck > 2 mbar
50	Dauerbetrieb bei Hochvakuumdruck < 10^{-4} mbar Umgebungstemp. < 50 °C	Ausheizen bei Umgebungstemp. < 40 °C Dauerbetrieb bei Hochvakuumdruck > 10^{-4} mbar Schneller Zyklusbetrieb	Umgebungstemp. > 50 °C Ausheizen bei Umgebungstemp. > 40 °C
151, 151 C, 361, 361 C	—	Ausheizen bei Umgebungstemp. < 35 °C oder Hochvakuumdruck < 10^{-3} mbar und Umgebungstemp. < 45 °C	Ausheizen bei Umgebungstemp. > 35 °C Hochvakuumdruck > 10^{-3} mbar Umgebungstemp. > 45 °C
600 C	—	Ausheizen bei Umgebungstemp. < 35 °C oder Hochvakuumdruck < 10^{-3} mbar und Umgebungstemp. < 45 °C	Ausheizen bei Umgebungstemp. > 35 °C Hochvakuumdruck > 10^{-3} mbar Umgebungstemp. > 45 °C
1000 C	—	Ausheizen bei Umgebungstemp. < 35 °C oder Hochvakuumdruck < 10^{-4} mbar und Umgebungstemp. < 45 °C	Ausheizen bei Umgebungstemp. > 35 °C Hochvakuumdruck > 10^{-4} mbar Umgebungstemp. > 45 °C

2 Anschluß

Achtung

Die TURBOVAC sind ohne geeignetes Zubehör **nicht** geeignet zum Abpumpen staubhaltiger, aggressiver oder korrosiver Medien.
Beim Abpumpen staubhaltiger Medien einen Feinfilter einbauen.
Beim Abpumpen von aggressiven oder korrosiven Medien müssen Pumpen der C-Version mit Sperrgas betrieben werden.
Beachten Sie die Hinweise zur Medienverträglichkeit am Anfang der Gebrauchsanleitung.

Die Verpackung erst unmittelbar vor der Montage öffnen.

Die Abdeckungen und Blindflansche an der Turbo-Molekularpumpe erst kurz vor dem Anbau an die Apparatur entfernen, damit die Montage der TURBOVAC unter saubersten Bedingungen durchgeführt werden kann.

Für den Transport der schwereren Pumpen eignen sich die unteren Flächen am Basisflansch für die Aufnahme einer Transportgabel; siehe Abb. 3.

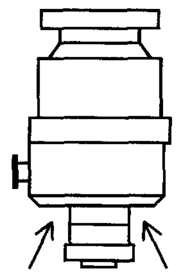


Abb. 3 Transport

Achtung

Stecker und Kühlwasser-Anschlüsse beim Transport nicht beschädigen.

Beim Anschließen oder Ausbauen der TURBOVAC nicht unter der Pumpe stehen.

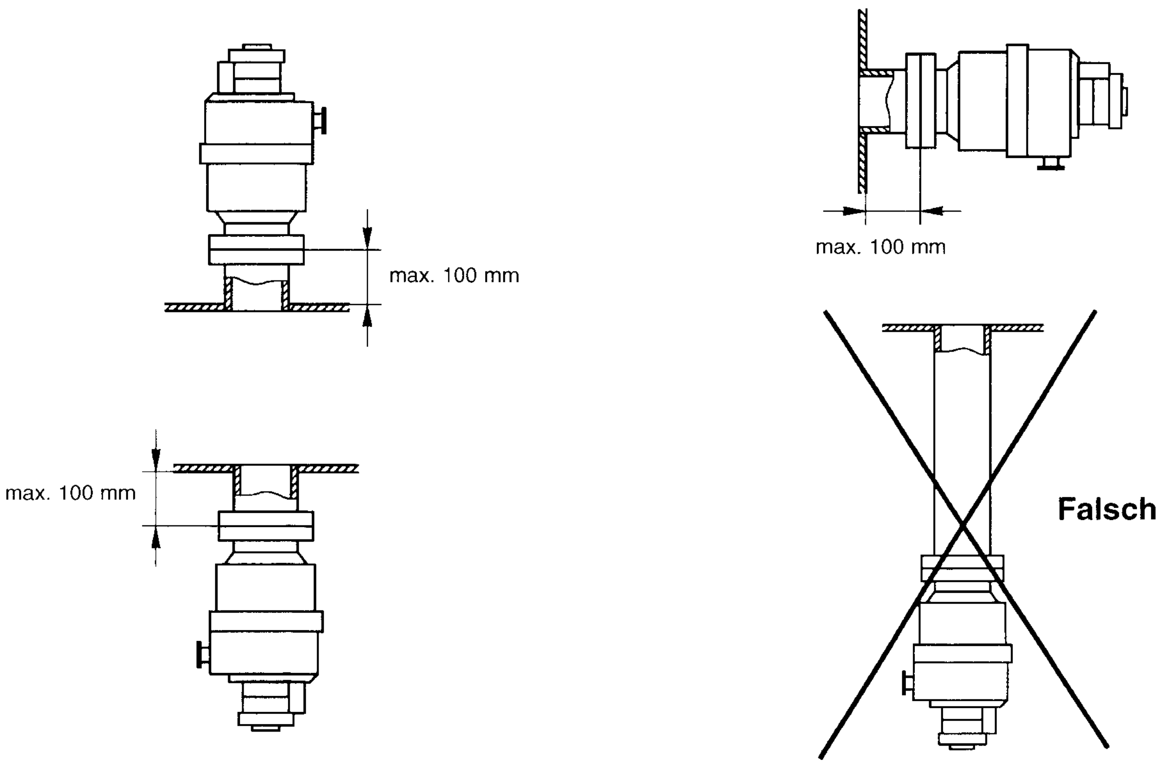


Abb. 4 Feste Anflanschung der TURBOVAC an den Vakuumbehälter

2.1 Umweltbedingungen

Sollte die TURBOVAC im Bereich eines Magnetfeldes zum Einsatz kommen, darf die magnetische Induktion an der Manteloberfläche der Pumpe nicht größer sein als:

TURBOVAC 50: B=7 mT

TURBOVAC 151 - 1000:
B=5 mT bei radialem Eintritt und
B=15 mT bei axialem Eintritt.

Werden diese Werte überschritten, geeignete Abschirmmaßnahmen vorsehen.

Die Standard-Ausführung ist strahlenfest bis 10^3 Gy

---

1 mT (milliTesla) = 10 G (Gauß)
1 Gy (Gray) = 100 rad

2.2 Pumpe an den Vakuumbehälter anbauen

Den Verpackungsflansch vom Hochvakuumflansch abnehmen. Beim Anschluß auf größte Sauberkeit achten.

Vorsicht

Der Hochvakuumflansch muß fest am Vakuumbehälter angebaut werden. Nicht ausreichende Befestigung kann bei Blockieren der Pumpe zum Losreißen der Pumpe oder zum Umherfliegen von Pumpen-Innenteilen führen. Die Pumpe niemals betreiben, ohne sie an den Vakuumbehälter anzuflanschen, z.B. im Tischversuch.

Bei plötzlichem Blockieren der Pumpe muß das Bremsmoment in der Anlage abgefangen werden. Dazu sind bei der Befestigung eines ISO-K-Hochvakuum-Flansches notwendig:

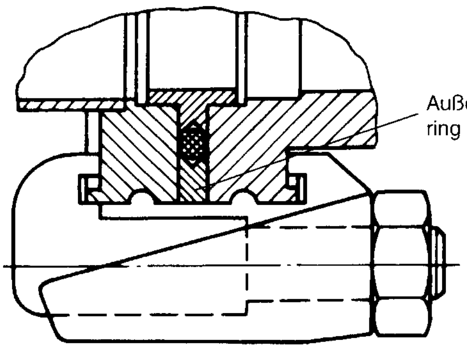


Abb. 5 Verwendung von ISO-K-Flanschen

TURBOVAC		Bremsmoment [Nm]	Klammerschrauben
50		63	4
50 D, 50 D2		150	4
151/151 C		283	4
361/361 C		580	6
600 C		1486	10
1000 C	DN 160	2457	16
	DN 250	2457	10

Das Anzieh-Drehmoment der Klammerschrauben ist 35 Nm bei Stahl- und 50 Nm bei Edelstahl-Schrauben.

Bei den CF-Flanschen nur die dafür vorgesehenen Schrauben benutzen (Anzieh-Drehmoment 15 Nm bei DN 40 CF, 30 Nm bei DN 63 CF und größer).

Die Bestell-Nummern der (Klammer-) Schrauben finden Sie im Leybold-Katalog.

Klammerschrauben gehören **nicht** mehr zum Lieferumfang der Pumpe.

Vorsicht

Die Kleinflansch Verbindung für den Hochvakuumflansch der TURBOVAC 50 und 50 D ist nicht fest genug, um Drehen der Pumpe bei plötzlichem Blockieren zu verhindern. Drehen der Pumpe kann zu Lecks in der Vorvakuumleitung führen.
Um Drehen der Pumpe bei plötzlichem Blockieren zu verhindern, die Pumpe zusätzlich befestigen.

In den meisten Anwendungsfällen wird die TURBOVAC direkt an den Hochvakuumflansch der Apparatur angeflanscht. Aufgrund des Schmiersystems läßt sich die TURBOVAC in jeder beliebigen Lage montieren und betreiben. Eine Abstützung der Pumpe ist nicht notwendig.

Wenn aus dem Vakuumbehälter Staub in die TURBOVAC gelangen kann, einen Feinfilter zwischen Vakuumbehälter und TURBOVAC einbauen.

Die TURBOVAC ist hochgenau ausgewuchtet und wird im allgemeinen ohne Schwingungsdämpfer betrieben. Zur Entkopplung höchstempfindlicher Geräte sowie zur Verhinderung externer Schwingungsübertragung auf die TURBOVAC ist ein Spezial-Schwingungsdämpfer lieferbar, der am Hochvakuumflansch der TURBOVAC montiert wird. Die TURBOVAC 1000 C bei Anbau über einen Schwingungsdämpfer zusätzlich am Basisflansch befestigen.

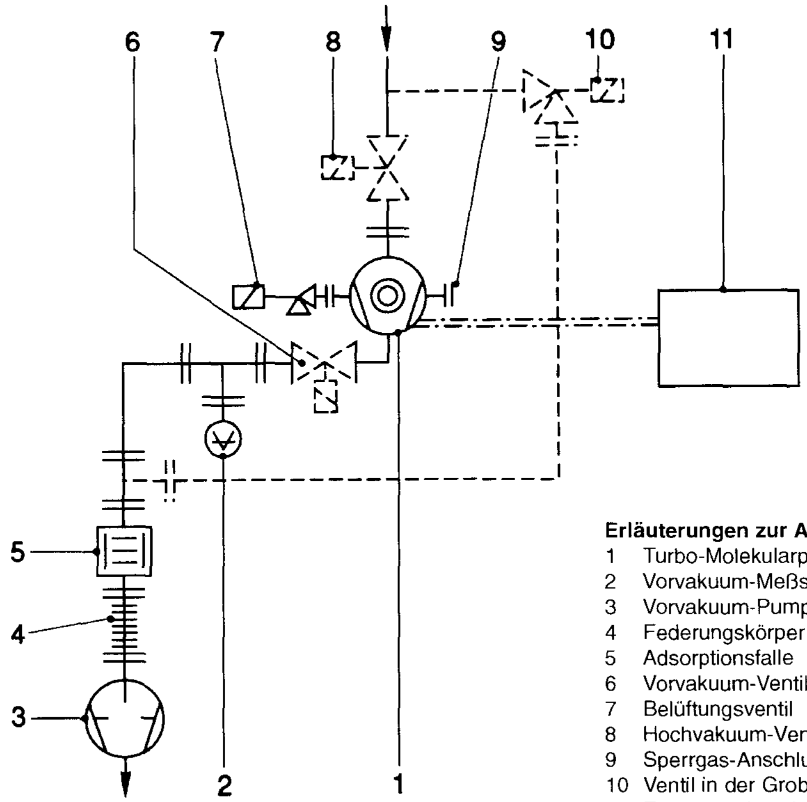
Ausführung mit Klammerflansch ISO-K

Den O-Ring an den Zentrierring anlegen.

Der O-Ring muß glatt und unverdreht eingelegt werden. Danach den Außenring dazulegen.

Zum Anschluß der TURBOVAC kann auch ein Überwurfflansch mit Sprengring und entsprechender Dichtscheibe verwendet werden.

Beim Einsatz von Ultra-Dichtscheiben ist ein Überwurfflansch erforderlich.



Erläuterungen zur Abb.6
1 Turbo-Molekularpumpe
2 Vorvakuum-Meßstelle
3 Vorvakuum-Pumpe
4 Federungskörper
5 Adsorptionsfalle
6 Vorvakuum-Ventil
7 Belüftungsventil
8 Hochvakuum-Ventil
9 Sperrgas-Anschluß
10 Ventil in der Grobpumpleitung
11 Elektronischer Frequenzwandler

— — — — Grobpumpleitung; zu empfehlen, wenn kürzeste Taktzeiten erreicht werden sollen

—·—·—· Antriebs- und Steuerleitung

Abb.6 Schema eines Turbo-Molekular-Pumpstandes

Splitterschutz

Im Hochvakuumflansch ist zum Schutz der TURBOVAC ein Splitterschutz eingesetzt.

Die Pumpe nur mit dem Splitterschutz betreiben, da einzelne Fremdkörper, die über den Ansaugstutzen in die Pumpe gelangen, zu schweren Schäden am Rotor führen. Schäden, die durch Eindringen von Fremdkörpern in den Rotorbereich entstehen, sind von der Gewährleistung ausgeschlossen.

Flanschheizung

(nur für Pumpen mit CF-Flansch)

Die Flanschheizung ermöglicht automatisch geregeltes Ausheizen des Hochvakuum-Anschlußflansches an TURBOVAC und Gegenflansch der Vakuumkammer.

Die Flanschheizung direkt am Ansaugflansch der TURBOVAC montieren. Dies ist auch bei angeflanschter Pumpe möglich.

Vorsicht

Die Flanschheizung kann bei Betrieb so heiß werden (> 80 °C), daß Verbrennungsgefahr besteht.
Die heißen Teile vor dem Berühren sichern.

Das Laufgeräusch der Pumpe liegt unter 70 dB(A); es sind keine lärmdämmenden Maßnahmen erforderlich.

2.3 Vorvakuum-Anschluß

Eine geeignete Vorvakuumpumpe am Vorvakuum-Anschlußflansch anschließen.

Abb. 6 zeigt den schematischen Aufbau eines Pumpstandes mit einer Turbo-Molekularpumpe TURBOVAC und einer Vorvakuumpumpe TRIVAC mit Saugstutzenventil.

Bei Vorvakuumpumpen, die ein solches Saugstutzenventil nicht besitzen, ein Sicherheitsventil gesondert vorsehen. Das Sicherheitsventil verhindert, daß Öl aus der Vorvakuumpumpe bei Stillstand in die TURBOVAC zurückströmt.

Um sicherzustellen, daß der Vorvakuumraum der TURBOVAC auch während des Betriebes weitgehend von Öldämpfen frei bleibt, empfehlen wir den Einsatz einer Adsorptionsfalle in der Vorvakuumleitung.

Zum Erreichen kürzester Taktzeiten eine Grobpumpleitung installieren.

Auf ausreichende Schwingungsentkopplung der TURBOVAC von der Vorvakuumpumpe achten.

Vorsicht

Die Vorvakuumleitung muß dicht sein.
Aus undichten Stellen können gefährliche Gase austreten oder die gepumpten Gase können mit Luft oder Luftfeuchtigkeit reagieren.

Wasserkühlung

Bei den TURBOVAC 50 und 50 D zum Anbauen der Wasserkühlung den Pumpenfuß entfernen und dann die Wasserkühlung unter der Pumpe festschrauben. Die Befestigungsschrauben gehören zum Lieferumfang der Wasserkühlung.

Kühlwasser-Schläuche an den Schlauchtüllen anschließen und mit Schlauchschellen sichern.

Wenn das Kühlwasser über ein elektrisches Ventil ein- und ausgeschaltet wird, das Ventil so anschließen, daß das Kühlwasser gemeinsam mit der Pumpe ein- und ausgeschaltet wird.

Kühlwasser-Spezifikationen

Zulaufdruck	3 - 7 bar absolut
Kühlwasserbedarf, Zulauftemperatur	siehe Abb. 7
Aussehen	farblos, klar, frei von Ölen und Fetten
Sinkstoffe	< 250 mg/l
Partikelgröße	< 150 µm
pH-Wert	7 - 8,5
Gesamthärte (Summe der Erdalkalien)	max. 20°dH (= 3,57 mmol/l)

2.4 Kühlung anschließen

Luftkühlung

Die Luftkühleinheit ist als Nachrüstsatz lieferbar.

Beim Aufbau der luftgekühlten TURBOVAC darauf achten, daß der Ventilator immer genügend Kühlluft ansaugen kann.

Immer einen Mindest-Abstand von 20 cm zum nächstgelegenen Objekt einhalten.

Darauf achten, daß keine Warmluft von benachbarten Aggregaten angesaugt wird.

Den Ventilator der Luftkühlung an das Wechselstrom-Netz anschließen.

Die Luftkühlung so anschließen, daß sie gleichzeitig mit der TURBOVAC einschaltet.

Die Gebrauchsanleitung zur Luftkühlung beachten (GA 05.199).

2.5 Sperrgas und Belüftung anschließen

TURBOVAC 50, 50 D, 50 D2 mit ISO-K-Anschluß

Die TURBOVAC werden über die Anlage belüftet.

TURBOVAC 50, 50 D mit CF-Anschluß und TURBOVAC 151, 361

Falls die Pumpe nicht über die Anlage belüftet werden kann, einen Stromausfallfluter an den Belüftungs-Anschlußflansch anschließen. Ein Stromausfallfluter verhindert, daß Öldampf aus der Vorvakuumleitung zurückdiffundiert.

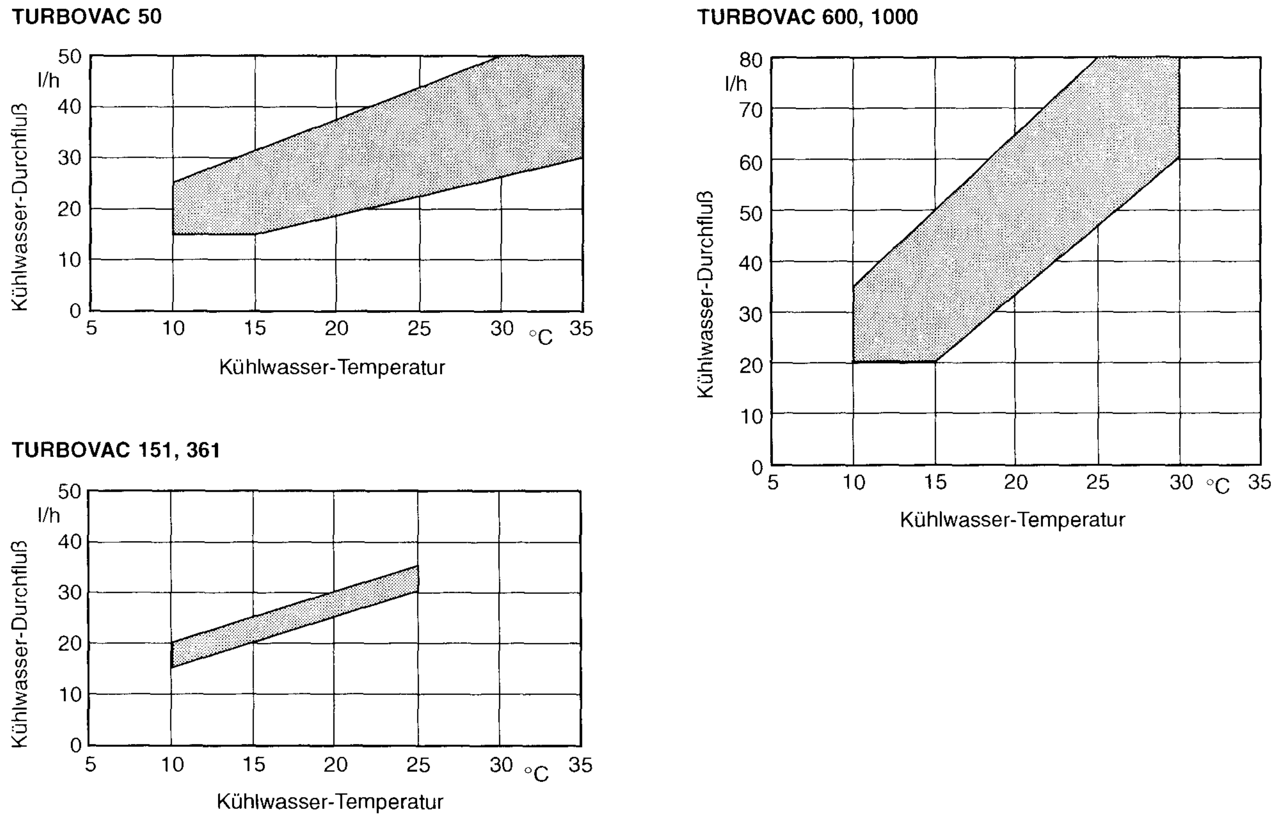


Abb. 7 Kühlwasserbedarf

TURBOVAC 151 C, 361 C, 600 C und 1000 C

Entweder einen Stromausfallfluter an den Belüftungs-Anschlußflansch anschließen oder ein Sperrgas- und Belüftungsventil an den Sperrgas-Anschlußflansch.

Welcher der beiden Flansche belegt wird, hängt vom Prozeß ab.

Beim Abpumpen **sauberer und nicht aggressiver Gase** einen Stromausfallfluter anschließen.

Beim Abpumpen **reaktiver Medien** ein Sperrgas- und Belüftungsventil anschließen.

Bei der Entscheidung, welche Medien mit oder ohne Sperrgas gepumpt werden dürfen, lassen Sie sich bitte von uns beraten.

Bei Prozessen, bei denen Sperrgas erforderlich ist, muß die Pumpe beim Abschalten über das Sperrgasventil belüftet werden.

Die Gebrauchsanleitung zum Sperrgas- und Belüftungsventil beachten.

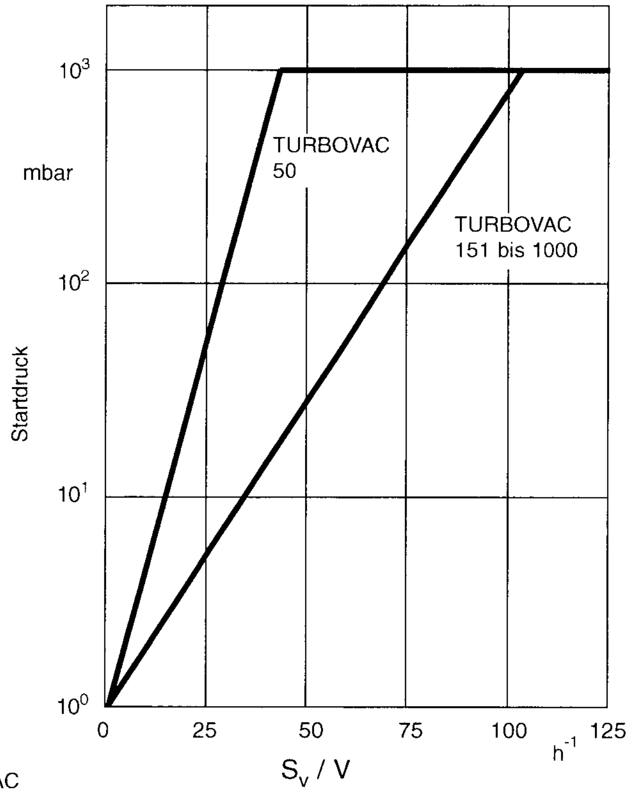
2.6 TURBOTRONIK anschließen

TURBOVAC mit der Verbindungsleitung an die TURBOTRONIK anschließen; siehe dazu die Gebrauchsanleitung zur TURBOTRONIK.

Vorsicht

Die Pumpe nur mit dem passenden Frequenzwandler und einer geeigneten Verbindungsleitung betreiben.
An der Verbindungsleitung zwischen Frequenzwandler und Pumpe liegen Spannungen bis 400 V an, am Lüfter, an Flanschheizungen oder an Ventilen oder deren Zuleitungen liegt Netzspannung an.
Leitungen so verlegen, daß sie nicht beschädigt werden können.

Die Schutzart der Verbindungen ist IP 40. Pumpe, Frequenzwandler und Verbindungen keinem Tropfwasser aussetzen.



Sv = Saugvermögen der Vorpumpe ($m^3 \cdot h^{-1}$)
V = Behältervolumen (m^3)

Abb. 8 Startdruck-Bestimmung einer TURBOVAC beim Evakuieren großer Volumina

3 Betrieb

3.1 Einschalten

Aus dem Diagramm in Abb. 8 kann man den Startdruck der TURBOVAC ablesen.

Wenn $S_v / V > 100$ [h^{-1}] ist, können TURBOVAC und Vorvakuumpumpe gleichzeitig gestartet werden.

Die TURBOVAC dient dabei von Anfang an als wirksames Baffle.

Bei großem Volumen muß der Vakuumbehälter zunächst mit der Vorvakuumpumpe evakuiert werden.

Dann die Kühlung einschalten und die TURBOVAC an der TURBOTRONIK einschalten.

Einzelheiten siehe Gebrauchsanleitung zur TURBOTRONIK.

Stöße und Schwingungs-Anregungen bei laufender Pumpe vermeiden.

3.2 Ausheizen

Sollen in kurzer Zeit Drücke im Bereich von 10^{-8} mbar erreicht werden, müssen die Vakuumkammer und die darin enthaltenen Komponenten ausgeheizt werden. Zusätzlich kann die TURBOVAC mit der dafür vorgesehenen Flanschheizung ausgeheizt werden.

Den Rotor vor starker und direkter Wärmestrahlung schützen. Beim Ausheizen an der Vorvakuumseite, z. B. einer Adsorptionsfalle, darauf achten, daß sich direkt angeflanschte Bauteile nicht über 80°C erwärmen.

Die Vorvakuumpumpe muß zum Abpumpen der aus der Adsorptionsfalle anfallenden Dämpfe in Betrieb sein.

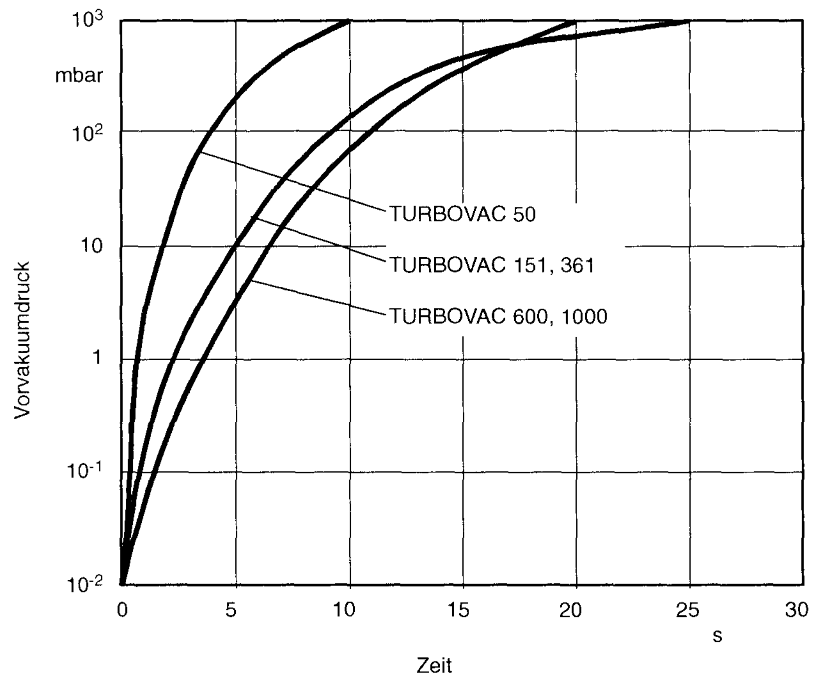


Abb. 9 Druckanstiegskurven

3.3 Betrieb

Während des Betriebes plötzliche Lageänderungen der Pumpe, extreme Fremdschwingungen und Stöße an die Pumpe vermeiden.

Wurde die TURBOVAC zum Abpumpen korrosiver Gase eingesetzt, soll sie vor dem Abschalten 1 Stunde mit trockenem Stickstoff gespült werden. Während Stillstandzeiten der Anlage darauf achten, daß weder Umgebungsluft noch Reinigungsmedien in die TURBOVAC gelangen können.

3.4 Abschalten

Die TURBOVAC an der TURBOTRONIK abschalten.

Einzelheiten siehe Gebrauchsanleitung zur TURBOTRONIK.

Die Vorvakuumpumpe abschalten.

Die TURBOVAC vor dem Stillstand belüften; siehe Abschnitt 3.5.

Bei TRIVAC-Pumpen schließt das eingebaute Saugstutzenventil automatisch und sperrt die Vorvakuumleitung ab. Bei Vorvakuumpumpen ohne Vakuumsicherung das Ventil in der Vorvakuumleitung schließen.

Unmittelbar nach dem Abschalten der TURBOVAC die Kühlwasserzufuhr absperren oder die Luftkühlung abschalten, um Kondensat-Bildung in der Pumpe zu vermeiden.

3.5 Belüften

Die TURBOVAC bei jedem Abschalten belüften, um eine mögliche Rückdiffusion von Öldämpfen aus der Vorvakuumleitung zur Hochvakuumseite zu vermeiden.

Zum Belüften z.B. trockenen Stickstoff verwenden.

Die TURBOVAC kann auf verschiedene Arten belüftet werden:

1. (nur C-Versionen) Bei Prozessen, bei denen Sperrgas erforderlich ist, muß die Pumpe beim Abschalten über das Sperrgasventil belüftet werden.

Bei einer zusätzlichen Belüftung des Vakuumbehälters mit Schutzgas, muß gleichzeitig oder vorher das Bypass-Ventil im Sperrgas- und Belüftungsventil geöffnet werden. Nur so wird im Motorraum ein höherer Druck als im Vorvakuumraum aufrechterhalten und eine schädliche Rückdiffusion von aggressiven Gasen vermieden.

Achtung

Der Druck im Motorraum der TURBOVAC muß immer höher sein als im Vorvakuumraum.

2. Bei allen anderen Prozessen empfehlen wir, die Pumpe über den Belüftungs-Anschlußflansch zu belüften. Eine in den Belüftungsflansch eingebaute Drossel stellt sicher, daß die Pumpe ohne Schaden belüftet wird.

3. Die Pumpe kann von der Hochvakuumseite belüftet werden.

Die Werte der Druckanstiegskurve müssen eingehalten werden.

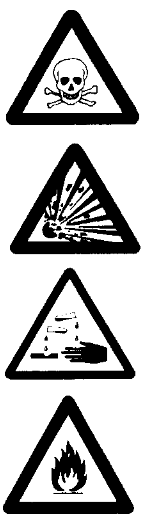
Die Pumpe kann bei voller Drehzahl belüftet werden.

Die TURBOVAC nicht über den Vorvakuum-Anschluß belüften. Dadurch können Öldämpfe in die TURBOVAC gelangen.

3.6 Pumpe aus der Anlage ausbauen

Pumpe abschalten und belüften gemäß den Abschnitten 3.4 und 3.5.

Vorsicht



Wenn die Pumpe vorher gefährliche Gase gefördert hat, vor dem Öffnen das Ansaug- oder Auspuff-Anschlusses entsprechende Vorsichtsmaßnahmen treffen.

Falls nötig, Handschuhe, Atemschutz oder Schutzkleidung tragen und unter einem Abzug arbeiten.

Wenn die Pumpe vorher korrosive Gase gefördert hat, das Sperrgas beim Ausbau so lange wie möglich weiterfließen lassen

TURBOVAC aus der Anlage ausbauen.

TURBOVACs, die z.B. in Halbleiter-Prozessen eingesetzt waren, sind mit Prozeßgasen verschmutzt. Diese Gase können giftig und gesundheitsschädlich sein. Außerdem können sie Beläge mit ähnlich gefährlichen Eigenschaften bilden. Viele dieser Gase und Beläge bilden Säuren, wenn sie mit feuchter Luft in Berührung kommen. Das führt zu schweren Korrosionsschäden in der Pumpe.

Um Gesundheits- und Korrosionsschäden bei ausgebauten TURBOVACs zu vermeiden, ein Trockenmittel auf den Splitterschutz legen, und dann die Pumpe sofort an allen Flanschen verschließen. Zur Lagerung die Pumpe mit Trockenmittel in einen PE-Beutel verpacken.

Bei den TURBOVAC mit einem „C" in der Typenbezeichnung gehört ein Verpackungs-Set zum Lieferumfang. Dieses Verpackungs-Set nach dem Ausbau benutzen.

Fehler beim dichten Verpacken einer TURBOVAC führen zum Verlust der Garantie.

Bestell-Informationen

Verpackungs-Set für Hochvakuum-Anschlußflansch	Best.-Nr.
DN 100/160	200 91 240
DN 200	200 91 295
DN 250, 6" ANSI	200 91 262

Die Pumpe so verpacken, daß sie beim Transport nicht beschädigt wird, und daß keine Schadstoffe aus der Verpackung austreten können. Besonders die Flansche, die Kühlwasser-Anschlußtüllen und die Stromdurchführung schützen.

Falls Sie eine Pumpe an Leybold schicken, beachten Sie Abschnitt 4.2.

4 Wartung

Die TURBOVAC ist wartungsfrei.

Das Sorptionsmittel in der Adsorptionsfalle regelmäßig regenerieren oder erneuern, siehe dazu die Gebrauchsanleitung der Adsorptionsfalle.

Abhängig vom Verschmutzungsgrad des Sperrgases setzt sich das Membran-Filter zu und muß gewechselt werden. Zum Filterwechsel siehe die Gebrauchsanleitung des Sperrgas- und Belüftungsventils.

4.1 Reinigen

Eine Verunreinigung der TURBOVAC zeigt sich durch zunehmende Verschlechterung des Arbeitsdruckes.

Bei einer leichten Verunreinigung, z. B. Belegung der inneren Flächen der TURBOVAC, durch längeres Stehenlassen an Atmosphäre, kann eine Reinigung bei der CF-Version durch Ausheizen mit der Flanschheizung erfolgen.

Während des Ausheizens unter Vakuum muß der Enddruck kontrolliert werden.

Für eine erste Überprüfung die Pumpe blindflanschen, um evtl. Leckagen und Desorptionen des Vakuumbehälters auszuschalten.

Bei starker Verschmutzung muß die Pumpe zerlegt werden. Hier muß grundsätzlich der LEYBOLD-Kundendienst hinzugezogen werden.

Achtung

Der Rotor ist hochgenau ausgewuchtet, jede Veränderung, z. B. das Lösen oder Verbiegen irgendwelcher Rotorteile macht neues Auswuchten erforderlich.

4.2 Service bei LEYBOLD

Falls Sie eine Pumpe an LEYBOLD schicken, geben Sie an, ob die Pumpe frei von gesundheitsgefährdenden Schadstoffen ist oder ob sie kontaminiert ist. Wenn sie kontaminiert ist, geben Sie auch die Art der Gefährdung an. Dazu müssen Sie ein von uns vorbereitetes Formular benutzen, das wir Ihnen auf Anfrage zusenden.

Eine Kopie dieses Formulars ist am Ende der Gebrauchsanleitung abgedruckt: “Erklärung über Kontaminierung von Vakuumgeräten und -komponenten”.

Befestigen Sie das Formular an der Pumpe oder legen Sie es der Pumpe bei. Das Formular nicht mit der Pumpe in den PE-Beutel packen.

Diese Erklärung über Kontaminierung ist erforderlich zur Erfüllung gesetzlicher Auflagen und zum Schutz unserer Mitarbeiter.

Pumpen ohne Erklärung über Kontaminierung muß LEYBOLD an den Absender zurückschicken.

5 Fehlersuche

Vorsicht

Bei angeschlossener Verbindungsleitung zur TURBOVAC sind die Ausgänge des Frequenzwandlers TURBOTRONIK nicht potentialfrei.

Bevor Sie mit einer Fehlersuche beginnen, sollten Sie folgende einfache Dinge prüfen:

Ist die TURBOVAC mit elektrischer Energie versorgt ?

Sind die Anschlüsse:
-Netzleitung zum Frequenzwandler,
-Verbindungsleitung Frequenzwandler/Netz in Ordnung?

Funktioniert ein eventuell angeschlossener Wasserströmungswächter?

Wasserströmungswächter zur Prüfung kurz überbrücken und die TURBOVAC starten.

Ist der Vorvakuumdruck ausreichend?

Ist der Vakuumbehälter dicht?

Beachten Sie auch die Fehlersuche in der TURBOTRONIK.

Störung	**Mögliche Ursache**	**Beseitigung**
TURBOVAC startet nicht.	Stecker oder Verbindungsleitung nicht gesteckt, lose oder defekt. Pumpe festgelaufen.	Verbindungsleitungen richtig einstecken, ggf. ersetzen. Pumpe ersetzen.
TURBOVAC verursacht starke Laufgeräusche und Vibrationen.	Unwucht am Rotor. Lager defekt. Pumpe läuft im Eigenfrequenzbereich der Apparatur.	Auswuchten (nur durch Leybold-Service). Lagerwechsel erforderlich. (nur durch Leybold-Service). Massen der Apparatur ändern oder Schwingungsdämpfer zur Schwingungsentkopplung einbauen.
TURBOVAC erreicht keinen Enddruck.	Meßgerät defekt. Meßröhre verschmutzt. Undichtheit an Apparatur, Leitungen oder Pumpe. Pumpe leicht verschmutzt. Pumpe verölt. Vorvakuumpumpe mit zu geringem Saugvermögen oder zu hohem Enddruck. Undichtheit an der Stromdurchführung. TURBOVAC hat die falsche Drehrichtung.	Meßgerät kontrollieren. Meßröhre reinigen oder ersetzen. Lecksuche. Pumpe ausheizen; siehe Abschnitt 4.1. Pumpe reinigen lassen. (nur durch Leybold-Service). Enddruck der Vorvakuumpumpe prüfen; ggf. größere Vorvakuumpumpe anbauen. Lecksuche / Reparatur. (nur durch Leybold-Service). Verbindungsleitung prüfen; ggf. die Leitungsbelegung ändern.
TURBOVAC wird zu heiß. (Fehlermeldung an der TURBOTRONIK)	Vorvakuumdruck zu hoch. Gasmenge zu groß / Leck in der Anlage. Lüftung behindert. Umgebungstemperatur zu hoch. Kühlwasser fehlt oder ist ungenügend. Lager defekt.	Vorvakuumpumpe prüfen; ggf. größere Vorvakuumpumpe einsetzen. Leck abdichten; ggf. größere Vovakuumpumpe einsetzen. Für ausreichende Kühlluft-Zufuhr sorgen. Kühlere Luft zuführen oder Wasserkühlung einsetzen. Für ausreichende Kühlwasser-Zufuhr sorgen. Pumpe reparieren lassen (nur durch Leybold-Service).
TURBOVAC oder Vakuumbehälter sind mit Öl verschmutzt.	Vakuumsicherung der Vorvakuumpumpe defekt. TURBOVAC wurde beim Abschalten nicht oder falsch belüftet. Falscher Aufbau der Anlage: Öldampf strömt beim Vorpumpen zurück. Adsorptionsfalle gesättigt.	Vorvakuumpumpe instandsetzen oder austauschen. Belüftungsventil prüfen, ggf instandsetzen. TURBOVAC richtig belüften, siehe Abschnitt 3.5. Grobpumpleitung installieren oder kürzere Zeit vorpumpen oder Adsorptionsfalle einbauen. Adsorptionsfalle regenerieren oder ersetzen.

EG-Herstellererklärung

im Sinne der Maschinenrichtlinie 89/392/EWG, Anhang IIb

LEYBOLD

Hiermit erklären wir, die Leybold Vakuum GmbH, daß die Inbetriebnahme der nachfolgend bezeichneten unvollständigen Maschine solange untersagt ist, bis festgestellt wurde, daß die Maschine, in die diese unvollständige Maschine eingebaut werden soll, den Bestimmungen der EG-Maschinenrichtlinie entspricht.

Gleichzeitig bestätigen wir Konformität zur Niederspannungsrichtlinie 73/23/EWG.

Bei Verwendung des entsprechenden Leybold-Zubehörs, z.B. Verbindungsleitungen, Flanschheizungen oder Lüftern, und bei Betrieb der Pumpe mit dem vorgesehenen Leybold-Frequenzwandler werden die Schutzziele der EMV-Richtlinie eingehalten.

Bezeichnung: Turbo-Molekularpumpe

Typen: TURBOVAC 50
TURBOVAC 50 D, 50 D2
TURBOVAC 151, 151 C
TURBOVAC 361, 361 C
TURBOVAC 600 C
TURBOVAC 1000 C

Katalog-Nummern:

853 99, 854 00/01/02

856 60/61/62/63/68

856 30/31/32/33/35, 894 13

856 70/71/72/73/74/75/77

856 82, 894 25

855 35/36/38/39, 894 89

ab Fabrikations-Nr. A 95 .....

Angewandte harmonisierte Normen:

• EN 292 Teil 1 und Teil 2	Nov. 1991
• EN 1012 Teil 2	1996
• EN 60 204	1993

Angewandte nationale Normen und technische Spezifikationen:

• DIN 31 001	April 1983
• DIN ISO 1940	Dez. 1993

Köln, den 8.9. 1998

Dr. Mattern-Klosson, Geschäftsbereichsleiterin
Turbo-Molekularpumpen

Köln, den 8.9. 1998

Hölzer, Konstruktionsleiter
Turbo-Molekularpumpen

Contents

Die deutsche Gebrauchsanleitung beginnt auf Seite 2

Conventions used in these instructions

Illustrations

The references to diagrams, e.g. (2/10), consist of the figure number and the item number, in that order.

Warning

This indicates procedures and operations which must be strictly observed to prevent hazards to persons.

Caution

This indicates procedures and operations which must be strictly observed to prevent damage to or destruction of the unit.

We reserve the right to change at any time the design and data given in these operating instructions.

The illustrations are approximate.

1 Description

The TURBOVAC models 50 to 1000 are turbomolecular pumps featuring grease-lubricated bearings. These units are engineered to pump vacuum chambers down to pressures in the high-vacuum range. A TURBOTRONIK frequency converter and a forevacuum pump are required for the operation of the TURBOVAC.

These units are **not** suitable for operation without a forevacuum pump.

Compatibility with pumped media

Turbomolecular pumps are **not** suitable for pumping either gases which contain dust particles or liquids.

Turbomolecular pumps without a purge gas feature are suitable only for moving air or inert gases. They are not suitable for pumping aggressive or reactive gases.

TURBOVAC versions identified with a "C" in the model number are equipped with this purge gas feature, it protects only the bearing area and the motor in the TURBOVAC.

Some media (such as aluminum trichloride) can sublime inside the pump and form deposits. Thick deposits reduce the play between moving parts to the point that the pump could seize. In some processes deposits can be prevented by heating the pump. Please consult with us in case such problems arise.

Corrosive gases (such as chlorine) can destroy the rotors.

During operation the pressure inside the TURBOVAC is so low that there is no danger of ignition (at pressures below about 100 mbar, 75 Torr). A hazardous condition will be created if flammable mixtures enter the hot pump at pressures above 100 mbar (75 Torr). During operation the pump can reach temperatures as high as 120°C (248 °F). Sparks could occur in case of damage to the pump and these could ignite explosive mixtures.

We would be glad to consult with you as regards the media which can safely be handled with this unit.

Warning

Never expose any parts of the body to the vacuum.

1.1 Standard equipment

The TURBOVAC is shipped in a sealed PE bag which also contains a desiccant.

The maximum effective life of the desiccant is one year.

for high-vacuum port with ISO-K flange:
Splinter guard,
Centering ring with FPM sealing ring; outer ring.

for high-vacuum port with CF flange:
Splinter guard.

for high-vacuum port with KF flange:
Splinter guard, centering ring with FPM O-ring and clamping ring.

for high-vacuum port with ANSI flange:
Splinter guard.

Forevacuum port
Centering ring with O-ring and clamping ring.

Both the purge gas port and the airing port are blanked off for shipping.

In addition the pivoted threaded fittings used to make the coolant connection are included as standard equipment for the TURBOVAC 151, 361 and 600; if needed, they can be used to replace the hose nipples installed at the factory.

The electronic frequency converter and the connector cables required for operation are not included as standard equipment with the pump.

PE = Polyethylene
FPM = Fluoroelastomer, resistant to temperatures of up to 150°C (300 °F)

1.2 Order data

TURBOVAC	50	50 D	50 D2	151	151 C	361	361 C	600 C	1000 C
High-vacuum flange									
DN 40 KF	854 00	856 61							
DN 40 CF	853 99	856 60							
DN 63 ISO-K	854 01	856 62	856 68	856 30	On request				
DN 63 CF	854 02	856 63							
2" ANSI				894 13	On request				
DN 100 ISO-K				856 31	856 35	856 70	856 75		
DN 100 CF				856 32	On request	856 71	On request		
DN 160 ISO-K						856 72	856 77	856 82	855 35 1) 855 38 2)
DN 160 CF						856 73	On request	On request	On request
4" ANSI						894 23	On request		
DN 200 CF									On request
6" ANSI								894 25	894 89 1)
DN 250 ISO-K									855 36 1) 855 39 2)

1) With forevacuum flange DN 40 KF
2) With forevacuum flange DN 63 ISO-K

1.3 Technical data

TURBOVAC		50	50	50	50	50 D	50 D	50 D	50 D	50 D2
High-vacuum port	nom.diam.	40 KF	40 CF	63 ISO-K	63 CF	40 KF	40 CF	63 ISO-K	63 CF	63 ISO-K
Pumping speed for N_2	l/sec	33	29	55	55	35	35	55	55	55
Ultimate pressure	mbar	$8 \cdot 10^{-9}$	$< 8 \cdot 10^{-9}$	$8 \cdot 10^{-9}$	$< 8 \cdot 10^{-9}$	$8 \cdot 10^{-9}$	$< 10^{-9}$	$8 \cdot 10^{-9}$	$< 10^{-9}$	$< 10^{-9}$
Forevacuum pressure	mbar	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}	5	5	5	5	15
Recommended fore-vacuum pump	TRIVAC	D 1,6 B	D 1,6 B	D 1,6 B	D 1,6 B	S 1,6 B	S 1,6 B	S 1,6 B	S 1,6 B	Diaphragm pump
Recommended frequency converter	NT	10/12/13	10/12/13	10/12/13	10/12/13	10/12/13	10/12/13	10/12/13	10/12/13	10/12/13
Speed	rpm	72 000	72 000	72 000	72 000	72 000	72 000	72 000	72 000	72 000
Run-up time	approx. min	2	2	2	2	3	3	3	3	3
Coolant flow rate at 15 °C*	l/hr	20	20	20	20	20	20	20	20	20
Forevacuum port	nom. diam.	16 KF	16 KF	16 KF	16 KF	16 KF	16 KF	16 KF	16 KF	16 KF
Purge gas port	nom. diam.	-	-	-	-	-	-	-	-	-
Vent port	nom. diam.	-	10 KF	-	10 KF	-	10 KF	-	10 KF	-
Weight, approx.	kg	2	2	2	2	2	2	2	2	2
Max. bakeout temperature at CF flange	°C	-	80	-	80	-	80	-	80	-

TURBOVAC		151	151	151 C	361	361	361 C	361 C
High-vacuum port	nom. diam.	63 ISO-K 2“ ANSI	100 ISO-K 100 CF	100 ISO-K	100 ISO-K 100 CF	160 ISO-K 160 CF 4“ ANSI	100 ISO-K	160 ISO-K
Pumping speed for N_2	l/sec	115	145	145	345	400	345	400
Ultimate pressure	mbar	$< 10^{-10}$	$< 10^{-10}$	$< 10^{-10}$	$< 10^{-10}$	$< 10^{-10}$	$< 10^{-10}$	$< 10^{-10}$
Forevacuum pressure	mbar	$10^{-3} - 10^{-2}$	$10^{-3} - 10^{-2}$	$10^{-3} - 10^{-2}$	$10^{-3} - 10^{-2}$	$10^{-3} - 10^{-2}$	$10^{-3} - 10^{-2}$	$10^{-3} - 10^{-2}$
Recommended fore-vacuum pump	TRIVAC	D 4 B	D 4 B	D 16 B	D 16 B	D 16 B	D 25 B	D 25 B
Recommended frequency converter	NT	151/361	151/361	151/361	151/361	151/361	151/361	151/361
or	NT	20	20	20	20	20	20	20
Speed	rpm	50 000	50 000	50 000	45 000	45 000	45 000	45 000
Run-up time	approx. min.	2	2	2	2	2	2	2
Coolant connection nozzle	mm	10	10	10	10	10	10	10
Coolant temperature	°C	10 – 25	10 – 25	10 – 25	10 – 25	10 – 25	10 – 25	10 – 25
Coolant flow rate at 15 °C	$l \cdot h^{-1}$	20	20	20	20	20	20	20
Forevacuum port	nom. diam.	25 KF	25 KF	25 KF	25 KF	25 KF	25 KF	25 KF
Purge gas port	nom. diam.	–	–	10 KF	–	–	10 KF	10 KF
Vent port	nom. diam.	10 KF	10 KF	10 KF	10 KF	10 KF	10 KF	10 KF
Weight approx.	kg	8	8	8	12	12	12	12
Max. bakeout temperature at CF flange	°C	–	100	–	100	100	–	–

* When using the water cooling option. Cat.no. 854 08

kg	lbs
2	4.4
8	17.7
12	26.5
17	37.5
25	55

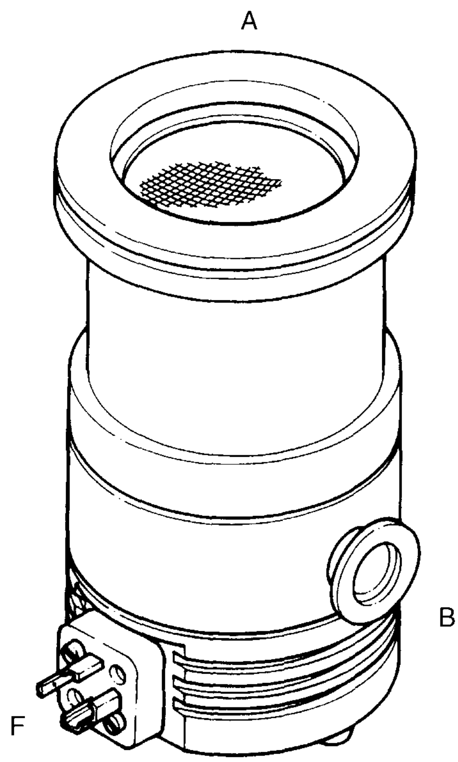
mm	inch
10	0.35
11	0.43

°C	°F
10	50
15	59
25	77
80	176
100	212

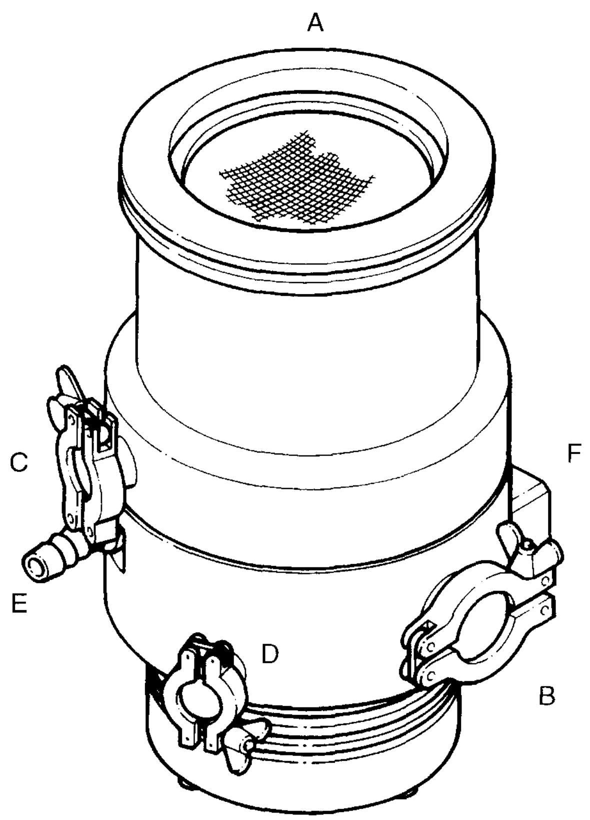
mbar	Torr
10^{-10}	$8 \cdot 10^{-11}$
$8 \cdot 10^{-9}$	$6 \cdot 10^{-9}$
10^{-3}	$8 \cdot 10^{-4}$
10^{-2}	$8 \cdot 10^{-3}$
1	0.8

TURBOVAC		600 C	600 C	1000 C	1000 C	1000 C
High-vacuum port	nom. diam.	160 ISO-K 160 CF	6" ANSI	160 ISO-K 160 CF	6" ANSI 200 CF	250 ISO-K
Pumping speed for N_2	$l \cdot s^{-1}$	560	620	850	1100	1150
Ultimate pressure	mbar	$< 10^{-10}$	$< 10^{-10}$	$< 10^{-10}$	$< 10^{-10}$	$< 10^{-10}$
Forevacuum pressure	mbar	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}	10^{-3} - 10^{-2}
Recommended fore- vacuum pump	TRIVAC	D 40 B	D 40 B	D 40 B	D 40 B	D 40 B
Recommended frequency converter or	 NT NT	 1000/1500 20	 1000/1500 20	 1000/1500 VH 20	 1000/1500 VH 20	 1000/1500 VH 20
Speed	rpm	36 000	36 000	36 000	36 000	36 000
Run-up time	approx. min.	3	3	4 1)	4 1)	4 1)
Coolant connection nozzle	mm	10	10	11 / 10 2)	11	11 / 10 2)
Coolant temperature	°C	10 - 30	10 - 30	10 - 30	10 - 30	10 - 30
Coolant flow rate at 15 °C	l/hr	30	30	30	30	30
Forevacuum port	nom. diam.	40 KF	40 KF	40 KF/63 ISO-K	40 KF	40 KF/63 ISO-K
Purge gas port	nom. diam.	10 KF	10 KF	10 KF 3)	10 KF 3)	10 KF 3)
Vent port	nom. diam.	10 KF	10 KF	10 KF 3)	10 KF 3)	10 KF 3)
Weight, approx.	kg	17	17	25	25	25
Max. bakeout temperature at CF flange	°C	100	-	100	100	-

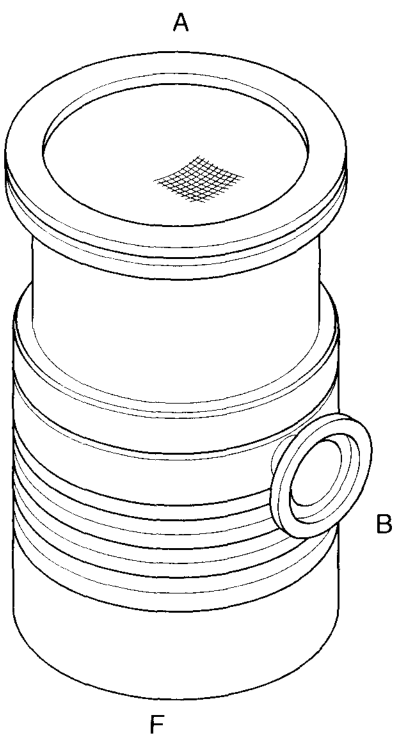
1) with the NT 20: 9 min
2) 11 mm with 40 mm type KF forevacuum port
10 mm with 63 mm type ISO-K forevacuum port
3) As of 1995 in some cases 16 mm KF



TURBOVAC 50 D/D2

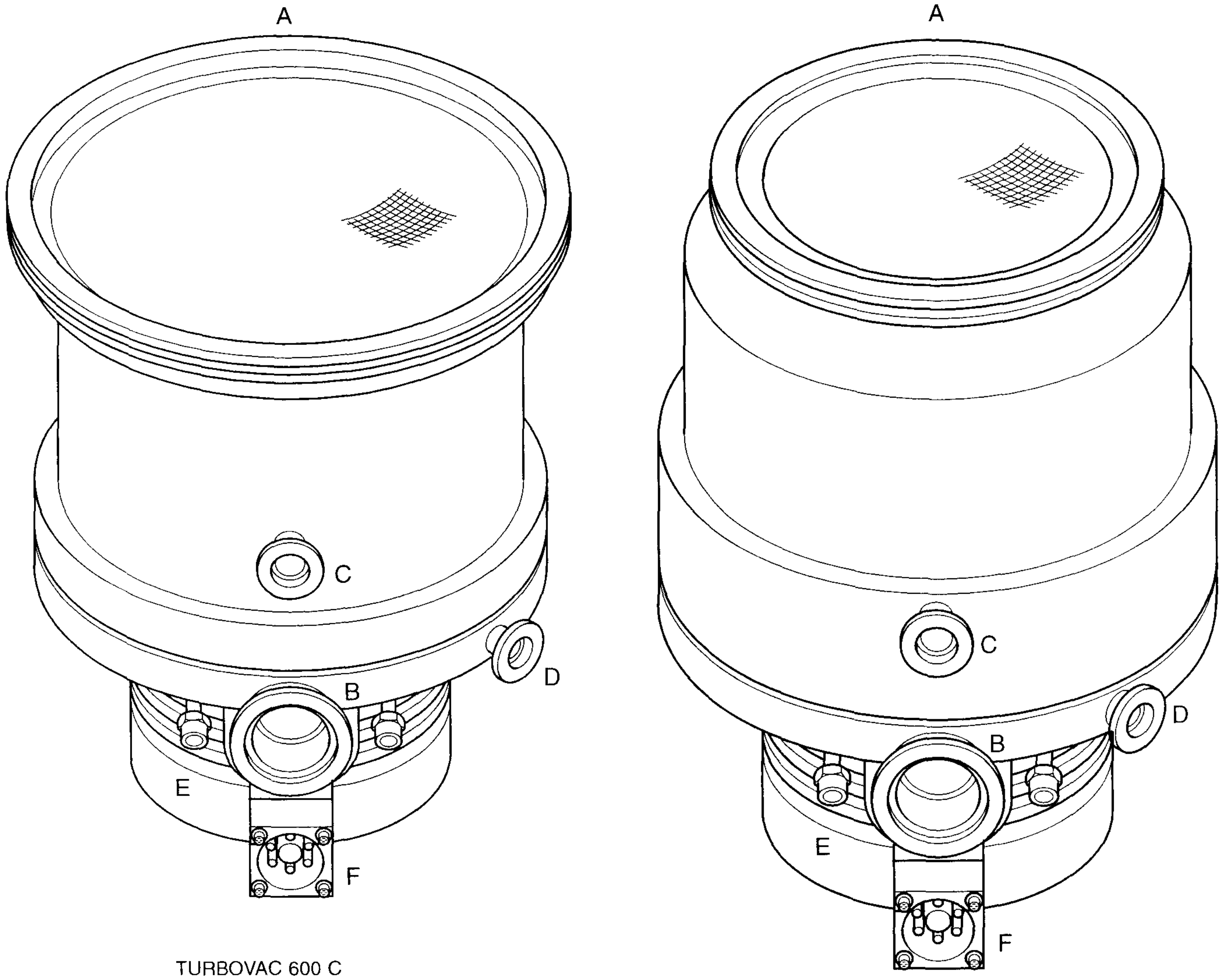


TURBOVAC 151 C; TURBOVAC 361 C is similar



TURBOVAC 50

Fig. 1



TURBOVAC 600 C

TURBOVAC 1000 C

A High-vacuum connector flange
B Forevacuum connector flange
C Airing flange
D Purge gas flange
E Connection for water cooling
F Electrical connection

Fig. 2

Operating environment and cooling

TURBOVAC	No additional cooling required if all these conditions are satisfied	Air or water cooling required	Water cooling required if any one of these conditions prevails
50 D, 50 D2	Ambient temperature < 30°C No bakeout operations High-vacuum pressure < 10^{-3} mbar Forevacuum pressure < $5 \cdot 10^{-1}$ mbar	Ambient temperature 30 to 40°C Bakeout operations High-vacuum pressure 10^{-3} to 10^{-2} mbar Forevacuum pressure $5 \cdot 10^{-1}$ to 2 mbar	Ambient temperature > 40°C Bakeout operations High-vacuum pressure > $5 \cdot 10^{-2}$ mbar Forevacuum pressure > 2 mbar
50	Continuous operation at high-vacuum pressure < 10^{-4} mbar Ambient temperature < 50°C	Bakeout at ambient temperature < 40°C Continuous operation at high-vacuum pressure > 10^{-4} mbar Rapid-cycling operation	Ambient temperature > 50°C Back-out at ambient temperature > 40°C
151, 151 C, 361, 361 C	–	Bakeout at ambient temperature < 35°C High-vacuum pressure < 10^{-3} mbar and ambient temperature < 45°C	Bakeout at ambient temperature > 35°C High-vacuum pressure > 10^{-3} mbar Ambient temperature > 45°C
600 C	–	Bakeout at ambient temperature < 35°C or high-vacuum pressure < 10^{-3} mbar and ambient temperature < 45°C	Bakeout at ambient temperature > 35°C High-vacuum pressure > 10^{-3} mbar Ambient temperature > 45°C
1000 C	–	Bakeout at ambient temperature < 35°C or high-vacuum pressure < 10^{-4} mbar and ambient temperature < 45°C	Bakeout at ambient temperature > 35°C High-vacuum pressure > 10^{-4} mbar Ambient temperature > 45°C

2 Connections

Caution

Unless appropriate accessories and attachments are used, the TURBOVAC **is not** suitable for aggressive or corrosive media, or those containing dust. When handling corrosive media the C version pump must be operated with purge gas; when handling media containing dust, a fine-mesh filter must be installed.
Observe the information on media compatibility, to be found at the beginning of these operating instructions.

Do not open the packaging until immediately prior to installation.

Remove the covers and the blank flanges at the turbomolecular pump only just before installing, to ensure that the TURBOVAC is installed under the cleanest possible conditions.

When moving the heavier pumps, the lower surfaces on the base flange are suitable for accepting a lifting fork; see Fig. 3.

°C	°F
30	86
35	95
40	104
45	113
50	122

mbar	Torr
10^{-4}	$8 \cdot 10^{-5}$
10^{-3}	$8 \cdot 10^{-4}$
10^{-2}	$8 \cdot 10^{-3}$
$5 \cdot 10^{-2}$	$4 \cdot 10^{-2}$
$5 \cdot 10^{-1}$	$4 \cdot 10^{-1}$
2	1.5

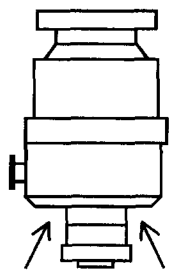


Fig. 3 Movement

Caution

Take care not to damage the plugs and coolant connections during movement.

Do not stand below the TURBOVAC pump while it is being connected to or detached from the system.

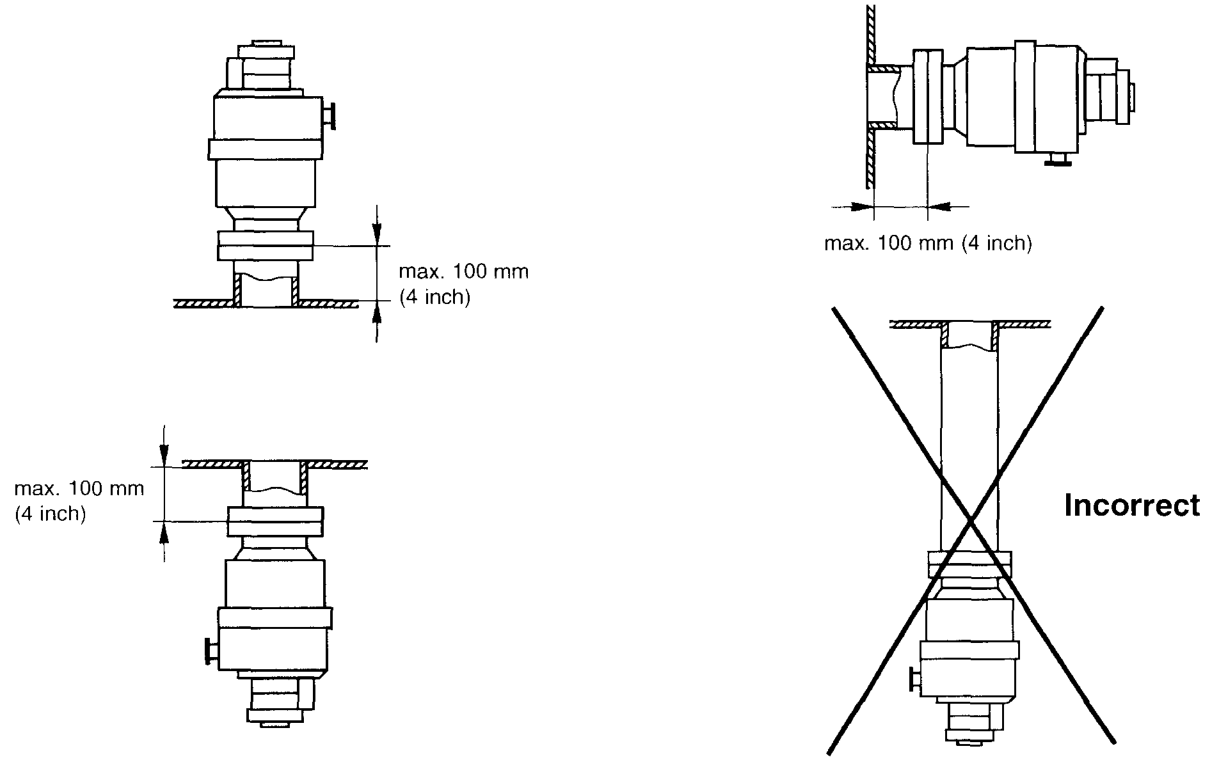


Fig. 4 Permanent flanging of the TURBOVAC to the vacuum chamber

2.1 Operating environment

When using the TURBOVAC inside a magnetic field, the magnetic induction at the pump housing surface may not exceed the following values:

TURBOVAC 50: B = 7 mT

TURBOVAC 151 – 1000:
B = 5 mT in case of radial impingement
B = 15 mT in case of axial impingement

Provide suitable shielding measures if these values are exceeded.

The standard version is resistant to radiation at levels up to 10^3 Gy.

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1 mT (milliTesla) = 10 G (Gauss)
1 Gy (Gray) = 100 rad

2.2 Connecting the pump to the vacuum chamber

Remove the packing flange from the high-vacuum flange. Pay attention to maintaining maximum cleanliness during connection work.

Warning

The high-vacuum flange must be securely attached to the vacuum chamber . If the pump were to become blocked, insufficient attachment could cause the pump to break away from its mount or allow internal pump parts to be discharged. Never operate the pump (in bench tests, for instance) without its being flanged to the vacuum chamber.

If the pump should suddenly seize, the ensuing deceleration torque will have to be absorbed by the system. To accomplish this, the following are required when securing an ISO-K type high-vacuum flange:

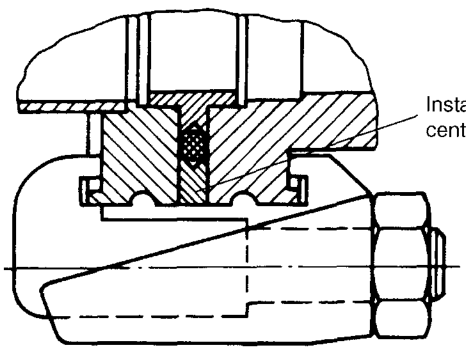


Fig. 5 Using ISO-K flanges

TURBOVAC		Braking torque [Nm]	Clamping bolts
50		63	4
50 D, 50 D2		150	4
151/151 C		283	4
361/361 C		580	6
600 C		1486	10
1000 C	DN 160	2457	16
	DN 250	2457	10

Clamping bolts made of steel must be torqued down to 35 Nm, those made of stainless steel to 50 Nm.

When installing CF flanges, use only the bolts specified (tightening torque is 15 Nm for DN 40 CF, 30 Nm for DN 63 CF and larger).

Nm	15	30	35	50
ft-lb	11	22	26	37

You will find the order numbers for the (clamping) bolts in the Leybold Catalog.

The clamping bolts are **not** included as standard equipment with the pump.

Warning

The small-flange connector for the high-vacuum flange at the TURBOVAC 50 and 50 D is not strong enough to keep the pump from rotating if it should suddenly seize. Rotation of the pump can cause leaks in the forevacuum line.
Secure the pump additionally to prevent rotation in case it should suddenly seize.

In most applications the TURBOVAC will be flanged direct to the high-vacuum flange for the system. The design of the lubricating system makes it possible to mount and run the TURBOVAC in any desired attitude. It is not necessary to support the pump.

If there is a danger that dust could pass from the vacuum chamber into the TURBOVAC, install a fine-mesh filter between the vacuum chamber and the TURBOVAC.

The TURBOVAC is precision balanced and is generally operated without a vibration damper. A special-design vibration damper is available for mounting at the TURBOVAC high-vacuum flange to decouple extremely sensitive equipment and to prevent external vibrations from being transferred to the TURBOVAC. If the TURBOVAC 1000 C are flanged via a vibration damper secure it in addition at the base flange.

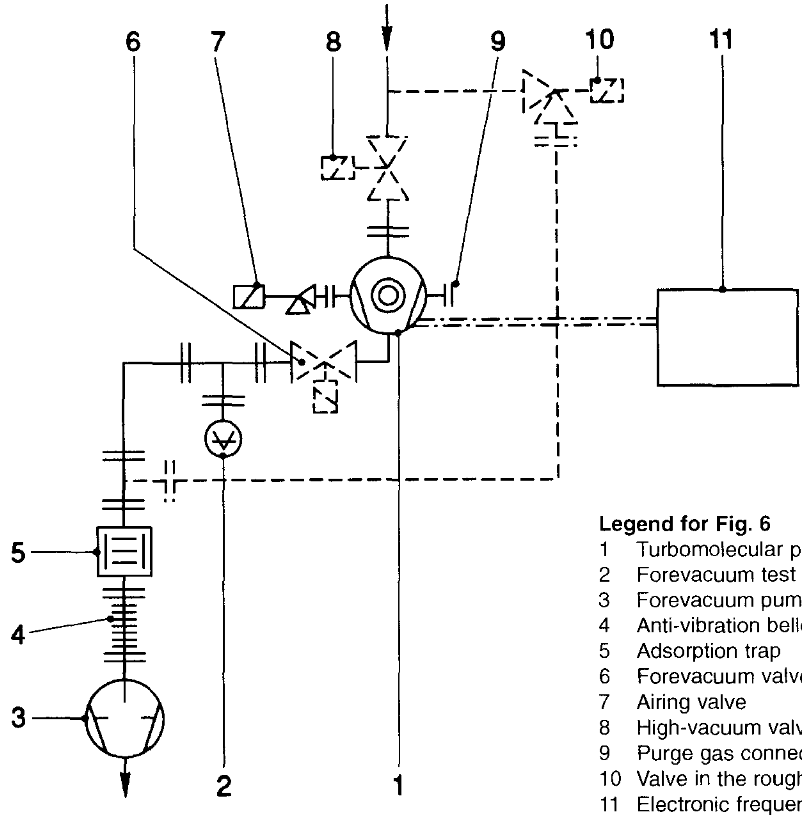
Design with ISO-K clamp flange

Fit the O-ring at the centering ring.

The O-ring should be flat and even; it must not be twisted. Then add the outer ring.

A collar flange with retaining ring and suitable sealing washer can also be used to connect the TURBOVAC.

A collar flange is required when using ultra-high-vacuum sealing washers.



Legend for Fig. 6
1 Turbomolecular pump
2 Forevacuum test point
3 Forevacuum pump
4 Anti-vibration bellows
5 Adsorption trap
6 Forevacuum valve
7 Airing valve
8 High-vacuum valve
9 Purge gas connection
10 Valve in the roughing pump line
11 Electronic frequency converter

— — — — Roughing pump line; recommended to achieve the shortest possible cycling times

— · — · — · — · Drive and control line

Fig. 6 Schematic of a turbomolecular pump system

Splinter guard

A splinter guard is installed in the high-vacuum flange to protect the TURBOVAC.

Operate the pump only with this splinter guard in place as foreign objects passing through the intake port and into the pump can cause serious damage to the rotor. Damage caused by foreign objects in the rotor section is excluded from the guarantee.

Flange heating

(only for pumps with the CF flange)

The flange heater is used to bake out, under automatic control, the high-vacuum connection port at the TURBO-VAC and the mating flange on the vacuum chamber.

The bakeout jacket or flange heater is mounted directly to the TURBOVAC intake flange. This can be done even with the pump flanged to the vacuum chamber.

Warning

The bakeout jacket can become so hot during operation (> 80°C, 176 °F) as to represent a burn hazard.
Shield the hot components against contact.

The pump running noise is below 70 dB(A); no noise-insulating measures are required.

2.3 Making the forevacuum connection

A suitable forevacuum pump is to be connected to the forevacuum connection flange.

Fig. 6 shows schematically the design of a pump system incorporating a TURBOVAC turbomolecular pump and a TRIVAC forevacuum pump with anti-suckback valve.

When using a forevacuum pump not having an anti-suckback valve, a separate safety valve should be provided. The safety valve keeps oil from backstreaming from the forevacuum pump and into the TURBOVAC when the system is not running.

We recommend installing a sorption trap in the forevacuum line to insure that the forevacuum chamber in the TURBOVAC remains largely free of oil vapors during operation, as well.

Install a roughing pump line to achieve the shortest possible cycling times.

Be sure that there is sufficient vibration decoupling between the TURBOVAC and the forevacuum pump.

Warning

The forevacuum line must be tight. Hazardous gases could escape from leaks or the gases being pumped could react with air or humidity.

Water cooling

When attaching the water cooling unit to the TURBOVAC 50 and 50 D, remove the pump foot and then bolt the cooling unit to the bottom of the pump. The mounting bolts are provided with the water cooling unit.

Connect the coolant hoses to the hose nipples and secure with hose clamps.

If the coolant flow is turned on and off by means of a solenoid valve, make the electrical connection in such a way that coolant flow will be started and stopped together with the pump itself.

Cooling water specifications

Inlet pressure	3 to 7 bar absolute
Cooling water requirement, Inlet temperature	See Fig. 7
Appearance	Colorless, clear, free of oils and greases
Sediments	< 250 mg/l
Particle size	< 150 µm
pH value	7 to 8.5
Overall hardness (total alkaline earths)	max. 20 ° German hardness scale (= 3.57 mmol/l)

2.4 Connecting the cooling

Air cooling

The air cooling unit is available as a supplementary kit for retrofitting.

When installing the air-cooled TURBOVAC, ensure that there is an unrestricted flow of air to the fan.

Always maintain a minimum distance of 20 cm (8 inch) to the nearest object.

Ensure that no heated air from neighboring equipment will be drawn in by the fan.

Connect the fan in the air ventilation unit to the AC mains.

Make the electrical connection for the ventilation unit in such a way that it will be started and stopped together with the pump itself.

Observe the information given in the operating instructions for the air ventilation unit (GA 05.199).

2.5 Connecting the purge gas and airing device

TURBOVAC 50, 50 D with ISO-K connectors

The TURBOVAC is aired through the system.

TURBOVAC 50, 50 D with CF connectors and TURBOVAC 151, 361

If the pump cannot be aired through the system, then a power failure airing valve shall be attached to the airing connection flange. This power failure airing valve prevents oil vapor from the forevacuum line from diffusing back into the system.

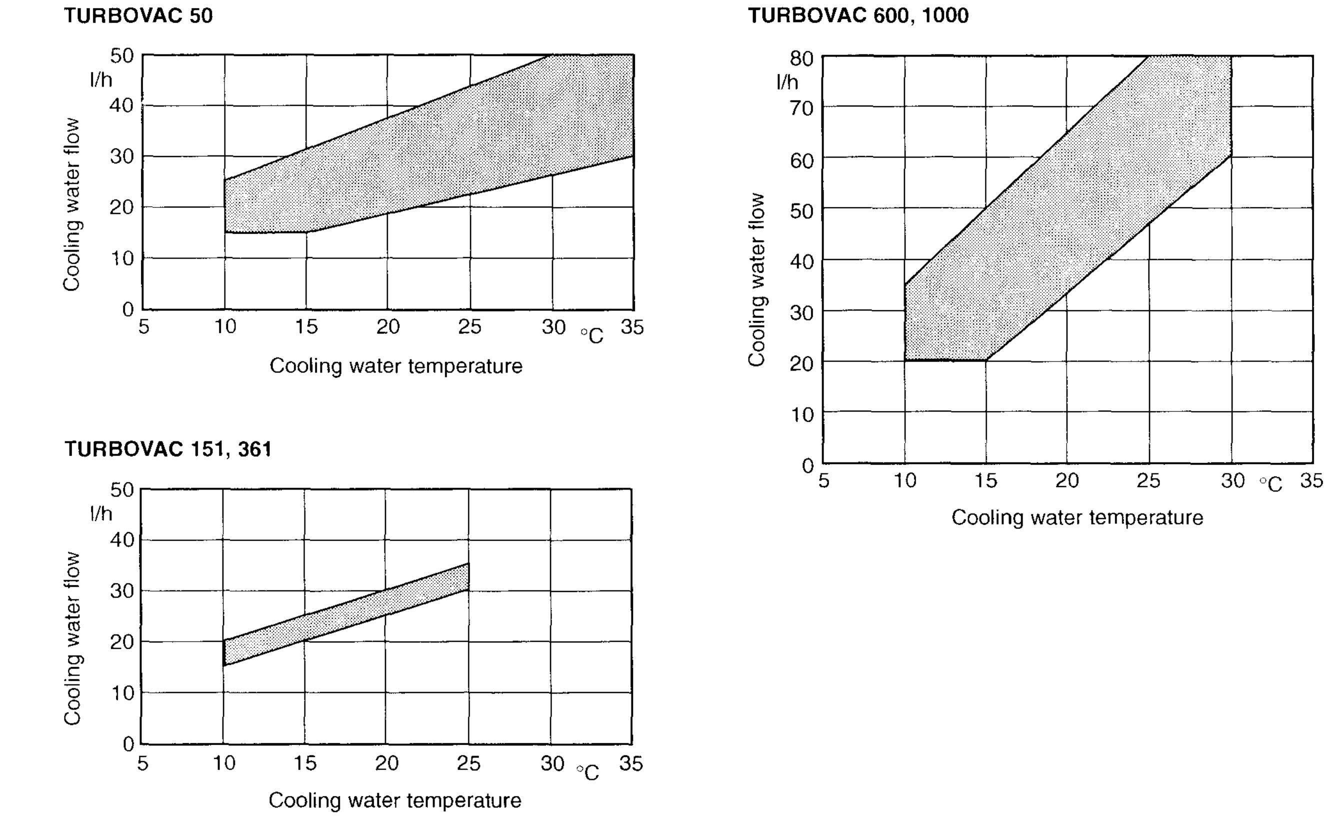


Fig. 7 Cooling water consumption

TURBOVAC 151 C, 361 C, 600 C and 1000 C

Either attach a power failure airing valve to the airing connection flange or a purge gas and airing valve at the purge gas connection flange.

Which of the two flanges is used will depend on the process.

When pumping **clean, non-corrosive gases**, a power failure airing valve is to be attached.

When pumping **reactive media**, connect a purge gas and airing valve.

Please contact Leybold for assistance in making the decision as to which media can be pumped with or without purge gas.

In processes which require purge gas the pump will have to be aired, when it is switched off, through the purge gas valve.

Observe the operating instructions for the purge gas and airing valve.

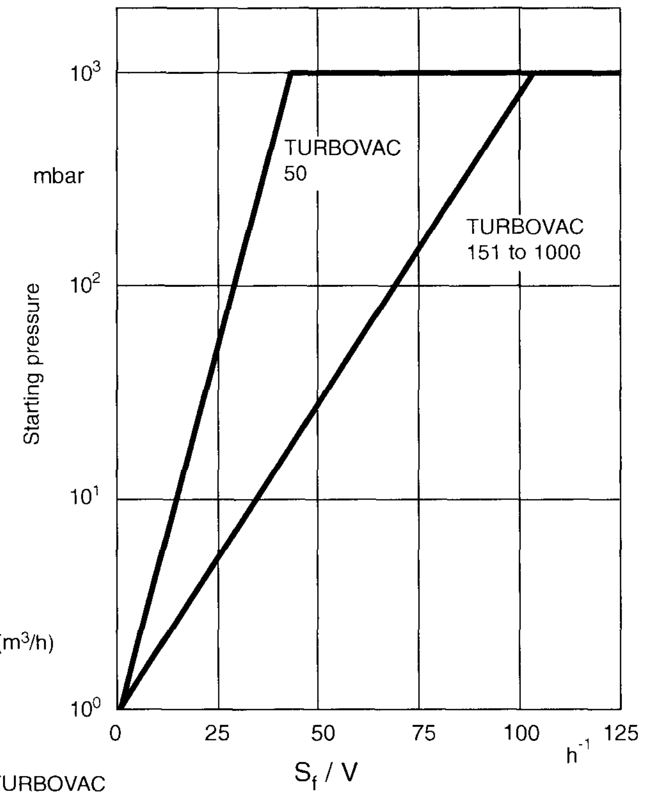
2.6 Connecting the TURBOTRONIK

Use the connector cable to attach the TURBOVAC and the TURBOTRONIK; see the operating instructions on the TURBOTRONIK for details.

Warning

Operate the pump only with the matching frequency converter and connector line.
Voltages of up to 400 V will be present at the connection cable between the frequency converter and the pump; mains voltage will be present at the fan, the flange heater, the valves and their supply leads.
Route the conductors and cables so as to protect them from damage.

The connections are of the IP 40 safety classification. Do not expose the pump, frequency converter or connectors to dripping water.



S_f = Pumping speed at the forevacuum pump (m^3/h)
V = Chamber volume (m^3)

Fig. 8 Determining the starting pressure for a TURBOVAC when evacuating larger volumes

3 Operation

3.1 Switching on

The starting pressure for the TURBOVAC can be read from the chart reproduced in Fig. 8.

Where S_f / V > 100[h^{-1}], the forevacuum pump and the TURBOVAC can be switched on simultaneously.

In such a situation the TURBOVAC serves from the very outset as an effective baffle.

When dealing with larger volumes, the vacuum chamber will first have to be pumped down with the forevacuum pump.

Then switch on the cooling and the TURBOVAC (at the TURBOTRONIK).

Kindly refer to the TURBOTRONIK operating instructions for details.

Avoid impact and vibration while the pump is running.

3.2 Bakeout

If pressures in the range of 10^{-8} mbar are to be developed within a short period of time, the vacuum chamber and the components installed therein will have to be baked out. In addition, the TURBOVAC can be baked out using the flange heater provided for this purpose.

Protect the rotor against intensive, direct heat radiation. When baking out at the forevacuum side – at a sorption trap, for example – ensure that the components attached direct are not heated to more than 80 °C (176 °F).

The forevacuum pump must be in operation so as to eliminate the vapors liberated at the sorption trap.

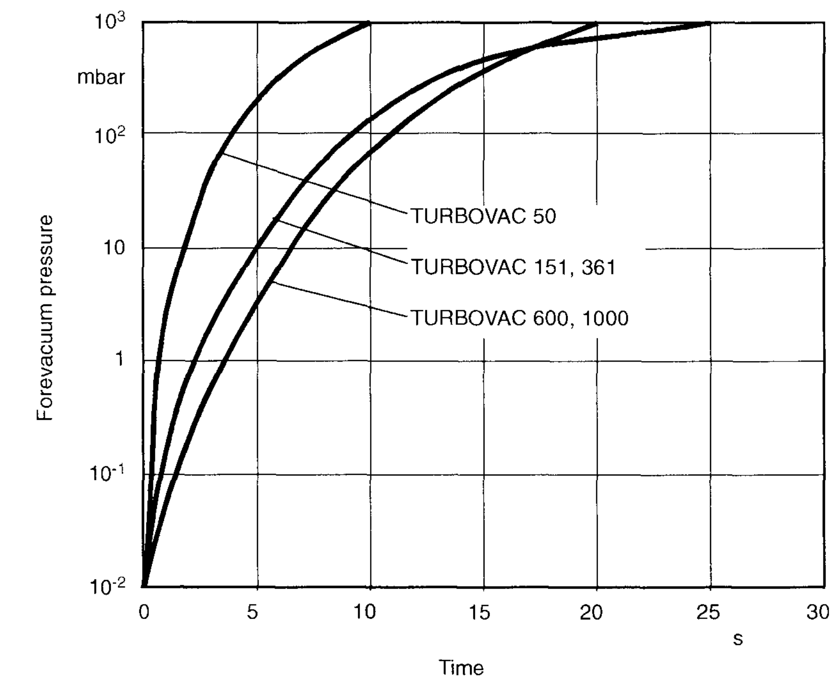


Fig. 9 Curves showing the pressure rise

3.3 Operation

Avoid sudden changes of attitude, extreme outside vibrations and shock to the pump during operation.

If the pump previously handled corrosive gases, it will be necessary to purge the pump with dry nitrogen for one hour prior to shut-down. When the system is not in operation, ensure that neither ambient air nor cleaning agents can enter the TURBOVAC.

3.4 Switching off

Switch off the TURBOVAC at the TURBOTRONIK.

Refer to the TURBOTRONIK operating instructions for details.

Switch off the forevacuum pump.

Air the TURBOVAC before it has come to a full standstill; refer to Section 3.5.

In TRIVAC pumps the built-in anti-suckback valve will close automatically and shut off the forevacuum line. When using forevacuum pumps without an anti-suckback valve, close the valve in the forevacuum line.

Close off the cooling water supply or switch off the ventilation immediately after switching off the TURBOVAC in order to avoid condensate formation in the pump.

3.5 Airing

Air the TURBOVAC each time it is shut down in order to prevent any return diffusion of oil fumes out of the forevacuum-line and into the high-vacuum section.

Use dry nitrogen, for instance, for airing purposes.

There are several methods which may be used to air the TURBOVAC:

1. (C versions only) In processes requiring purge gas, the pump will have to be vented through the purge gas valve when it is shut off.

   If the vacuum chamber is vented additionally with purge gas, the bypass valve in the purge gas and airing valve will have to be opened beforehand or simultaneously. Only in this way will a higher pressure be maintained in the motor chamber than in the forevacuum chamber, avoiding damaging return diffusion of corrosive gases.

Caution

The pressure in the TURBOVAC motor chamber must always be higher than that in the forevacuum chamber.

2. In all other processes we recommend airing the pump through the airing connection flange. A choke integrated into the airing flange will ensure that the pump is aired without damage.
3. The pump can be aired from the high-vacuum side.

In all cases the values shown in the curves for pressure rise must be observed.

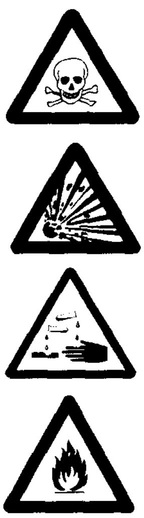
The pump can be aired while running at full speed.

Do not vent the TURBOVAC via the forevacuum connection as oil vapors could enter the TURBOVAC in this way.

3.6 Removing the pump from the system

Switch off the pump and vent it as per the instructions in Sections 3.4 and 3.5.

Warning



Take the appropriate precautionary measures prior to opening the intake or discharge connection if the pump has previously handled hazardous gases.

If necessary, use gloves, a respirator and/or protective clothing and work under an exhaust hood.

If the pump previously handled corrosive gases, then allow the purge gas to flow for as long as possible before detaching the pump from the system.

Remove the TURBOVAC from the system.

TURBOVAC pumps which are used in semiconductor processes, for example, will be contaminated with process gases. These gases may be toxic and hazardous to health. In addition, deposits with similarly dangerous properties may have formed. Many of these gases and deposits form acids when they come into contact with humid air. This will result in serious corrosion damage to the pump.

To avoid health hazards and corrosion damage when the pumps are detached from the system, lay a container of desiccant on the splinter guard and then close the pump immediately at all flange connections. Store the pump, with a desiccant, in a PE bag.

A packing set is included with TURBOVAC models with a "C" in the type designation. Use this packing set after detaching the pump from the system.

Faulty (leaky) packing of a TURBOVAC will nullify the guarantee.

Ordering data

Packing set for high-vacuum connection flange	Order No.
DN 100/160	200 91 240
DN 200	200 91 295
DN 250, 6" ANSI	200 91 262

Pack the pump so that it cannot be damaged during shipping and so that no contaminants can escape from the packaging. Protect in particular the flanges, the coolant connection nipples and the cable grommets.

If you return a pump to Leybold, be absolutely sure to observe the instructions given in Section 4.2.

4 Maintenance

The TURBOVAC requires no maintenance.

Regenerate or replace the agent in the sorption trap at regular intervals; please refer to the operating instructions for the sorption trap for details.

Depending on the degree of contamination in the purge gas the diaphragm filter will become clogged and will have to be replaced. Refer to the operating instructions for the purge gas and airing valve for instructions on replacing the filter.

4.1 Cleaning

Contamination inside the TURBOVAC is indicated by a deterioration in performance, i.e. an increasing decline in working pressure.

If there is only slight contamination, such as a coating on the TURBOVAC interior surfaces due to exposure to the atmosphere over an extended period of time, for the CF version the flange heater can be used for cleaning.

The ultimate pressure must be monitored while baking out under vacuum.

When making the initial examination of the pump, mount blank flanges to eliminate any possibility of leaks and desorption in the vacuum chamber.

The pump will have to be disassembled if there is more extensive contamination. The LEYBOLD Customer Service Department will have to be consulted here in all cases.

Caution

The rotor is precision balanced; any change whatsoever, such as loosening or bending any rotor component, will make re-balancing necessary.

4.2 Service by LEYBOLD

Whenever you send a pump to LEYBOLD, indicate whether the pump is contaminated or is free of substances which could pose a health hazard. If it is contaminated, specify exactly which substances are involved. You must use the form we have prepared for this purpose; we will forward that form on request.

A copy of the form is printed at the end of the operating instructions: “Declaration of contamination for vacuum equipment and components”.

Attach the form to the pump or enclose it to the pump. Do not place it together with the pump inside the PE bag.

This statement detailing the contamination is required to satisfy legal requirements and for the protection of our employees.

LEYBOLD must return to the sender any pumps which are not accompanied by a contamination statement.

5 Troubleshooting

Warning

When the connector cable to the TURBOVAC is attached, the outputs of the TURBOTRONIK frequency converter are not free of voltage.

Before commencing troubleshooting procedures, make the following simple checks:

Is the TURBOVAC being supplied with electrical energy?

Are the connections . . .
- from the mains power cord to the frequency converter
- at the connector cable from the frequency converter to the mains network in good working order?

If a water flow monitoring device is connected, is it functioning properly?

Check the water flow monitoring device by jumping its terminals and starting the TURBOVAC.

Is the forevacuum pressure sufficient?

Is the vacuum chamber free of leaks?

Observe also the troubleshooting instructions for the TURBOTRONIK.

Malfunction	Possible cause	Rectification
TURBOVAC does not start.	Motor connection cable not attached, is loose or is defective. Pump has seized.	Check the motor connection cable and connect correctly; replace if necessary. Replace the pump.
TURBOVAC generates loud running noises and vibrations.	Rotor is out of balance. Bearing is defective. Pump running within the natural frequency range of the system, causing resonance.	Balance the rotor (only by the Leybold Service Department). Bearings will have to be replaced (only by the Leybold Service Department). Change the masses of the system or install vibration damper to isolate oscillations.
The TURBOVAC does not achieve ultimate pressure.	Measurement device is defective. Measurement gauges are soiled. Leak at the system, lines or pump. Minor grime collection at the pump. The pump is oily. Forevacuum pump with insufficient pumping speed or ultimate pressure which is too high. Leak at the power cord passage port. TURBOVAC is rotating in the wrong direction.	Check the measurement device. Clean or replace the measurement gauges. Locate the leaks. Bake out the pump; see Section 4.1. Have the pump cleaned (only by the Leybold Service Department). Check ultimate pressure of the forevacuum pump or install a more powerful forevacuum pump. Locate and repair leaks (only by the Leybold Service Department). Check the connector lines; interchange poles if necessary.
TURBOVAC overheats (malfunction indication at the TURBOTRONIK).	Forevacuum pressure too high. Gas volume too great / leak in the system. Ventilation unit blocked. Ambient temperature is too high. Cooling water is lacking or insufficient. Bearings are defective.	Check the forevacuum pump; install a more powerful forevacuum pump if necessary. Seal leak; install a more powerful forevacuum pump if necessary. Ensure sufficient supply of cooling air. Route cooler air to the fan or employ water cooling option. Ensure sufficient supply of cooling water. Have the pump repaired (only by the Leybold Service Department).
The TURBOVAC or the vacuum chamber is contaminated with oil.	Anti-suckback valve at the forevacuum pump is defective. The TURBOVAC was not aired or improperly aired when shut down. System configured incorrectly: oil vapor streams back during forepump operation. Sorption trap is saturated.	Repair or replace the forevacuum pump. Check the airing valve and replace if indicated. Air the TURBOVAC correctly; see Section 3.5. Install a roughing line or pre-pump for a shorter period of time or install a sorption trap. Regenerate or replace the sorption trap.

EC Manufacturer's Declaration

in the spirit of Appendix IIb to the 89/392/EEC Machinery Guidelines

LEYBOLD

We, the Leybold Vakuum GmbH, declare herewith that the commissioning of the incomplete machine designated below is prohibited until such time as it has been determined that the system in which this complete machine is to be installed corresponds with the EC Machinery Guidelines.

At the same time we certify conformity with the Low-Voltage Guidelines 73/23/EEC.

When using the appropriate Leybold accessories, e.g. connector lines, flange heaters or fans, and when powering the pump with the specified Leybold frequency converters, the protection level prescribed in the EMC Guidelines will be attained

Designation: Turbomolecular pump

Models: TURBOVAC 50
TURBOVAC 50 D, 50 D2
TURBOVAC 151, 151 C
TURBOVAC 361, 361 C
TURBOVAC 600 C
TURBOVAC 1000 C

Catalog numbers:

853 99, 854 00/01/02

856 60/61/62/63/68

856 30/31/32/33/35, 894 13

856 70/71/72/73/74/75/77

856 82, 894 25

855 35/36/38/39, 894 89

As from serial No. A 95 .....

Applicable, harmonized standards:

- EN 292 Part 1 and Part 2 — November 1991
- EN 1012 Part 2 — 1996
- EN 60 204 — 1993

Applied national standards and technical specifications:

- DIN 31 001 — April 1983
- DIN ISO 1940 — December 1993

Cologne, September 8, 1998

Dr. Mattern-Klosson, Turbomolecular Pump
Division Manager

Cologne, September 8, 1998

Mr. Hölzer, Turbomolecular Pump
Engineering Manager

LEYBOLD

VDMA

Erklärung über Kontaminierung von Vakuumgeräten und -komponenten

Die Reparatur und/oder die Wartung von Vakuumgeräten und -komponenten wird nur durchgeführt, wenn eine korrekt und vollständig ausgefüllte Erklärung vorliegt. Ist das nicht der Fall, kommt es zu Verzögerungen der Arbeiten. Wenn die Reparatur/Wartung im Herstellerwerk und nicht am Ort ihres Einsatzes erfolgen soll, wird die Sendung gegebenenfalls zurückgewiesen.

Diese Erklärung darf nur von autorisiertem Fachpersonal ausgefüllt und unterschrieben werden.

1. Art der Vakuumgeräte und -komponenten:

- Typenbezeichnung: ____________________
- Artikelnummer: ____________________
- Seriennummer: ____________________
- Rechnungsnummer: ____________________
- Lieferdatum: ____________________

2. Grund für die Einsendung:

____

____

____

____

____

3. Zustand der Vakuumgeräte und -komponenten:

- Waren die Vakuumgeräte und -komponenten in Betrieb?

  ja ☐ nein ☐
- Welches Pumpenöl wurde verwendet ? ________
- Sind die Vakuumgeräte und -komponenten frei von gesundheitsgefährdenden Schadstoffen?

  ja ☐ (weiter siehe Absatz 5)

  nein ☐ (weiter siehe Absatz 4)

4. Einsatzbedingte Kontaminierung der Vakuumgeräte und -komponenten:

- toxisch	ja ☐	nein ☐
- ätzend	ja ☐	nein ☐
- mikrobiologisch*)	ja ☐	nein ☐
- explosiv*)	ja ☐	nein ☐
- radioaktiv*)	ja ☐	nein ☐
- sonstige Schadstoffe	ja ☐	nein ☐

*) Mikrobiologisch, explosiv oder radioaktiv kontaminierte Vakuumgeräte und -komponenten werden nur bei Nachweis einer vorschriftsmäßigen Reinigung entgegengenommen!

Art der Schadstoffe oder prozessbedingter, gefährlicher Reaktionsprodukte, mit denen die Vakuumgeräte und -komponenten in Kontakt kamen:

Handelsname Produktname Hersteller	Chemische Bezeichnung (evtl. auch Formel)	Gefahrklasse	Maßnahmen bei Freiwerden der Schadstoffe	Erste Hilfe bei Unfällen
1.				
2.				
3.				
4.				
5.				

5. Rechtsverbindliche Erklärung

Hiermit versichere(n) ich/wir, daß die Angaben in diesem Vordruck korrekt und vollständig sind. Der Versand der kontaminierten Vakuumgeräte und -komponenten erfolgt gemäß den gesetzlichen Bestimmungen.

Firma/Institut: ____________________________________

Straße: ____________________ PLZ, Ort: ____________________

Telefon: ____________________________________

Fax: ____________________ Telex: ____________________

Name: (in Druckbuchstaben) ____________________________________

Position: ____________________________________

Datum: ____________________ Firmenstempel

Rechtsverbindliche Unterschrift:

____

Verteiler: Blatt 1 (weiß) an den Hersteller oder seinen Beauftragten senden - Blatt 2 (gelb) den Begleitpapieren der Sendung beifügen - Blatt 3 (blau) Kopie für den Versender

Ron Hawranko

609-953-1550

724-327-5700

LEYBOLD

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Rev E, 3/99
Instruction Manual

MKS Type 1179A and 2179A Mass-Flo® Controller and Type 179A Mass-Flo Meter

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WARRANTY

Type 1179A/2179A/179A Equipment

MKS Instruments, Inc. (**MKS**) warrants that for three years from the date of shipment the equipment described above (the "equipment") manufactured by **MKS** shall be free from defects in materials and workmanship and will correctly perform all date-related operations, including without limitation accepting data entry, sequencing, sorting, comparing, and reporting, regardless of the date the operation is performed or the date involved in the operation, provided that, if the equipment exchanges data or is otherwise used with equipment, software, or other products of others, such products of others themselves correctly perform all date-related operations and store and transmit dates and date-related data in a format compatible with **MKS** equipment. THIS WARRANTY IS **MKS'** SOLE WARRANTY CONCERNING DATE-RELATED OPERATIONS.

For the period commencing with the date of shipment of this equipment and ending three years later, **MKS** will, at its option, either repair or replace any part which is defective in materials or workmanship or with respect to the date-related operations warranty without charge to the purchaser. The foregoing shall constitute the exclusive and sole remedy of the purchaser for any breach by **MKS** of this warranty.

The purchaser, before returning any equipment covered by this warranty, which is asserted to be defective by the purchaser, shall make specific written arrangements with respect to the responsibility for shipping the equipment and handling any other incidental charges with the **MKS** sales representative or distributor from which the equipment was purchased or, in the case of a direct purchase from **MKS**, with the **MKS** home office in Andover, Massachusetts, USA.

This warranty does not apply to any equipment which has not been installed and used in accordance with the specifications recommended by **MKS** for the proper and normal use of the equipment. **MKS** shall not be liable under any circumstances for indirect, special, consequential, or incidental damages in connection with, or arising out of, the sale, performance, or use of the equipment covered by this warranty.

MKS recommends that all **MKS** pressure and flow products be calibrated periodically (typically every 6 to 12 months) to ensure accurate readings. When a product is returned to **MKS** for this periodic re-calibration it is considered normal preventative maintenance not covered by any warranty.

THIS WARRANTY IS IN LIEU OF ALL OTHER RELEVANT WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING THE IMPLIED WARRANTY OF MERCHANTABILITY AND THE IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, AND ANY WARRANTY AGAINST INFRINGEMENT OF ANY PATENT.

116527-P1
Rev E, 3/99

MKS Type 1179A and 2179A Mass-Flo® Controller and Type 179A Mass-Flo Meter

Printed in the United States of America

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Figures

Tables

Mass Flow Controller Safety Information

Symbols Used in This Instruction Manual

Definitions of WARNING, CAUTION, and NOTE messages used throughout the manual.

Warning

The WARNING sign denotes a hazard to personnel. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.

Caution

The CAUTION sign denotes a hazard to equipment. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of all or part of the product.

Note

The NOTE sign denotes important information. It calls attention to a procedure, practice, condition, or the like, which is essential to highlight.

Symbols Found on the Unit

The following table describes symbols that may be found on the unit.

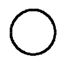
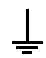
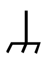
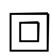
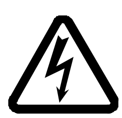
Definition of Symbols Found on the Unit			
On (Supply) IEC 417, No.5007	 Off (Supply) IEC 417, No.5008	 Earth (ground) IEC 417, No.5017	 Protective earth (ground) IEC 417, No.5019
 Frame or chassis IEC 417, No.5020	 Equipotentiality IEC 417, No.5021	 Direct current IEC 417, No.5031	 Alternating current IEC 417, No.5032
 Both direct and alternating current IEC 417, No.5033-a	 Class ll equipment IEC 417, No.5172-a	 Three phase alternating current IEC 617-2 No.020206	
 Caution, refer to accompanying documents ISO 3864, No.B.3.1	 Caution, risk of electric shock ISO 3864, No.B.3.6	 Caution, hot surface IEC 417, No.5041	

Table 1: Definition of Symbols Found on the Unit

Safety Procedures and Precautions

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of intended use of the instrument and may impair the protection provided by the equipment. MKS Instruments, Inc. assumes no liability for the customer's failure to comply with these requirements.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an MKS Calibration and Service Center for service and repair to ensure that all safety features are maintained.

SERVICE BY QUALIFIED PERSONNEL ONLY

Operating personnel must not attempt component replacement and internal adjustments. Any service must be made by qualified service personnel only.

USE CAUTION WHEN OPERATING WITH HAZARDOUS MATERIALS

If hazardous materials are used, observe the proper safety precautions, completely purge the instrument when necessary, and ensure that the material used is compatible with the wetted materials in this product, including any sealing materials.

PURGE THE INSTRUMENT

After installing the unit, or before removing it from a system, purge the unit completely with a clean, dry gas to eliminate all traces of the previously used flow material.

USE PROPER PROCEDURES WHEN PURGING

This instrument must be purged under a ventilation hood, and gloves must be worn for protection.

DO NOT OPERATE IN AN EXPLOSIVE ENVIRONMENT

To avoid explosion, do not operate this product in an explosive environment unless it has been specifically certified for such operation.

USE PROPER FITTINGS AND TIGHTENING PROCEDURES

All instrument fittings must be consistent with instrument specifications, and compatible with the intended use of the instrument. Assemble and tighten fittings according to manufacturer's directions.

CHECK FOR LEAK-TIGHT FITTINGS

Carefully check all vacuum component connections to ensure leak-tight installation.

OPERATE AT SAFE INLET PRESSURES

Never operate at pressures higher than the rated maximum pressure (refer to the product specifications for the maximum allowable pressure).

INSTALL A SUITABLE BURST DISC

When operating from a pressurized gas source, install a suitable burst disc in the vacuum system to prevent system explosion should the system pressure rise.

KEEP THE UNIT FREE OF CONTAMINANTS

Do not allow contaminants to enter the unit before or during use. Contamination such as dust, dirt, lint, glass chips, and metal chips may permanently damage the unit or contaminate the process.

ALLOW THE UNIT TO WARM UP

If the unit is used to control dangerous gases, they should not be applied before the unit has completely warmed up. Use a positive shutoff valve to ensure that no erroneous flow can occur during warm up.

Sicherheitshinweise für den Massenflußregler

In dieser Betriebsanleitung vorkommende Symbole

Bedeutung der mit WARNUNG!, VORSICHT! und HINWEIS gekennzeichneten Absätze in dieser Betriebsanleitung.

Warnung!

Das Symbol WARNUNG! weist auf eine Gefahr für das Bedienpersonal hin. Es macht auf einen Arbeitsablauf, eine Arbeitsweise, einen Zustand oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. ungenügende Berücksichtigung zu Verletzungen führen kann.

Vorsicht!

Das Symbol VORSICHT! weist auf eine Gefahr für das Gerät hin. Es macht auf einen Bedienungsablauf, eine Arbeitsweise oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. ungenügende Berücksichtigung zu einer Beschädigung oder Zerstörung des Gerätes oder von Teilen des Gerätes führen kann.

Hinweis

Das Symbol HINWEIS macht auf wichtige Informationen bezüglich eines Arbeitsablaufs, einer Arbeitsweise, eines Zustands oder einer sonstige Gegebenheit aufmerksam.

Erklärung der am Gerät angebrachten Symbole

Nachstehender Tabelle sind die Bedeutungen der Symbole zu entnehmen, die am Gerät angebracht sein können.

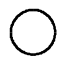
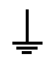
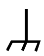
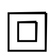
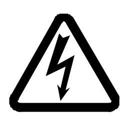
Bedeutung der am Gerät angebrachten Symbole			
 Ein (Energie) IEC 417, No.5007	 Aus (Energie) IEC 417, No.5008	 Erdanschluß IEC 417, No.5017	 Schutzleiteranschluß IEC 417, No.5019
 Masseanschluß IEC 417, No.5020	 Aquipotential- anschluß IEC 417, No.5021	 Gleichstrom IEC 417, No.5031	 Wechselstrom IEC 417, No.5032
 Gleich- oder Wechselstrom IEC 417, No.5033-a	 Durchgängige doppelte oder verstärkte Isolierung IEC 417, No.5172-a	 Dreileiter- Wechselstrom (Drehstrom) IEC 617-2, No.020206	
 Warnung vor einer Gefahrenstelle (Achtung, Dokumen- tation beachten) ISO 3864, No.B.3.1	 Warnung vor gefährlicher elektrischer Spannung ISO 3864, No.B.3.6	 Höhere Temperatur an leicht zugänglichen Teilen IEC 417, No.5041	

Tabelle 2: Bedeutung der am Gerät angebrachten Symbole

Sicherheitsvorschriften und Vorsichtsmaßnahmen

Folgende allgemeine Sicherheitsvorschriften sind während allen Betriebsphasen dieses Gerätes zu befolgen. Eine Mißachtung der Sicherheitsvorschriften und sonstiger Warnhinweise in dieser Betriebsanleitung verletzt die für dieses Gerät und seine Bedienung geltenden Sicherheitsstandards, und kann die Schutzvorrichtungen an diesem Gerät wirkungslos machen. MKS Instruments, Inc. haftet nicht für Mißachtung dieser Sicherheitsvorschriften seitens des Kunden.

Niemals Teile austauschen oder Änderungen am Gerät vornehmen!

Ersetzen Sie keine Teile mit baugleichen oder ähnlichen Teilen, und nehmen Sie keine eigenmächtigen Änderungen am Gerät vor. Schicken Sie das Gerät zwecks Wartung und Reparatur an den MKS-Kalibrierungs- und -Kundendienst ein. Nur so wird sichergestellt, daß alle Schutzvorrichtungen voll funktionsfähig bleiben.

Wartung nur durch qualifizierte Fachleute!

Das Auswechseln von Komponenten und das Vornehmen von internen Einstellungen darf nur von qualifizierten Fachleuten durchgeführt werden, niemals vom Bedienpersonal.

Vorsicht beim Arbeiten mit gefährlichen Stoffen!

Wenn gefährliche Stoffe verwendet werden, muß der Bediener die entsprechenden Sicherheitsvorschriften genauestens einhalten, das Gerät, falls erforderlich, vollständig spülen, sowie sicherstellen, daß der Gefahrstoff die von ihm benetzten, am Gerät verwendeten Materialien, insbesondere Dichtungen, nicht angreift.

Spülen des Gerätes mit Gas!

Nach dem Installieren oder vor dem Ausbau aus einem System muß das Gerät unter Einsatz eines reinen Trockengases vollständig gespült werden, um alle Rückstände des Vorgängermediums zu entfernen.

Anweisungen zum Spülen des Gerätes

Das Gerät darf nur unter einer Ablufthaube gespült werden. Schutzhandschuhe sind zu tragen.

Gerät nicht zusammen mit explosiven Stoffen, Gasen oder Dämpfen benutzen!

Um der Gefahr einer Explosion vorzubeugen, darf dieses Gerät niemals zusammen mit (oder in der Nähe von) explosiven Stoffen aller Art eingesetzt werden, sofern es nicht ausdrücklich für diesen Zweck zugelassen ist.

Anweisungen zum Installieren der Armaturen!

Alle Anschlußstücke und Armaturenteile müssen mit der Gerätespezifikation übereinstimmen, und mit dem geplanten Einsatz des Gerätes kompatibel sein. Der Einbau, insbesondere das Anziehen und Abdichten, muß gemäß den Anweisungen des Herstellers vorgenommen werden.

Verbindungen auf Undichtigkeiten prüfen!

Überprüfen Sie sorgfältig alle Verbindungen der Vakuumkomponenten auf undichte Stellen.

Gerät nur unter zulässigen Anschlußdrücken betreiben!

Betreiben Sie das Gerät niemals unter Drücken, die den maximal zulässigen Druck (siehe Produktspezifikationen) übersteigen.

Geeignete Berstscheibe installieren!

Wenn mit einer unter Druck stehenden Gasquelle gearbeitet wird, sollte eine geeignete Berstscheibe in das Vakuumsystem installiert werden, um eine Explosionsgefahr aufgrund von steigendem Systemdruck zu vermeiden.

Verunreinigungen im Gerät vermeiden!

Stellen Sie sicher, daß Verunreinigungen jeglicher Art weder vor dem Einsatz noch während des Betriebs in das Instrumenteninnere gelangen können. Staub- und Schmutzpartikel, Glassplitter oder Metallspäne können das Gerät dauerhaft beschädigen oder Prozeß und Meßwerte verfälschen.

Geräteeinheit auf Arbeitstemperatur bringen!

Wird das Gerät zur Flußregelung gefährlicher Gase verwendet, so dürfen diese nur nach Abschluß des Anwärmvorgangs zugeführt werden. Um das versehentliche Fließen von Gas während der Aufheizperiode zu verhindern, sollte ein Absperrventil (normal geschlossen) eingebaut werden.

Informations relatives à la sécurité pour le contrôleur de débit de masse

Symboles utilisés dans ce manuel d'utilisation

Définitions des indications AVERTISSEMENT, ATTENTION, et REMARQUE utilisées dans ce manuel.

Avertissement

L'indication AVERTISSEMENT signale un danger pour le personnel. Elle attire l'attention sur une procédure, une pratique, une condition, ou toute autre situation présentant un risque d'accident pour le personnel, en cas d'exécution incorrecte ou de non respect des consignes.

Attention

L'indication ATTENTION signale un danger pour l'appareil. Elle attire l'attention sur une procédure d'exploitation, une pratique, ou toute autre situation, présentant un risque d'endommagement ou de destruction d'une partie ou de la totalité de l'appareil, en cas d'exécution incorrecte ou de non respect des consignes.

Remarque

L'indication REMARQUE signale une information importante. Elle attire l'attention sur une procédure, une pratique, une condition, ou toute autre situation, présentant un intérêt particulier.

Symboles apparaissant sur l'unité

Le tableau suivant décrit les symboles pouvant apparaître sur l'unité.

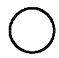
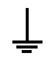
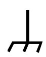
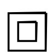
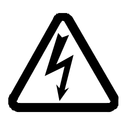
Définition des symboles apparaissant sur l'unité			
 Marche (sous tension) IEC 417, No.5007	 Arrêt (hors tension) IEC 417, No.5008	 Terre (masse) IEC 417, No.5017	 Terre de protection (masse) IEC 417, No.5019
 Masse IEC 417, No.5020	 Equipotentialité IEC 417, No.5021	 Courant continu IEC 417, No.5031	 Courant alternatif IEC 417, No.5032
 Courant continu et alternatif IEC 417, No.5033-a	 Matériel de classe II IEC 417, No.5172-a	 Courant alternatif triphasé IEC 617-2, No.020206	
 Attention : se reporter à la documentation ISO 3864, No.B.3.1	 Attention : risque de choc électrique ISO 3864, No.B.3.6	 Attention : surface brûlante IEC 417, No.5041	

Tableau 3: Définition des symboles apparaissant sur l'unité

Mesures de sécurité et précautions

Prendre les précautions générales de sécurité suivantes pendant toutes les phases d'exploitation de cet appareil. Le non respect des ces précautions ou des avertissements contenus dans ce manuel constitue une violation des normes de sécurité relatives à l'utilisation de l'appareil et peut diminuer la protection fournie par l'appareil. MKS Instruments, Inc. n'assume aucune responsabilité concernant le non respect des consignes par les clients.

PAS DE SUBSTITUTION DE PIÈCES OU DE MODIFICATION DE L'APPAREIL

Ne pas installer des pièces de substitution ou effectuer des modifications non autorisées sur l'appareil. Renvoyer l'appareil à un centre de service et de calibrage MKS pour tout dépannage ou réparation afin de garantir l'intégrité des dispositifs de sécurité.

DÉPANNAGE UNIQUEMENT PAR DU PERSONNEL QUALIFIÉ

Le personnel d'exploitation ne doit pas essayer de remplacer des composants ou de faire des réglages internes. Tout dépannage doit être uniquement effectué par du personnel qualifié.

PRÉCAUTION EN CAS D'UTILISATION AVEC DES PRODUITS DANGEREUX

Si des produits dangereux sont utilisés, prendre les mesures de précaution appropriées, purger complètement l'appareil quand cela est nécessaire, et s'assurer que les produits utilisés sont compatibles avec les composants liquides de l'appareil, y compris les matériaux d'étanchéité.

PURGE DE L'APPAREIL

Après l'installation de l'unité, ou avant son enlèvement d'un système, purger l'unité complètement avec un gaz propre et sec afin d'éliminer toute trace du produit de flux utilisé précédemment.

UTILISATION DES PROCÉDURES APPROPRIÉES POUR LA PURGE

Cet appareil doit être purgé sous une hotte de ventilation, et il faut porter des gants de protection.

PAS D'EXPLOITATION DANS UN ENVIRONNEMENT EXPLOSIF

Pour éviter toute explosion, ne pas utiliser cet appareil dans un environnement explosif, sauf en cas d'homologation spécifique pour une telle exploitation.

UTILISATION D'ÉQUIPEMENTS APPROPRIÉS ET PROCÉDURES DE SERRAGE

Tous les équipements de l'appareil doivent être cohérents avec ses spécifications, et compatibles avec l'utilisation prévue de l'appareil. Assembler et serrer les équipements conformément aux directives du fabricant.

VÉRIFICATION DE L'ÉTANCHÉITÉ DES CONNEXIONS

Vérifier attentivement toutes les connexions des composants pour le vide afin de garantir l'étanchéité de l'installation.

EXPLOITATION AVEC DES PRESSIONS D'ENTRÉE NON DANGEREUSES

Ne jamais utiliser des pressions supérieures à la pression nominale maximum (se reporter aux spécifications de l'unité pour la pression maximum admissible).

INSTALLATION D'UN DISQUE D'ÉCHAPPEMENT ADAPTÉ

En cas d'exploitation avec une source de gaz pressurisé, installer un disque d'échappement adapté dans le système à vide afin d'éviter une explosion du système en cas d'augmentation de la pression.

MAINTIEN DE L'UNITÉ À L'ABRI DES CONTAMINATIONS

Ne pas laisser des produits contaminants pénétrer dans l'unité avant ou pendant l'utilisation. Des produits contaminants tels que des poussières et des fragments de tissu, de glace et de métal peuvent endommager l'unité d'une manière permanente ou contaminer le processus.

RESPECT DU TEMPS D'ÉCHAUFFEMENT

Si l'unité est utilisée pour contrôler des gaz dangereux, ceux-ci ne doivent pas être appliqués avant l'échauffement complet de l'unité. Utiliser une valve de fermeture positive afin de garantir qu'aucun flux ne se produise par erreur pendant l'échauffement.

Medidas de seguridad del controlador de flujo de masa

Símbolos usados en este manual de instrucciones

Definiciones de los mensajes de advertencia, precaución y de las notas usados en el manual.

Advertencia

El símbolo de advertencia indica la posibilidad de que se produzcan daños personales. Pone de relieve un procedimiento, práctica, estado, etc. que en caso de no realizarse u observarse correctamente puede causar daños personales.

Precaución

El símbolo de precaución indica la posibilidad de producir daños al equipo. Pone de relieve un procedimiento operativo, práctica, estado, etc. que en caso de no realizarse u observarse correctamente puede causar daños o la destrucción total o parcial del equipo.

Nota

El símbolo de notas indica información de importancia. Este símbolo pone de relieve un procedimiento, práctica o condición cuyo conocimiento es esencial destacar.

Símbolos hallados en la unidad

La tabla siguiente contiene los símbolos que puede hallar en la unidad.

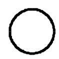
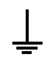
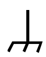
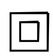
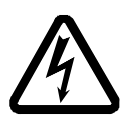
Definición de los símbolos hallados en la unidad			
Encendido (alimentación eléctrica) IEC 417, N° 5007	 Apagado (alimentación eléctrica) IEC 417, N° 5008	 Puesta a tierra IEC 417, N° 5017	 Protección a tierra IEC 417, N° 5019
 Caja o chasis IEC 417, N° 5020	 Equipotencialidad IEC 417, N° 5021	 Corriente continua IEC 417, N° 5031	 Corriente alterna IEC 417, N° 5032
 Corriente continua y alterna IEC 417, N° 5033-a	 Equipo de clase II IEC 417, N° 5172-a	 Corriente alterna trifásica IEC 617-2, N° 020206	
 Precaución. Consulte los documentos adjuntos ISO 3864, N° B.3.1	 Precaución. Riesgo de descarga eléctrica ISO 3864, N° B.3.6	 Precaución. Superficie caliente IEC 417, N° 5041	

Tabla 4: Definición de los símbolos hallados en la unidad

Procedimientos y precauciones de seguridad

Las precauciones generales de seguridad descritas a continuación deben observarse durante todas las etapas de funcionamiento del instrumento. La falta de cumplimiento de dichas precauciones o de las advertencias específicas a las que se hace referencia en el manual, constituye una violación de las normas de seguridad establecidas para el uso previsto del instrumento y podría anular la protección proporcionada por el equipo. Si el cliente no cumple dichas precauciones y advertencias, MKS Instruments, Inc. no asume responsabilidad legal alguna.

NO UTILICE PIEZAS NO ORIGINALES O MODIFIQUE EL INSTRUMENTO

No instale piezas que no sean originales o modifique el instrumento sin autorización. Para asegurar el correcto funcionamiento de todos los dispositivos de seguridad, envíe el instrumento al Centro de servicio y calibración de MKS toda vez que sea necesario repararlo o efectuar tareas de mantenimiento.

LAS REPARACIONES DEBEN SER EFECTUADAS ÚNICAMENTE POR TÉCNICOS AUTORIZADOS

Los operarios no deben intentar reemplazar los componentes o realizar tareas de ajuste en el interior del instrumento. Las tareas de mantenimiento o reparación deben ser realizadas únicamente por personal autorizado.

TENGA CUIDADO CUANDO TRABAJE CON MATERIALES TÓXICOS

Cuando se utilicen materiales tóxicos, es responsabilidad de los operarios cumplir las medidas de seguridad correspondientes, purgar totalmente el instrumento cuando sea necesario y comprobar que el material utilizado sea compatible con los materiales humedecidos de este producto e inclusive, con los materiales de sellado.

PURGUE EL INSTRUMENTO

Una vez instalada la unidad o antes de retirarla del sistema, purgue completamente la unidad con gas limpio y seco para eliminar todo resto de la sustancia líquida empleada anteriormente.

USE PROCEDIMIENTOS ADECUADOS PARA REALIZAR LA PURGA

El instrumento debe purgarse debajo de una campana de ventilación y deben utilizarse guantes protectores.

NO HAGA FUNCIONAR ESTE INSTRUMENTO EN UN AMBIENTE CON RIESGO DE EXPLOSIONES

Para evitar que se produzcan explosiones, no haga funcionar este producto en un ambiente con riesgo de explosiones, excepto cuando el mismo haya sido certificado específicamente para tal uso.

USE ACCESORIOS ADECUADOS Y REALICE CORRECTAMENTE LOS PROCEDIMIENTOS DE AJUSTE

Todos los accesorios del instrumento deben cumplir las especificaciones del mismo y ser compatibles con el uso que se debe dar al instrumento. Arme y ajuste los accesorios de acuerdo con las instrucciones del fabricante.

COMPRUEBE QUE LAS CONEXIONES SEAN A PRUEBA DE FUGAS

Inspeccione cuidadosamente las conexiones de los componentes de vacío para comprobar que hayan sido instalados a prueba de fugas.

HAGA FUNCIONAR EL INSTRUMENTO CON PRESIONES DE ENTRADA SEGURAS

No haga funcionar nunca el instrumento con presiones superiores a la máxima presión nominal (en las especificaciones del instrumento hallará la presión máxima permitida).

INSTALE UNA CÁPSULA DE SEGURIDAD ADECUADA

Cuando el instrumento funcione con una fuente de gas presurizado, instale una cápsula de seguridad adecuada en el sistema de vacío para evitar que se produzcan explosiones cuando suba la presión del sistema.

MANTENGA LA UNIDAD LIBRE DE CONTAMINANTES

No permita el ingreso de contaminantes en la unidad antes o durante su uso. Los productos contaminantes tales como polvo, suciedad, pelusa, lascas de vidrio o virutas de metal pueden dañar irreparablemente la unidad o contaminar el proceso.

PERMITA QUE LA UNIDAD SE CALIENTE

Si se utiliza la unidad para controlar gases peligrosos, no libere los gases hasta que la unidad termine de calentarse. Use una válvula de cierre positivo para impedir todo flujo no deseado durante el período de calentamiento.

Chapter One: General Information

Introduction

The Type 1179A Mass-Flo® controller and the Type 2179A Mass-Flo controller with a positive shutoff valve, accurately measure and control the mass flow rates of gases. The Type 179A Mass-Flo Meter measures the flow rate of gases. Based upon an MKS measurement technique, patent pending, these instruments use a laminar flow device whose precise indication of mass flow is achieved through the use of a bypass element in parallel with a sensor tube. The 1179 controller and 179 meter have a three-inch footprint. The 1179 and 2179 controllers feature the ability to accept TTL level commands to remotely open and close the control valve. The controller includes a metal cover and RF bypass capacitors, and incorporates a design that virtually eliminates RFI and EMI interference.

The 1179 Series units can interface to complementary MKS equipment (Type 647, 246, 247, PR4000) to display the reading and to provide the power, and set point commands. (Additionally, the 167 unit can be used as a readout and set point generator, but it does not supply power; the 660 unit can be used as a power supply and readout, though it cannot send a set point to the flow controller.) Refer to the corresponding manuals for requirements and instructions.

The 1179 Series flow units are available in a variety of types and configurations to suit specific needs. The options that must be specified when you order the flow unit include:

- *Connector:* 9-pin or 15-pin Type "D" connector, recessed P.C. Edge Card connector, Digital RS-485, Digital DeviceNet®
- *Range:* 10, 20, 50, 100, 200, 500, 1000, 2000, 5000, 10,000, 20,000, 30,000 sccm (N_2 equivalent)
- *Fittings:* Swagelok® 4-VCR® male compatible, Cajon 4-VCO® male compatible, and ¼ inch Swagelok® compatible
- *Seals:* Viton®, Neoprene, Buna-N, Kalrez®, all-metal

All 1179 controllers have normally *closed* valves.

Design Features

The design of the 1179 flow controller incorporates an advanced flow sensor, a new control valve, and an optimized bypass. (U.S. and Foreign Patents; Patents Pending on the sensor.) The latest generation two-element sensing circuit provides accurate, repeatable performance even in low flow ranges (< 10 sccm). Low temperature effect from ambient temperature change and a low attitude sensitivity effect are also ensured. The newly optimized sensor/bypass arrangement minimizes the flow splitting error for gases with different densities, which dramatically improves measurement accuracy when gases other than the calibration gas are used. The surface mount electronics feature optional pin-to-pin compatibility with other manufacturer's flow controllers. In addition, the variable valve control electronics provides for fast response to any set point.

Reliability

To help provide excellent reliability, the design contains a low mechanical and electronic components count and has successfully passed the following tests:

- STRIFE, including temperature cycling and vibration (sine and random tests)

and with an overall metal braided shielded cable, properly grounded at both ends:

- CE Compliance - EMC Directive 89/336/EEC (units with a Type "D" connector only; the Edge Card connector is not CE compliant)

Cleanliness Features

With only three elastomeric external seals, the design of the flow controller ensures extremely low external leakage and minimizes a key source of particle generation, outgassing, and permeation. The design also incorporates minimal wetted surface area. To further ensure its cleanliness, the 1179 controller undergoes precision machining as well as a proprietary cleaning process. The instrument is assembled and double-bagged under Class 100 conditions.

How This Manual is Organized

This manual is designed to provide instructions on how to set up and install a Type 1179 Series unit.

Before installing your Type 1179 Series unit in a system and/or operating it, carefully read and familiarize yourself with all precautionary notes in the *Safety Messages and Procedures* section at the front of this manual. In addition, observe and obey all WARNING and CAUTION notes provided throughout the manual.

Chapter One: General Information, (this chapter) introduces the product and describes the organization of the manual.

Chapter Two: Installation, explains environmental requirements and practical considerations to take into account when selecting the proper setting for the mass flow controller.

Chapter Three: Overview, describes, in a general way, how the flow controller operates in a gas flow system. This chapter also provides information on how to use a Gas Correction Factor when interpreting the output signal for a gas other than the calibration gas.

Chapter Four: Operation, explains how to start up and operate the mass flow controller. It also discusses how to override the control valve.

Chapter Five: Theory of Operation, provides additional information on how the flow controller operates.

Chapter Six: Maintenance, lists a few general practices to follow to ensure that the flow controller will perform optimally.

Chapter Seven: Troubleshooting, includes a table of hints for reference in the event that your flow controller malfunctions.

Appendix A: Product Specifications, lists the specifications of the instrument.

Appendix B: Model Code Explanation, describes the instrument's ordering code.

Appendix C: Gas Correction Factors, provides a table listing the gas correction factors for the most commonly used gases.

Appendix D: MFC Sizing Guidelines, is provided for reference and describes how to calculate the correct size MFC for an application. This information is useful if you need to purchase another MFC or if you plan to use your MFC in another, different application.

Appendix E: Positive Shutoff Valve Information, describes how to attach a solenoid valve to a Type 2179 MFC.

Customer Support

Standard maintenance and repair services are available at all of our regional MKS Calibration and Service Centers, listed on the back cover. In addition, MKS accepts the instruments of other manufacturers for recalibration using the Primary and Transfer Standard calibration equipment located at all of our regional service centers. Should any difficulties arise in the use of your Type 1179 instrument, or to obtain information about companion products MKS offers, contact any authorized MKS Calibration and Service Center. If it is necessary to return the instrument to MKS, please obtain an ERA Number (Equipment Return Authorization Number) from the MKS Calibration and Service Center before shipping. The ERA Number expedites handling and ensures proper servicing of your instrument.

Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Warning **All returns to MKS Instruments must be free of harmful, corrosive, radioactive, or toxic materials.**

Chapter Two: Installation

How To Unpack the Type 1179 Series Unit

MKS has carefully packed the 1179 Series unit so that it will reach you in perfect operating order. Upon receiving the unit, however, you should check for defects, cracks, broken connectors, etc., to be certain that damage has not occurred during shipment.

Note Do *not* discard any packing materials until you have completed your inspection and are sure the unit arrived safely.

If you find any damage, notify your carrier and MKS immediately. If it is necessary to return the unit to MKS, obtain an ERA Number (Equipment Return Authorization Number) from the MKS Service Center before shipping. Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Opening the Package

The 1179 Series unit is assembled, leak tested with helium, and calibrated in a clean room environment. The instrument is double-bagged in this environment to ensure maintenance of its particle free condition during shipment. It is very important to remove the bags according to clean room practices. To maintain at least a minimal level of clean room standards, follow the instructions below.

1. Remove the outer bag in an ante room (garmenting room) or transfer box.

   Do not allow this outer bag to enter the clean room.

2. Wipe down the exterior of the inner bag with a clean room wipe.

   This step reduces the contamination introduced into the clean room.

3. Remove the inner bag in the clean room.

Unpacking Checklist

Standard Parts:

- The 1179 or 2179 mass flow controller, or 179 mass flow meter
- The 1179/2179/179 instruction manual (this book)

Optional Equipment:

- Electrical Connector Accessories Kit, M100B-K1 (includes a mate to the electrical connector if you choose to make your own interface cable)
- Interface cables (refer to *Interface Cables*, page 24)
- Power supply readout, such as the Type 647, 246, 247, PR4000, 167 (no power supply, readout, and set point generator only), or 660 (no set point, readout and power supply only)
- Length Adapter Kit - allows the 1179 Series unit to be a drop-in replacement for a 1259/1260 or 2259/2260 unit

Environmental Requirements

Follow the guidelines listed below when installing and using the 1179 flow controller.

1. Maintain the normal operating temperature between 0° and 50° C (32° and 122° F).

2. Observe the pressure limits:

   A. Maximum gas inlet pressure is 150 psig.

   B. Operational differential pressure is:

      10 to 40 psid for ≤ 5000 sccm units

      15 to 40 psid for 10,000 to 30,000 sccm units

      The standard orifice is sized for control over this range with the outlet at atmospheric pressure.

3. Provide power input at ±15 VDC (±5%) @ 200 mA.

   A. Maximum voltage/current at startup is ±15 VDC (±5%) @ 200 mA.

   B. Typical steady state voltage/current should be ±15 VDC (±5%) @ 100 mA.

4. Allow 2 minutes for warm-up time.

5. Use high purity gas and filters in line upstream of the MFC.

6. Leave the power to the instrument on at all times, for optimal performance.

For additional information refer to *Appendix A: Product Specifications*, page 57.

Interface Cables

As of January 1, 1996, most products shipped to the European Community must comply with the EMC Directive 89/336/EEC, which covers radio frequency emissions and immunity tests. In addition, as of January 1, 1997, some products shipped to the European Community must also comply with the Product Safety Directive 92/59/EEC and Low Voltage Directive 73/23/EEC, which cover general safety practices for design and workmanship. MKS products that meet these requirements are identified by application of the CE Mark.

Note Only 1179 Series units with a Type "D" connector or digital communications connector can be CE marked. The Edge Card connector is not CE compliant.

To ensure compliance with EMC Directive 89/336/EEC, an overall metal braided shielded cable, properly grounded at both ends, is required during use. No additional installation requirements are necessary to ensure compliance with Directives 92/59/EEC and 73/23/EEC.

Note

1. An overall metal braided, shielded cable, properly grounded at both ends, is required during use to meet CE specifications.
2. To order an overall metal braided shielded cable, add an "S" after the cable type designation. For example, to order a cable to connect an 1179 unit equipped with a 15-pin Type "D" connector to a 146 unit, use part number CB47-1-XX, where XX designates the cable length; for a braided, shielded cable use part number CB147S-1-XX.

MKS offers a variety of interface cables, listed in Table 5.

MKS Cables			
To Connect To A . . .	**15-pin Type "D"**	**9-pin Type "D"**	**20-pin Edge Card**
PR4000, 146, 186, 167, 647	CB147-1-xx	CB147-12-xx	CB147-7-xx
246, 247	CB259-5-xx	CB147-12-xx	CB259-10-xx
where xx indicates the cable length			

Table 5: MKS Cables

Generic Shielded Cable Description

Note

1. To meet CE specifications, an overall metal braided shielded cable, properly grounded at both ends, is required during use.
2. Use an overall metal braided shielded cable assemblies, especially if the environment contains high EMI/RFI noise.
3. Provide adequate clearance for Type “D” cable assemblies:
   - Straight Shielded connectors require approximately 3” height.
   - Right Angle connectors require approximately 2” height.

Should you choose to manufacture your own cables, follow the guidelines listed below:

1. The cable must have a *braided* shield, covering all wires. Neither aluminum foil nor spiral shielding will be as effective; using either may nullify regulatory compliance.

2. The connectors must have a metal case which has direct contact to the cable’s shield on the whole circumference of the cable. The inductance of a flying lead or wire from the shield to the connector will seriously degrade the shield’s effectiveness. The shield should be grounded to the connector before its internal wires exit.

3. With very few exceptions, the connector(s) must make good contact to the device’s case (ground). “Good contact” is about 0.01 ohms; and the ground should surround all wires. Contact to ground at just one point may not suffice.

4. For shielded cables with flying leads at one or both ends; it is important at each such end, to ground the shield *before* the wires exit. (A ¼ inch piece of #22 wire may be undesirably long since it has approximately 5 nH of inductance, equivalent to 31 ohms at 1000 MHz). After picking up the braid’s ground, keep wires and braid flat against the case. With very few exceptions, grounded metal covers are not required over terminal strips. If one is required, it will be stated in the Declaration of Conformity or in this instruction manual.

5. In selecting the appropriate type and wire size for cables, consider:
   A. The voltage ratings.
   B. The cumulative I^2R heating of all the conductors (keep them safely cool).
   C. The IR drop of the conductors, so that adequate power or signal voltage gets to the device.
   D. The capacitance and inductance of cables which are handling fast signals, (such as data lines or stepper motor drive cables).
   E. That some cables may need internal shielding from specific wires to others; please see the instruction manual for details regarding this matter.

Setup

Follow the guidelines below when setting up the 1179 flow controller.

1. Set the controller into position where it will be connected to a gas supply.

   Placement of flow components in an orientation other than that in which they were calibrated (typically horizontal) may cause a small zero shift. The zero offset can be removed according to the instructions in *How To Zero the Flow Controller,* page 40.

2. Install the flow controller in the gas stream such that the flow will be in the direction of the arrow on the side of the controller.

3. Allow adequate clearance for the cable connector and tubing.

   Straight Shielded connectors require approximately 3" height. Right Angle connectors require approximately 2" height.

4. Position the flow controller to provide access to the zero potentiometer.

   The zero potentiometer is located on the inlet side of the flow controller body.

Refer to Figures 1, and 2, page 28, for outline dimensions, and Figure 4, page 29, for mounting dimensions of the flow controller.

Dimensions

Note All dimensions are listed in inches with millimeters referenced in parentheses.

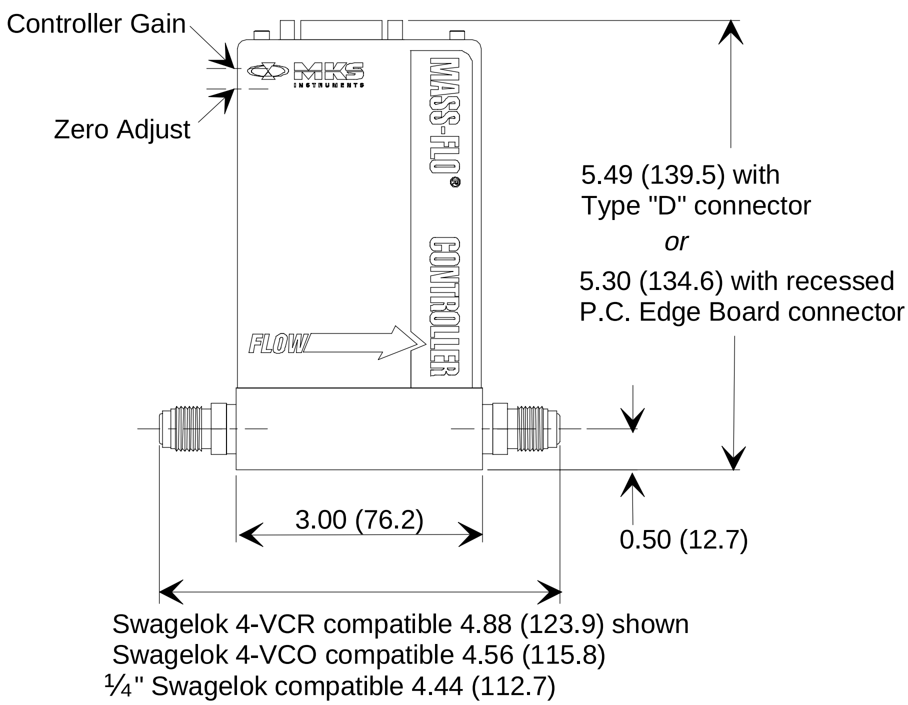


Figure 1: Outline Dimensions of the Type 1179 MFC and Type 179 MFM

Note The method used to measure the overall length of the unit varies with the type of fitting. For VCR and VCO compatible fittings, the unit is measured from mating face to mating face. For Swagelok compatible fittings, the unit is measured from fitting end to fitting end (less nut).

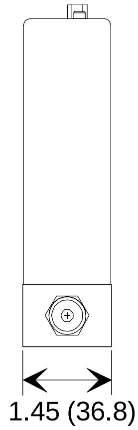


Figure 2: Side View of the Type 1179 MFC and Type 179 MFM

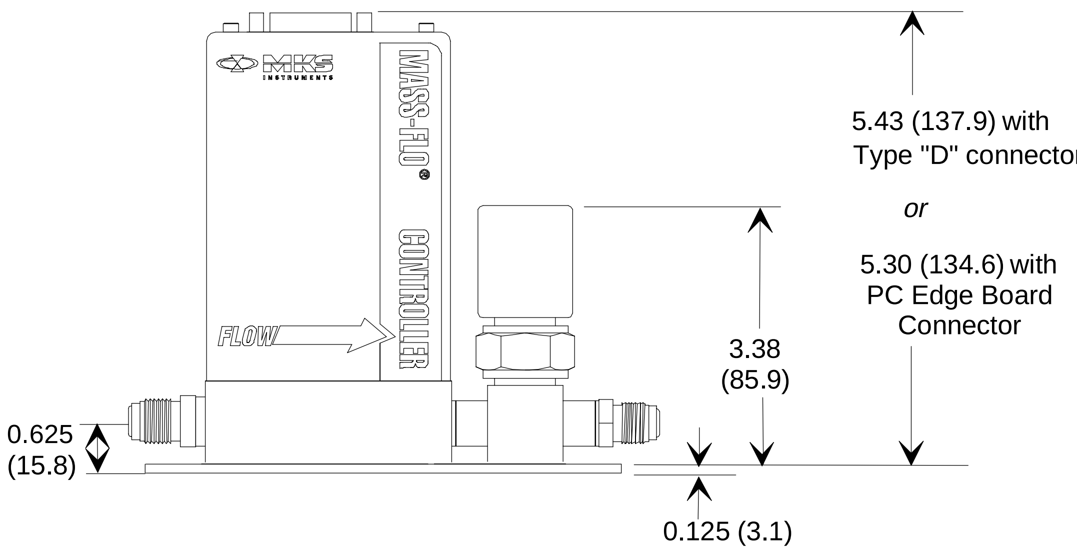


Figure 3: Outline Dimensions of the Type 2179 MFC (with optional mounting plate)

Gas Line Connections

Connect the gas line (via tubing) from the gas supply to the flow controller's inlet, and from the flow controller's outlet, to the downstream tubing.

Standard Fittings

The 1179 flow controller is equipped with Swagelok 4-VCR male compatible fittings. For specific information regarding these fittings, refer to the manufacturer's documentation.

Optional Fittings

As an option, ¼ inch Swagelok compatible, or Swagelok 4-VCO male compatible fittings, are available when specified.

Mounting a Type 1179 MFC

Tapped holes are provided in the base of the unit for mounting. Refer to Figure 4 for the size and location of the mounting holes.

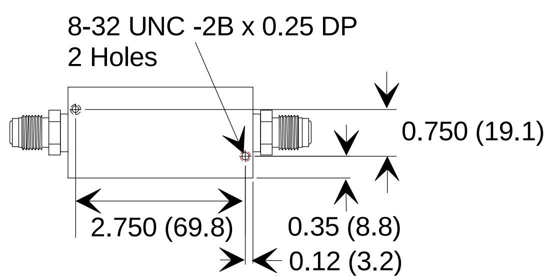


Figure 4: Mounting Dimensions of the 1179 Flow Controller

Mounting a Type 2179 MFC

The Type 2179 MFC includes a positive shutoff valve. Mount each assembly horizontally, if possible. Placement of flow components in a different orientation may cause a small zero shift. The zero offset can be removed according to the instructions in *How To Zero the Flow Controller*, page 40. The air operator port is a 1/8 NPT (National Pipe Thread) internal fitting. The aluminum plate can be mounted via four mounting holes. Refer to Figure 5 for the location of the mounting holes on the aluminum plate.

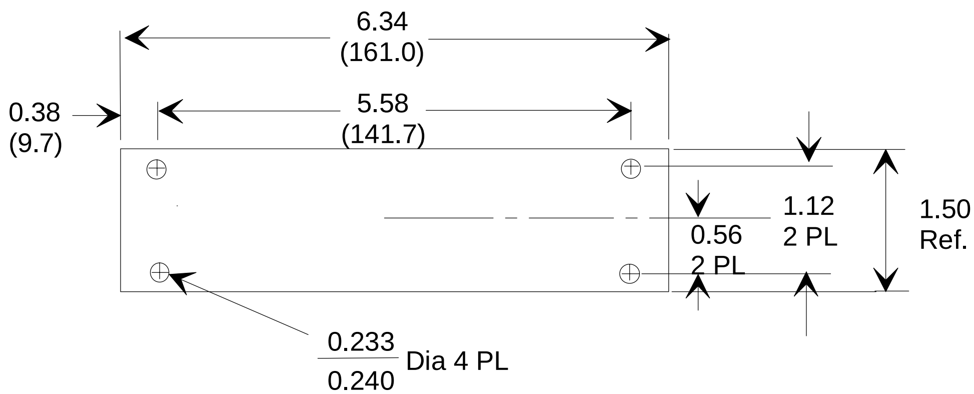


Figure 5: Mounting Dimensions of the Base Aluminum Plate

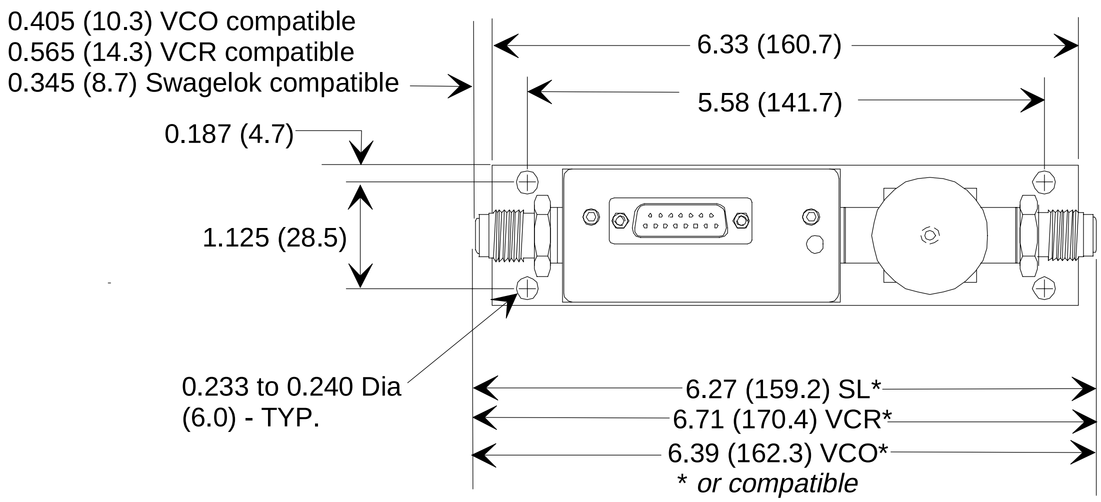


Figure 6: Mounting Dimensions of the Type 2179 Flow Controller

Chapter Three: Overview

Type 2179 MFC with a Positive Shutoff Valve

The Type 2179 consists of a Type 1179 flow controller configured with a positive shutoff valve downstream. A pneumatically operated valve may be used in series with a mass flow controller when a no-leakage condition is required. The shutoff valve is an all 316L VAR SST diaphragm valve with a Kel-F® valve seat. It has a maximum leak rate across the ports of 4 x 10^{-9} sccm He and a leak rate of less than $1x10^{-9}$ sccm He, to the outside.

Refer to Figure 3, page 28, for the dimensions of a Type 2179 flow controller.

Electrical Connections

If you are using the 1179 instrument with any equipment other than corresponding MKS power supply/readout units, consult the manufacturer's specifications for connection, and for proper electrical and power characteristics. Refer to *Appendix A: Product Specifications,* page 57, for electrical requirements of the Type 1179 flow controller.

The 1179 flow controller is available with either a Type "D" or an Edge Card connector.

9-Pin Type "D" Connector

Table 8 lists the pinout of the 9-pin Type "D" connector for a mass flow controller.

9-Pin Type "D" Connector Pinout	
Pin Number	**Assignment**
1	Valve Open/Close*
2	Flow Signal Output
3	+15 V
4	Power Common
5	-15 V
6	Set Point*
7	Signal Common
8	Signal Common
9	MKS Test Point*
** For an MFC only, No Connection for an MFM*	

Table 6: 9-Pin Type "D" Connector Pinout

Note

1. Chassis ground is not available on a separate pin. Instead, it is carried out through the cable shielding. Be sure that the connector on the other end of the cable is properly grounded to its chassis ground.
2. The 0 to 5 VDC flow signal output comes from pin 2 and is referenced to pin 7 (signal common).
3. Use any appropriate 0 to 5 VDC input signal of less than 20K ohm source impedance referenced to pin 7 as the set point signal to pin 8.

P.C. Edge Card Connector

Table 7 shows the pinout of the 20-pin Edge Card connector for a mass flow controller.

20-Pin Edge Card Connector Pinout			
Pin Number	**Function**	**Pin Number**	**Function**
1	Chassis Ground	A	Set Point Input (0 to +5 VDC)*
2	Power Supply Common	B	Signal Common
3	Flow Output (0 to +5 VDC)	C	Signal Common
4	+15 VDC	D	Valve Open (TTL low)*
5	Optional Input*	E	No Connection
6	No Connection	F	-15 VDC
7	Key	H	Key
8	No Connection	J	MKS Test Point*
9	No Connection	K	No Connection
10	Signal Common	L	Valve Close (TTL low)*
** For an MFC only, No Connection for an MFM*			

Table 7: 20-Pin Edge Card Connector Pinout

Note

1. The “No Connection” pin assignment refers to a pin with no internal connection.
2. Pins 1 through 10 are located on one side of the gold finger connection and pins A through L are located on the opposite side of the gold finger connection.
3. The 0 to 5 VDC flow signal output comes from pin 3 and is referenced to pin B (signal ground).
4. Any appropriate 0 to 5 VDC input signal of less than 20K ohm source impedance referenced to pin B can be used to supply a set point signal to pin A.

15-Pin Type "D" Connector

Table 8 lists the pinout of the 15-pin Type "D" connector for a mass flow controller.

15-Pin Type "D" Connector Pinout			
Pin	**Assignment**	**Pin**	**Assignment**
1	MKS Test Point*	9	No Connection
2	Flow Signal Output (0 to +5 VDC)	10	Optional Input*
3	Valve Close* (TTL low)	11	Signal Common
4	Valve Open* (TTL low)	12	Signal Common
5	Power Supply Common	13	No Connection
6	-15 VDC	14	No Connection
7	+15 VDC	15	Chassis Ground
8	Set Point Input* (0 to +5 VDC)		
** For an MFC only, No Connection for an MFM*			

Table 8: 15-Pin Type "D" Connector Pinout

Note

1. The "No Connection" pin assignment refers to a pin with no internal connection.
2. The 0 to 5 VDC flow signal output comes from pin 2 and is referenced to pin 12 (signal common).
3. Any appropriate 0 to 5 VDC input signal of less than 20K ohm source impedance referenced to pin 12 can be used to supply a set point signal to pin 8.

The Gas Correction Factor (GCF)

A Gas Correction Factor (GCF) is used to indicate the ratio of flow rates of different gases which will produce the same output voltage from a mass flow controller. The GCF is a function of specific heat, density, and the molecular structure of the gases. Nitrogen is used as the baseline gas (GCF = 1) since flow controllers are usually calibrated with nitrogen.

Appendix C: Gas Correction Factors, page 65, lists the gas correction factors for some commonly used pure gases. If the gas you are using is not listed in *Appendix C: Gas Correction Factors*, page 65, you must calculate its GCF. The equations for calculating gas correction factors are listed in *How To Calculate the GCF for Pure Gases*, page 35, and *How To Calculate the GCF for Gas Mixtures*, page 36.

Note

1. When using the GCF, the accuracy of the flow reading may vary by ±5%, however, the repeatability will remain ±0.2% of FS.
2. All MKS readouts have Gas Correction Adjustment controls to provide direct readout.

How To Calculate the GCF for Pure Gases

To calculate the Gas Correction Factor for *pure* gases, use the following equation:

$$GCF_x = \frac{(0.3106)\ (s)}{(d_x)\ (cp_x)}$$

where:

GCF_X = Gas Correction Factor for gas X

0.3106 = (Standard Density of nitrogen) (Specific Heat of nitrogen)

s = Molecular Structure correction factor where S equals:

1.030 for Monatomic gases

1.000 for Diatomic gases

0.941 for Triatomic gases

0.880 for Polyatomic gases

d_X = Standard Density of gas X, in g/l (at 0° C and 760 mm Hg)

cp_X = Specific Heat of gas X, in cal/g° C

How To Calculate the GCF for Gas Mixtures

For gas mixtures, the calculated Gas Correction Factor is not simply the weighted average of each component's GCF. Instead, the GCF (relative to nitrogen) is calculated by the following equation:

$$GCF_M = \frac{(0.3106)\ (a_1 s_1 + a_2 s_2 + \ldots a_n s_n)}{(a_1 d_1 cp_1 + a_2 d_2 cp_2 + \ldots a_n d_n cp_n)}$$

where:

GCF_M = Gas Correction Factor for a gas mixture

0.3106 = (Standard Density of nitrogen) (Specific Heat of nitrogen)

a_1 through a_n = Fractional Flow of gases 1 through n
Note: a_1 through a_n must add up to 1.0

s_1 through s_n = Molecular Structure correction factor for gases 1 through n where S equals:

1.030 for Monatomic gases

1.000 for Diatomic gases

0.941 for Triatomic gases

0.880 for Polyatomic gases

d_1 through d_n = Standard Density for gases 1 through n, in g/l (at 0° C and 760 mmHg)

cp_1 through cp_n = Specific Heat of gases 1 through n, cal/g° C

Note

The values for s, d, and cp_x are available for most gases, refer to *Appendix C: Gas Correction Factors*, page 65.

The values for a_1 through a_n (which must add up to 1.0) are application dependent.

Example

Calculate the GCF for a gas mixture of argon (gas 1) flowing at 150 sccm and nitrogen (gas 2) flowing at 50 sccm, where:

Argon (Ar)	**Nitrogen (N_2)**
$a_1 = \frac{150}{200} = 0.75$	$a_2 = \frac{50}{200} = 0.25$
$s_1 = 1.030$	$s_2 = 1.000$
$d_1 = 1.782$ g/l	$d_2 = 1.250$ g/l
$cp_1 = 0.1244$ cal/g ° C	$cp_2 = 0.2485$ cal/g ° C

then:

$$GCF_M = \frac{(0.3106)\ [(0.75)(1.030)+(0.25)(1.000)]}{(0.75)(1.782)(0.1244)\ +(0.25)(1.250)(0.2485)}$$

$$= \frac{(0.3106)\ [(0.7725)+(0.25)]}{(0.1663)\ +(0.0777)}$$

$$= \frac{(0.3106)\ (1.0225)}{0.244}$$

$$= \frac{0.3176}{0.244}$$

$$GCF_M = 1.302$$

How To Read Mass Flow at a Different Reference Temperature

The equations for calculating the GCF assume that the MFC was calibrated at a reference temperature of 0° C (~273° K). If you want to read the mass flow as if the MFC was calibrated at a different reference temperature, adjust the calculated GCF value using the following equation:

$$\text{Temperature Corrected GCF} = \text{GCF} \times \frac{T_x}{T_s}$$

where:

T_X = Reference temperature (° K)

T_S = 273.15° K (~ equal to 0° C)

Labels

Each 1179 unit has two serial number labels, a small one on top side and the standard, larger label on the back side. Each label shows the serial number, the model code, the full scale flow range, and the calibration gas.

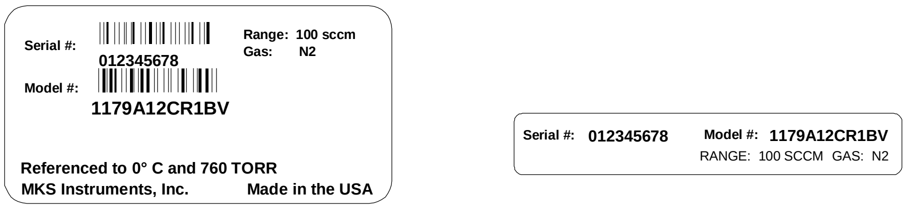


Figure 7: Serial Number Label

Control Valve (MFC only)

The Control Valve is a specially constructed solenoid valve in which the armature (moving valve mechanism) is suspended by two springs. This arrangement ensures that no friction is present and makes precise control possible. The 1179 controller has the valve normally *closed*, the control current is used to *lift* the armature *from* the seat, allowing a controlled flow of gas.

Chapter Four: Operation

How To Start Up the MFC/MFM

1. Leak test the fittings on the MFC/MFM using standard leak test procedures.

   Do *not* proceed to the next step until you are certain that there is no gas leakage.

2. Plug the power supply/readout cable (MKS or customer-supplied) into the connector (either a 9-pin Type "D", 15-pin Type "D" or a PC Edge Card connector) located at the top of the flow controller.

   Plug the other end of the cable into an MKS or MKS-compatible power supply/readout unit.

3. Apply power to the MFC/MFM instrument.

   When power is first applied, the output signal jumps to + 7.5 VDC.

   You can monitor the flow output signal as the heaters stabilize and the output approaches zero. Approximately 2 minutes after power up, the output signal should be within 10 mV (0.2% F.S.) of the final voltage at all specified flow rates.

Warning

If the instrument is being used to control dangerous gases, be sure that the system is *fully warmed up* before applying gases to the system. You may choose to install a positive shutoff valve to prevent inadvertent gas flow during the warm-up period.

Once the MFC/MFM is completely warmed up, you can proceed to zero the unit as required.

How To Zero the Flow Controller

Ensure that no gas flow is entering the flow controller.

1. Apply gas, at a regulated pressure, to the flow controller.

2. If your system includes a positive shutoff valve, located either upstream or downstream of the instrument, close it.

3. *For an MFC:* Command the control valve open by sending a full scale set point (5 VDC) signal, or:

   15-pin Type "D" connector: Connect pin 4 (valve open) to pin 11 or 12 (signal ground).

   9-pin Type "D" connector: Supply +5 Volts to pin 1 (to open the valve).

   Edge Card connector: Connect pin D (valve open) to pins 10, B, or C (signal ground).

   A positive flow may occur momentarily while the gas pressure equalizes across the flow controller.

Note A set point command signal greater than 50 mV (1% of full scale) is required for the flow controller to generate an output.

For an MFM: Skip to step 2 in *Adjust the Zero Pot*

Adjust the Zero Pot

1. *For an MFC:* Once flow through the controller has stopped (reached zero flow), remove the set point or valve open command.

2. Turn the Zero pot (located on the inlet side of the flow controller) until the readout displays zero.

   Refer to Figure 1, page 27, for the location of the Zero pot.

   If you are using an MKS power supply/readout unit, the flow controller can also be zeroed at the front panel of the readout unit.

Note A DeviceNet™ MFC/MFM does not have a zero pot, use the zero offset command instead.

3. Open the positive shutoff valve.

   An MFC may indicate a small, positive flow (<1.0% F.S.) due to a leak through its control valve. However, do ***not*** "zero out" this flow since it represents an actual flow measurement inherent in the system.

How To Adjust the Controller Gain (MFC only)

Adjust the controller gain if the flow signal oscillates. Reducing the controller gain will reduce the signal oscillation. The controller gain adjustment pot is located on the upstream side of the controller.

- *To decrease flow signal oscillation:* Turn the controller gain counter-clockwise to decrease the controller gain setting.

Note Lowering the supply pressure to the MFC will have the same effect as decreasing the gain since it will reduce the overflow/underflow effect of the valve.

If the MFC responds too slowly to a change in set point, you may need to increase the controller gain slightly. To increase the controller gain, turn the controller gain pot clockwise.

How To Override the Valve (MFC only)

The valve override feature enables the control valve to be fully opened (purged) or closed independent of the set point command signal. Refer to Table 8, page 34, or Table 7, page 33, for the appropriate pin locations.

If the 1179 flow controller is equipped with a 15-pin Type "D" connector:

To *open* the valve, apply a TTL low to pin 4 *or* connect pin 4 to signal ground (pin 12).

To *close* the valve, apply a TTL low to pin 3 *or* connect pin 3 to signal ground (pin 12).

If the 1179 flow controller is equipped with a 9-pin Type "D" connector:

To *open* the valve, apply a +5 Volt signal to pin 1.

To *close* the valve, apply ground to pin 1.

Note To control with a TTL signal, use a tri-stated device.

If the 1179 flow controller is equipped with an Edge Card connector:

To *open* the valve, apply a TTL low to pin D *or* connect pin D to signal ground (pin 10).

To *close* the valve, apply a TTL low to pin L *or* connect pin L to signal ground (pin 10).

Priority of the Commands

The 1179 flow controller executes commands based on a hierarchical command structure. The highest priority command is Valve Open, followed by Valve Close, and Set Point Control. Therefore, if the flow controller is operating under Set Point Control, you can send a Valve Open command to force the valve to the full open position.

Note When both the Valve Close and Valve Open pins are pulled down, the Valve Open command takes precedence and the valve is moved to the open position.

How To Use the Optional Input (MFC only)

The 1179 and 2179 units provide an optional input feature which allows them to control flow based on 0 to 5 V signals from external sensing devices. A common application of this feature is pressure control using inputs from a pressure transducer.

Implement the optional feature by simply routing the output from the desired external device to the appropriate "optional input" position for the particular connector. Refer to Table 8, page 34, and Table 7, page 33, for the pinout assignments. Voltage to the optional input overrides the signal generated by the unit's own internal flow sensor. The control electronics drives the valve so that the optional input signal matches the set point. Provide the 0 to 5 V set point to the same input pin as in standard flow control.

Metered flow output is still available on the standard output pin identified in the applicable pin assignments. Refer to Table 8, page 34, and Table 7, page 33, for the pinout assignments.

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Chapter Five: Theory of Operation

General Information

The 1179 Flow Controller measures the mass flow rate of a gas and controls the flow rate according to a given set point. The control range is from 2 to 100% of Full Scale (F.S.) with an accuracy of ± 1% of F.S.

Flow Path

Upon entering the flow controller, the gas stream passes first through the metering section of the instrument for its mass flow to be measured. The gas moves on through the control valve for its rate of flow to be regulated according to the given set point, and then exits the instrument at the established rate of flow.

The metering section consists of one of the following:

- A sensor tube for ranges $\leq$ 10 sccm (N_2 equivalent)
- A sensor tube and parallel bypass for ranges > 10 sccm (N_2 equivalent)

The geometry of the sensor tube, in conjunction with the specified full scale flow rate, ensures fully developed laminar flow in the sensing region. The bypass elements, in those instruments containing them, are specifically matched to the characteristics of the sensor tube to achieve a laminar flow splitting ratio which remains constant throughout each range.

Measurement Technique

The flow measurement is based on differential heat transfer between temperature sensing heater elements which are attached symmetrically to the sensor tube. This senses the thermal mass movement which is converted to mass flow via the specific heat, C_p, of the gas. The resulting signal is amplified to provide a 0 to 5 VDC output which is proportional to mass flow.

Control Circuitry

The controller employs the above measurement technique and utilizes a control circuit that provides drive current for the proportioning control valve. The flow controller accepts a 0 to 5 VDC set point signal, compares it to its own flow signal, and generates an error voltage. This error signal is then conditioned by a PID (Proportional-Integral-Derivative) algorithm and amplified so that it can reposition the controlling valve, thus reducing the controller error to within the resolution specification of the instrument.

Since the control valve is *normally closed*, the 1179 unit pulls the plug *away* from the seat to regulate the gas flow rate.

Chapter Six: Maintenance

General

In general, no maintenance is required other than proper installation and operation, and zero adjustment. If a controller fails to operate properly upon receipt, check for shipping damage, and check the power/signal cable for correct continuity. Any damage should be reported to the carrier and MKS Instruments immediately. If there is no obvious damage and the continuity is correct, obtain an ERA Number (Equipment Return Authorization Number) before returning the unit to MKS Instruments for service.

Zero Adjustment

For best accuracy and repeatability, you should check the zero setting periodically and reset it, if necessary. Refer to *How To Zero the Flow Controller*, page 40, for instructions on setting the zero. The frequency of checking the zero is dependent on the specific accuracy and repeatability required by your process. It is also recommended that the instrument be recalibrated annually if no other time interval has been specifically established. Refer to the inside of the back cover of this instruction manual for a complete list of MKS Calibration and Service centers.

Repair

Contact any authorized MKS Sales Office or Calibration and Service Center should you encounter any difficulties or problems using your flow controller.

Note If it is necessary to return the instrument to MKS for repair, please contact any of the MKS international service/calibration centers listed on the inside of the back cover of this manual for an ERA (Equipment Return Authorization) number to expedite handling and ensure proper servicing of your instrument.

Chapter Seven: Troubleshooting

Troubleshooting Chart

Symptoms	**Possible Cause**	**Remedy**
No output or overrange at zero (after warm-up)	Improper cable	Check cable for type
	Valve override function applied	Disconnect valve override
	Electronics malfunctioning	Return for service
Unit indicates a negative flow	Unit installed in gas stream backwards	Reinstall unit in proper flow direction
Controller does not track set point	Improper zero adjustment	Zero meter output, according to *How To Zero the Flow Controller,* page 40.
Controller does not function	Electronics malfunctioning	Return for service
	Valve sticking	Readjust the valve, following the instructions in *How To Adjust the Valve Preload,* page 50.
Oscillation	Too high a controller gain setting	Reduce (turn counter-clockwise)
	Incorrect upstream pressure regulator	Check manufacturers' specifications
	Upstream pressure too high	Reduce upstream pressure
Excessive closed conductance	Inadequate valve preload	Readjust the valve, according to *How To Adjust the Valve Preload*, page 50.
Unit does not achieve full flow	Upstream pressure too low	Increase upstream pressure
	Excessive valve preload	Readjust the valve, according to *How To Adjust the Valve Preload*, page 50.

Table 9: Troubleshooting Chart

How To Adjust the Valve Preload (MFC only)

Warning

Before performing MFC valve adjustments, you MUST purge your process equipment and the MFC with an inert gas, such as argon or nitrogen, and isolate the MFC from toxic and hazardous gases. Use an inert surrogate gas while adjusting the valve preload as a safeguard against inadvertent exposure to any toxic or hazardous gas. A release of hazardous or toxic gas could cause serious injury. If necessary, remove the MFC from the process equipment to adjust the valve.

Questions concerning the safe handling of toxic or hazardous gases may be answered by consulting your corporate policy, a government agency such as OSHA or NIOSH, or experts familiar with your process gas.

MKS assumes no liability for safe handling of toxic or hazardous gases.

Caution

All valves are adjusted at the factory for proper leak integrity and flow control response. Adjust the valve *only* if the *Troubleshooting Chart,* page 49, recommends that you do so.

This procedure requires the following equipment:

- Any special safety equipment necessary to handle the gas in use
- $^{3}/_{32}$” allen wrench for retaining screws (4-40 socket head cap screws)
- $^{3}/_{16}$” allen wrench for the centershaft
- $^{9}/_{16}$” wrench for the lock nut
- Digital Multi Meter (DMM)

1. Disconnect the cable to power down the unit.

2. Use a 3/32" allen wrench to remove the enclosure retaining screws. Remove the enclosure cover.

   Figure 8 shows the location of the retaining screws.

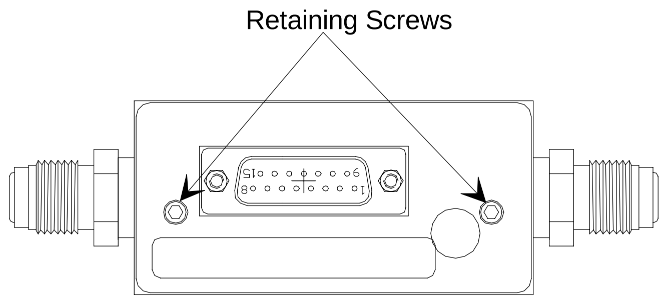

Figure 8: Location of the Retaining Screws

3. Reconnect the cable to power up the unit.

4. Set your processing system to supply the MFC with a non-hazardous gas (Ar, N_2, or He) and purge thoroughly.

Warning

You MUST use a "safe" gas while making any valve adjustments to safeguard against inadvertent exposure to any toxic or hazardous gas. DO NOT adjust the valve while a hazardous or toxic gas is flowing through the MFC.

If you cannot use a "safe" gas within your processing system, remove the MFC and purge the unit as required by your corporate policies and any appropriate safety procedures. Once the unit is purged properly perform the valve adjustment outside of the system, maintaining the same orientation (flow direction) as used in the processing system.

Choose a "safe" gas with a similar molecular weight as the actual process gas. More specifically, helium is best used as a substitute for other very light gases such as hydrogen.

5. Set the gas supply regulator to the maximum expected operating pressure of your processing system.

Warning **Follow your corporate policy on handling toxic or hazardous gases. Your corporate policy on handling these gases *supersedes* the instructions in this manual. MKS assumes no liability for the safe handling of such materials.**

If appropriate, remove the MFC from the process tool and make the adjustments using a surrogate gas.

6. Close all isolation valves in the system, both upstream and downstream of the MFC.

7. Zero the unit, following the instructions in *How To Zero the Flow Controller,* page 40.

8. Disconnect one electrical valve lead from its post on the PC Control board and connect a DMM in series. Set the DMM to measure current in the 10 to 100 mA range.

9. Open all upstream and downstream isolation valves in the system.

10. Hold the centershaft in place with a $^{3}/_{16}$” allen wrench and loosen the jam nut using a $^{9}/_{16}$” crescent wrench.

    Refer to Figure 9 for the location of the lock nut and centershaft.

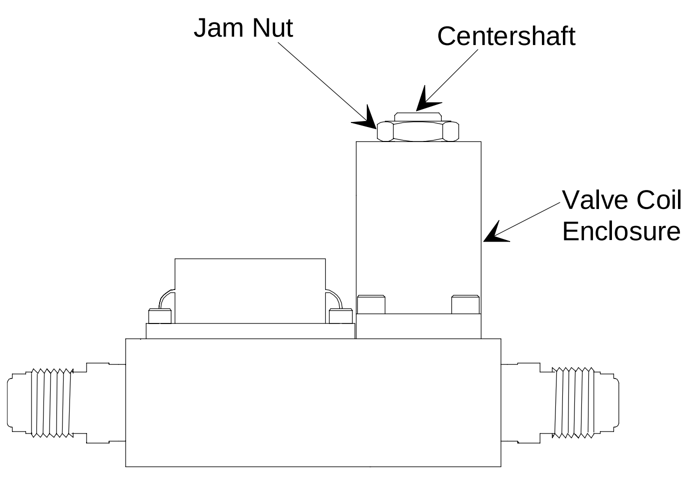

Figure 9: Location of the Lock Nut and Centershaft

11. Provide a set point input signal to the MFC of 0.25 Volts to represent 5% flow.

12. *Slowly* turn the centershaft while monitoring the DMM: clockwise rotation increases the current required to open the valve; counterclockwise rotation decreases it. ***Adjust to a target value of 25 mA, except for 10, 20, and 50 sccm units containing Viton, Buna-N, or Neoprene elastomers which require 20 mA preload.***

Note

Always make adjustments by turning counterclockwise first and then turning clockwise to the proper setting. This procedure ensures that the adjustment will remain fixed when you retighten the lock nut.

Caution

Do not overturn the centershaft! Excessive turning may damage the plug and cause poor closed conductance and flow control.

13. Holding the centershaft in place, re-tighten the jam nut. As you tighten the jam nut, monitor the DMM to ensure that the current remains within 1 mA of the target value.

14. Change the set point input signal to 0.0 Volts.

15. Monitor the MFC output to verify that the valve closed conductance is within specification.

    Refer to *Appendix A: Product Specifications*, page 57, for the valve closed conductance specification. If the valve fails to meet the closed conductance specification, return the unit to MKS for service.

16. Change the inlet pressure to the minimum expected in use.

17. Change the set point input signal to 5.0 Volts (100% of full scale).

18. Observe the MFC output and control valve current. *Record the valve current.*

    The MFC output should be 5.0 Volts (100%) and the valve current no greater than the limits in Table 10. If the valve current exceeds these limits, return the unit to MKS for service.

Maximum Valve Currents	
UUT Flow Capacity (N_2 Equivalent)	**Maximum Valve Current at 100% Set Point and Minimum Pressure**
50 sccm and under	39 milliAmps
100 to 500 sccm	45 milliAmps
1000 sccm and above	51 milliAmps

Table 10: Maximum Valve Currents

19. Re-adjust the Valve Current Limit Potentiometer, R85.

    a. Find the current limiting potentiometer, R85, on the PC board.

       Refer to Figure 10, page 55. R85 is located in the top right hand corner of the board. It is the only ***black*** potentiometer on the board and is much smaller than the others.

    b. Determine the required valve current limit by adding the appropriate headroom from Table 11 to the valve current recorded in Step 18.

Valve Current Headroom	
UUT Flow Capacity (N_2 Equivalent)	**Required Valve Current Headroom**
50 sccm and under	24 milliAmps
100 to 500 sccm	18 milliAmps
1000 sccm and above	12 milliAmps

Table 11: Valve Current Headroom

    c. Provide a 5 V set point signal and turn the gas supply off.

    d. When the indicated flow output has dropped to zero, adjust R85 until the required valve current limit is obtained. Note that *counterclockwise* rotation *increases* the maximum current, while *clockwise* rotation *decreases* it.

20. Remove the DMM and reconnect the valve lead.

21. Reposition the enclosure over the unit and tighten the retaining screws.

22. Reconnect the cable.

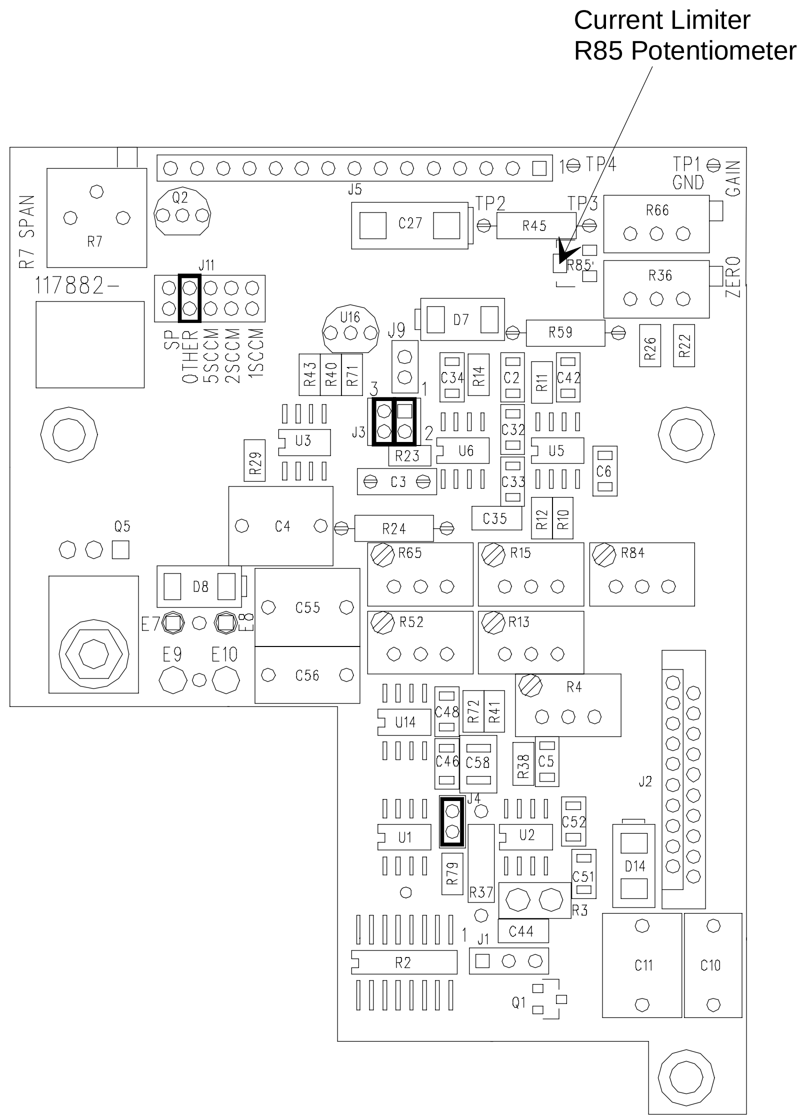

Figure 10: Location of the R85 Potentiometer on the PC Board

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Appendix A: Product Specifications

Performance Specifications

Accuracy[1]	± 1% F.S.
CE Compliance[2, 3]	EMC Directive 89/336/EEC
Control Range (MFC only)	2.0 to 100% F.S.
Controller Settling Time[4] (MFC only)	<2 seconds (to within 2% of set point)
Full Scale Ranges (nitrogen equivalent)	10, 20, 50, 100, 200, 500, 1000, 2000, 5000, 10,000, 20,000, 30,000 sccm
Maximum Inlet Pressure	150 psig
Operational Differential Pressure[5]	
≤ 5000 sccm	10 to 40 psid
10,000 to 30,000 sccm	15 to 40 psid
Pressure Coefficient	0.02% Rdg./psi
Repeatability (MFC only)	± 0.2% F.S.
Resolution (measurement)	0.1% F.S.
Temperature Coefficients	
Zero	< 0.05% F.S./° C (500 ppm)
Span	<0.08% of Rdg/° C (800 ppm)
Warm up Time (to within 0.2% of steady-state)	2 minutes

[1]Includes non-linearity, hysteresis, and non-repeatability referenced to 760 mmHg and 0° C.

[2]An overall metal braided, shielded cable, properly grounded at both ends, is required during use.

[3]Units with Edge Card connectors are not CE compliant.

[4]Controller settling time per SEMI E17-91, specified for flows starting from 0 to 10% (or greater) F.S.

[5]Operational differential pressure is referenced to an MFC outlet pressure at atmosphere.

Environmental Specifications

Storage Humidity Range	0 to 95% relative humidity, non-condensing
Operating Temperature	0° to 50° C (32° to 122° F)
Storage Temperature	-20° to 50° C (-4° to 122° F)

Electrical Specifications

Connector Options	9-pin Type "D", 15-pin Type "D" 20-pin Edge Card, Digital RS-485, Digital DeviceNet
Input Voltage/Current Required	
Maximum at Start Up (first 5 seconds)[6]	±15 VDC (±5%) @ 200 mA
Typical at Steady State	±15 VDC (±5%) @ 100 mA
Output Impedance	< 1 ohm
Output Signal/Minimum Load	0 to 5 VDC into > 10K ohm
Set Point Command Signal (MFC only)	0 to 5 VDC from < 20K ohm

[6]Add 100 mA to start up current if the valve is energized.

Physical Specifications

Body (height x width x length) *without fittings*	<5.5 in x ≤ 1.5 in x 3 in <14.0 cm x ≤ 3.8 cm x 7.6 cm
Fittings	Swagelok® 4-VCR® male compatible Swagelok 4-VCO® (male) compatible, ¼” Swagelok compatible
Internal Surface Area (500 sccm unit)	7.7 in^2 (49.7 cm^2)
Internal Volume (500 sccm unit)	0.27 in^3 (4.43 cm^3)
Leak Integrity	
External (scc/sec He)	< 1×10^{-9}
Through closed valve (MFC only)	< 1.0% F.S. @40 psi
Materials Wetted	
Body and Valve Seat	316L SST, nickel, Elgelloy
Seals	Viton®, Buna-N, Kalrez® Neoprene, all-metal
Weight	≤1.9 lbs (0.86 kg)

Due to continuing research and development activities, these product specifications are subject to change without notice.

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Appendix B: Model Code Explanation

Model Code

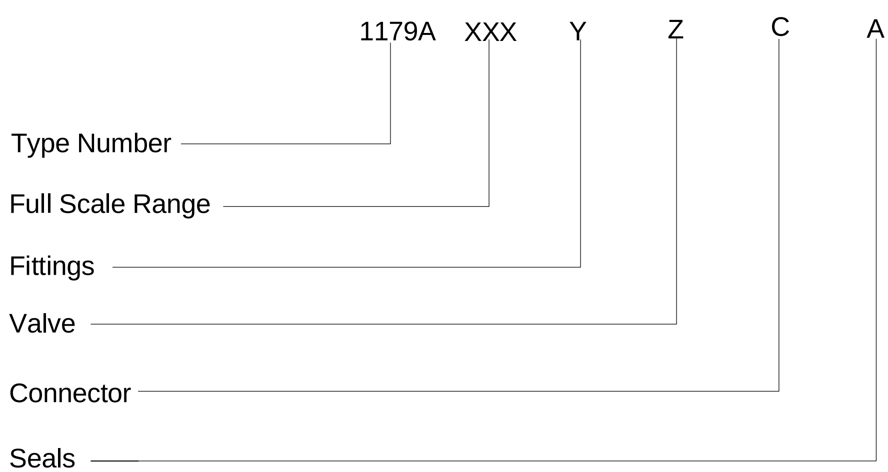
Use the MKS Type 1179 Mass-Flo® Controller (MFC) when both gas flow control and measurement are required. The instrument is available with the flow control valve in a normally closed configuration. Use the MKS Type 179 Mass-Flo® Meter (MFM) when only gas measurement is required.

The desired instrument and options are identified in the model code when you order the unit. All parts of the product code apply to both the mass flow controller and the mass flow meter.

The model code is identified as follows:

XXXXAXXXYZCA

where:



Type Number (XXXXA)

This designates the model number of the instrument.

The mass flow controller is identified as the Type 1179A.

The mass flow controller and a positive shutoff valve is identified as the Type 2179A.

The mass flow meter is identified as the Type 179A.

Full Scale Range - sccm of Nitrogen (XXX)

The full scale range is indicated by a two digit / one letter code.

	Ordering Code
10	11C
20	21C
50	51C
100	12C
200	22C
500	52C
1,000	13C
2,000	23C
5,000	53C
10,000	14C
20,000	24C

Fittings (Y)

Three types of fittings are available, designated by a single letter code.

	Ordering Code
Swagelok 4-VCR Male	R
Swagelok 4-VCO Male	G
Swagelok ¼" tube	S
Length adapter with VCR fittings	L
Length adapter with Swagelok fittings	W

Valve (Z)

Two valve configurations are available, designated by a single number code.

	Ordering Code
Normally Closed (Type 1179 MFC *only*)	1
No Valve (Type 179 MFM *only*)	3

Connector (C)

The type of connector is indicated by a single code.

	Ordering Code
9-pin Type "D"	A
15-pin Type "D"	B
20-pin Edge Card	C
Digital RS-485	5
Digital, DeviceNet*	6

** Consult factory for availability*

Seals (A)

The seal material is indicated by a single letter code.

	Ordering Code
Viton, standard	V
Neoprene (with Kel-F plugs)	N
Buna-N (with Kel-F plugs)	B
Kalrez (with Kel-F plugs)	K
All-metal (Type 179 MFM *only*)	M

How To Order a Mass Flow Controller

To order the Type 1179 MFC with a 500 sccm full scale range, Swagelok 4-VCR fittings, a normally closed valve, 15-pin Type "D" connector, and Viton sealing materials, the product code is:

1179A 52C R 1 B V

How To Order a Mass Flow Meter

To order the Type 179 MFM with a 500 sccm full scale range, Swagelok 4-VCR fittings, 15-pin Type "D" connector, no valve, and all-metal sealing materials, the product code is:

179A 52C R 3 B M

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Appendix C: Gas Correction Factors

Common Gases

GAS	SYMBOL	SPECIFIC HEAT, Cp cal/g^{o}C	DENSITY g/l @ 0^{o}C	CONVERSION FACTOR
Air	- - -	0.240	1.293	1.00
Ammonia	NH_3	0.492	0.760	0.73
Argon	Ar	0.1244	1.782	1.39[1]
Arsine	AsH_3	0.1167	3.478	0.67
Boron Trichloride	BCl_3	0.1279	5.227	0.41
Bromine	Br_2	0.0539	7.130	0.81
Carbon Dioxide	CO_2	0.2016	1.964	0.70[1]
Carbon Monoxide	CO	0.2488	1.250	1.00
Carbon Tetrachloride	CCl_4	0.1655	6.86	0.31
Carbon Tetraflouride (Freon - 14)	CF_4	0.1654	3.926	0.42
Chlorine	Cl_2	0.1144	3.163	0.86
Chlorodifluoromethane (Freon - 22)	$CHClF_2$	0.1544	3.858	0.46
Chloropentafluoroethane (Freon - 115)	C_2ClF_5	0.164	6.892	0.24
Chlorotrifluoromethane (Freon - 13)	$CClF_3$	0.153	4.660	0.38
Cyanogen	C_2N_2	0.2613	2.322	0.61
Deuterium	D_2	1.722	0.1799	1.00
Diborane	B_2H_6	0.508	1.235	0.44
Dibromodifluoromethane	CBr_2F_2	0.15	9.362	0.19
Dichlorodifluoromethane (Freon - 12)	CCl_2F_2	0.1432	5.395	0.35
Dichlorofluoromethane (Freon - 21)	$CHCl_2F$	0.140	4.592	0.42
Dichloromethysilane	$(CH_3)_2SiCl_2$	0.1882	5.758	0.25

(Table continued on next page)

GAS	SYMBOL	SPECIFIC HEAT, Cp cal/g^{o}C	DENSITY g/l @ 0^{o}C	CONVERSION FACTOR
Dichlorosilane	SiH_2Cl_2	0.150	4.506	0.40
1,2-Dichlorotetrafluoroethane (Freon - 114)	$C_2Cl_2F_4$	0.160	7.626	0.22
1,1-Difluoroethylene (Freon - 1132A)	$C_2H_2F_2$	0.224	2.857	0.43
2,2-Dimethylpropane	C_5H_{12}	0.3914	3.219	0.22
Ethane	C_2H_6	0.4097	1.342	0.50
Fluorine	F_2	0.1873	1.695	0.98
Fluoroform (Freon - 23)	CHF_3	0.176	3.127	0.50
Freon - 11	CCl_3F	0.1357	6.129	0.33
Freon - 12	CCl_2F_2	0.1432	5.395	0.35
Freon - 13	$CClF_3$	0.153	4.660	0.38
Freon - 13 B1	$CBrF_3$	0.1113	6.644	0.37
Freon - 14	CF_4	0.1654	3.926	0.42
Freon - 21	$CHCl_2F$	0.140	4.592	0.42
Freon - 22	$CHClF_2$	0.1544	3.858	0.46
Freon - 23	CHF_3	0.176	3.127	0.50
Freon - 113	$C_2Cl_3F_3$	0.161	8.360	0.20
Freon - 114	$C_2Cl_2F_4$	0.160	7.626	0.22
Freon - 115	C_2ClF_5	0.164	6.892	0.24
Freon - 116	C_2F_6	0.1843	6.157	0.24
Freon - C318	C_4F_8	0.185	8.397	0.17
Freon - 1132A	$C_2H_2F_2$	0.224	2.857	0.43
Helium	He	1.241	0.1786	.- - -2
Hexafluoroethane (Freon - 116)	C_2F_6	0.1843	6.157	0.24
Hydrogen	H_2	3.419	0.0899	.- - -2
Hydrogen Bromide	HBr	0.0861	3.610	1.00

(Table continued on next page)

GAS	SYMBOL	SPECIFIC HEAT, Cp cal/g^{o}C	DENSITY g/l @ 0^{o}C	CONVERSION FACTOR
Hydrogen Chloride	HCl	0.1912	1.627	1.00
Hydrogen Fluoride	HF	0.3479	0.893	1.00
Isobutylene	C_4H_8	0.3701	2.503	0.29
Krypton	Kr	0.0593	3.739	1.543
Methane	CH_4	0.5328	0.715	0.72
Methyl Fluoride	CH_3F	0.3221	1.518	0.56
Molybdenum Hexafluoride	MoF_6	0.1373	9.366	0.21
Neon	Ne	0.246	0.900	1.46
Nitric Oxide	NO	0.2328	1.339	0.99
Nitrogen	N_2	0.2485	1.250	1.00
Nitrogen Dioxide	NO_2	0.1933	2.052	.- - -2
Nitrogen Trifluoride	NF_3	0.1797	3.168	0.48
Nitrous Oxide	N_2O	0.2088	1.964	0.71
Octafluorocyclobutane (Freon - C318)	C_4F_8	0.185	8.937	0.17
Oxygen	O_2	0.2193	1.427	0.993
Pentane	C_5H_{12}	0.398	3.219	0.21
Perfluoropropane	C_3F_8	0.194	8.388	0.17
Phosgene	$COCl_2$	0.1394	4.418	0.44
Phosphine	PH_3	0.2374	1.517	0.76
Propane	C_3H_8	0.3885	1.967	0.36
Propylene	C_3H_6	0.3541	1.877	0.41
Silane	SiH_4	0.3189	1.433	0.60
Silicon Tetrachloride	$SiCl_4$	0.1270	7.580	0.28
Silicon Tetrafluoride	SiF_4	0.1691	4.643	0.35
Sulfur Dioxide	SO_2	0.1488	2.858	0.69

(Table continued on next page)

GAS	SYMBOL	SPECIFIC HEAT, Cp cal/g^{o}C	DENSITY g/l @ 0^{o}C	CONVERSION FACTOR
Sulfur Hexafluoride	SF_6	0.1592	6.516	0.26
Trichlorofluoromethane (Freon - 11)	CCl_3F	0.1357	6.129	0.33
Trichlorosilane	$SiHCl_3$	0.1380	6.043	0.33
1,1,2-Trichloro - 1,2,2-Trifluoroethane (Freon - 113)	CCl_2FCClF_2 or ($C_2Cl_3F_3$)	0.161	8.360	0.20
Tungsten Hexafluoride	WF_6	0.0810	13.28	0.25
Xenon	Xe	0.0378	5.858	1.32

[1]Empirically defined [2]Consult MKS Instruments, Inc. for special applications.

NOTE: Standard Pressure is defined as 760 mmHg (14.7 psia). Standard Temperature is defined as 0^{o}C.

Appendix D: MFC Sizing Guidelines

General Information

To select the correct MFC for an application, you must determine the:

- flow controller range
- appropriate valve configuration

The flow controller range depends on the desired flow rate and the gas correction factor for the gas to be used. MKS states the flow controller ranges based on flow rate of nitrogen; the flow rate for other gases may vary.

The proper valve configuration depends upon the flow range, inlet pressure, differential pressure across the unit, and density of the gas. Proper valve configurations have been established for all standard flow ranges flowing nitrogen under standard operating pressures. These configurations are suitable for virtually all gases and pressure conditions.

How To Determine the Flow Controller Range

The Type 1179 controller is available in ranges of 10, 20, 50, 100, 200, 500, 1000, 2000, 5000, 10,000, 20,000, and 30,000 sccm (N_2 equivalent). To select the appropriate range, you must determine the flow rate of nitrogen that is equivalent to the flow rate of the desired gas. Calculate the ratio of the GCF of nitrogen (1.00) to the GCF of the desired gas (refer to *Appendix C: Gas Correction Factors*, page 65) as shown in the following example.

Example:

You need a flow rate of 250 sccm of argon (Ar). What range flow controller should you use?

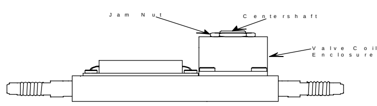
1. Find the Gas Correction Factor of Ar (refer to *Appendix C: Gas Correction Factors*, page 65).

   The GCF for Ar is 1.41.

2. Insert the GCF of Ar in the following formula:

$$\frac{(\text{GCF of } N_2)}{(\text{GCF of Ar})} = \frac{(x)}{(\text{Desired flow rate of Ar})}$$

where x is the equivalent flow rate of nitrogen (sccm).



$$x = 177 \text{ sccm } N_2$$

A flow rate of 250 sccm of Ar will produce a flow rate equivalent to 177 sccm of N_2. This falls within the range of a 200 sccm flow controller.

When calculating equivalent N_2 flows using gas correction factors, be sure to use a flow controller with a sufficient flow rate range. For example, if the calculated equivalent N_2 flow in the example shown above is 205 sccm, use a 500 sccm flow controller. The 500 sccm instrument can then be calibrated such that 205 sccm N_2 = full scale.

Note When using a gas with a density *higher* than nitrogen, be sure that the control valve Full Scale range can accommodate the desired flow rate. Please call the MKS Applications group if you have any questions.

How To Determine the Valve Configuration

1. Determine the maximum flow coefficient (C_V), for the gas of interest, using the equation:

$$C_V\ (\text{max}) = \left(\text{Max. Flow Rate, sccm}\right)\left(\sqrt{\frac{\text{Gas Density}}{1.293}}\right)\left(C_V\ \text{Pressure Factor}\right)$$

where:

Gas Density is listed in *Appendix C: Gas Correction Factors*, page 65.

C_V *Pressure Factor* is listed in Table 12, page 71.

C_V Pressure Factors (multiplied by 100,000)										
P1 (psia)	**Differential Pressure (psid)**									
	50	**40**	**30**	**20**	**15**	**10**	**5**	**2**	**1**	**0.5**
165	0.042	0.046	0.052	0.063	0.072	0.087	0.122	0.192	0.272	0.384
150	0.044	0.048	0.055	0.066	0.075	0.092	0.128	0.202	0.285	0.403
125	0.049	0.054	0.061	0.073	0.083	0.101	0.141	0.221	0.312	0.441
100	0.058	0.062	0.069	0.082	0.094	0.113	0.158	0.248	0.349	0.493
75	0.077	0.077	0.082	0.097	0.110	0.132	0.183	0.286	0.404	0.570
50	0.116	0.116	0.116	0.123	0.138	0.164	0.226	0.352	0.495	0.699
30	—	—	0.194	0.194	0.194	0.220	0.297	0.458	0.642	0.904
25	—	—	—	0.232	0.232	0.246	0.329	0.503	0.704	0.991
20	—	—	—	0.291	0.291	0.291	0.373	0.565	0.789	1.109
15	—	—	—	—	0.387	0.387	0.441	0.659	0.915	1.283
10	—	—	—	—	—	0.578	0.581	0.821	1.131	1.578
5	—	—	—	—	—	—	1.156	1.232	1.643	2.261
2	—	—	—	—	—	—	—	2.890	2.905	3.725
1	—	—	—	—	—	—	—	—	5.779	5.811

Table 12: C_V Pressure Factors

2. Select the valve configuration with the C_V value that is closest to, though larger than, the C_V value calculated in step 1.

   The C_V value represents the *maximum* flow rate for the unit. Choose the valve configuration *above* your calculated C_V value to ensure that the unit can deliver the required flow.

Valve Configuration Selection Guide		
Valve Configuration	**Nominal Range (N_2) sccm**	**Cv x 10^5**
1	10	2.44
2	20	4.88
3	50	12.21
4	100	24.42
5	200	48.84
6	500	122.11
7	1000	244.22
8	2000	488.44
9	5000	1221.11
10	10000	1924.47
11	20000	3848.94
12	30000	5773.41

Table 13: Valve Configuration Selection Guide

Example

Suppose you need to flow boron trichloride at a rate of 250 sccm and the inlet pressure is 20 psia. Your process runs at atmospheric pressure, so the differential pressure is 5 psid.

1. Determine the maximum flow factor (C_V) for the gas of interest, using the equation listed in step 1, on page 71.

The *Gas Density* for boron trichloride, listed in *Appendix C: Gas Correction Factors*, page 65, is 5.227. The *C_V Pressure Factor*, read from Table 12, page 71, for a 20 psia inlet and 5 psid differential pressure, is 0.373. Therefore, our equation becomes:

$$C_V \text{ (max)} = \left(250 \text{ sccm}\right)\left(\sqrt{\frac{5.227}{1.293}}\right)\left(0.373\right)$$

$$C_V = 187.5$$

2. Select the valve configuration with a C_V value that is closest to, though larger than, the C_V value calculated in step 1.

   A C_V value of 187.5 falls between 122.11 (configuration 6) and 244.22 (configuration 7). To ensure that the unit can deliver the 250 sccm flow, choose configuration 7.

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Appendix E: Positive Shutoff Valve Information

How To Operate the Positive Shutoff Valve

The Type 2179 mass flow controller includes a NUPRO® positive shutoff valve. The positive shutoff valve is a normally closed, air actuated valve, therefore, you must connect an air supply to operate the valve. The air supply should be between 70 and 80 psig.

The valve opens when air is supplied to the valve; the air pressure must be released for the valve to close. NUPRO offers several 2-way solenoid valves which can serve this purpose. When the solenoid is energized, the air pressure is applied to the actuator of the positive shutoff valve, so the valve opens. When the solenoid is de-energized, the air supply is disconnected from the positive shutoff valve and the actuator is vented to atmosphere, so the valve closes.

Suitable NUPRO solenoid valves are listed in Table 14.

Suitable Two-Way Solenoid Valves		
For BN Valves	**All Others**	**Operating Voltage**
MS-SOL-1K-BN	MS-SOL-1K	24 VDC
MS-SOL-2K-BN	MS-SOL-2K	110/120 VAC
MS-SOL-3K-BN	MS-SOL-3K	24 VAC
MS-SOL-4K-BN	MS-SOL-4K	12 VDC
MS-SOL-5K-BN	MS-SOL-5K	220/240 VAC
MS-SOL-6K-BN	MS-SOL-6K	5 VDC

Table 14: Suitable Two-Way Solenoid Valves

Figure 11 shows how to connect the 2179 MFC to the solenoid valve.

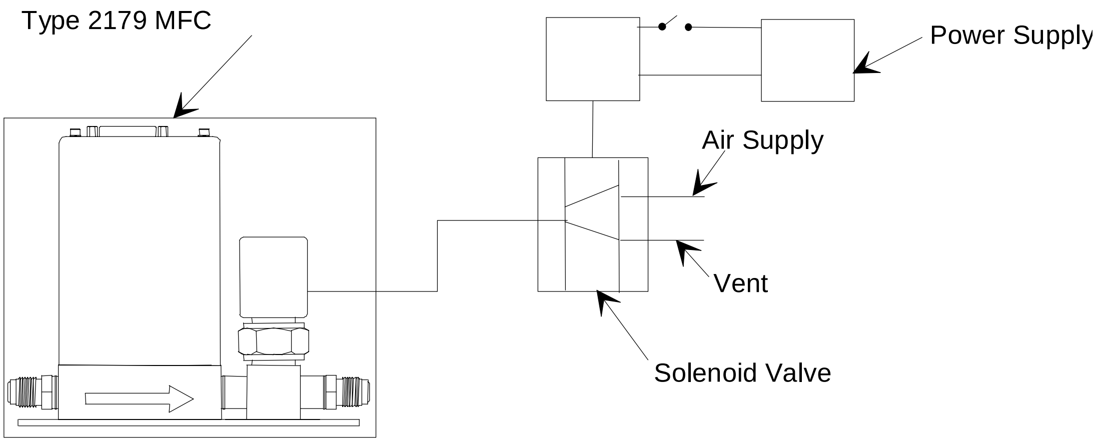

Figure 11: Connecting the Type 2179 MFC to a Solenoid Valve

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120714-P1
Rev A, 7/97
Instruction Manual

MKS Type 247D
Four-Channel Readout

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WARRANTY

Type 247D Equipment

MKS Instruments, Inc. (**MKS**) warrants that the equipment described above (the "equipment") manufactured by **MKS** shall be free from defects in materials and workmanship for a period of one year from date of shipment and will for a period of two years from the date of shipment, correctly perform all date-related operations, including without limitation accepting data entry, sequencing, sorting, comparing, and reporting, regardless of the date the operation is performed or the date involved in the operation, provided that, if the equipment exchanges data or is otherwise used with equipment, software, or other products of others, such products of others themselves correctly perform all date-related operations and store and transmit dates and date-related data in a format compatible with **MKS** equipment. THIS WARRANTY IS **MKS'** SOLE WARRANTY CONCERNING DATE-RELATED OPERATIONS.

For the period commencing with the date of shipment of this equipment and ending one year later in the case of defects in materials and workmanship, but two years later in the case of failure to comply with the date-related operations warranty, **MKS** will, at its option, either repair or replace any part which is defective in materials or workmanship or with respect to the date-related operations warranty without charge to the purchaser. The foregoing shall constitute the exclusive and sole remedy of the purchaser for any breach by **MKS** of this warranty.

The purchaser, before returning any equipment covered by this warranty, which is asserted to be defective by the purchaser, shall make specific written arrangements with respect to the responsibility for shipping the equipment and handling any other incidental charges with the **MKS** sales representative or distributor from which the equipment was purchased or, in the case of a direct purchase from **MKS**, with the **MKS** home office in Andover, Massachusetts, USA.

This warranty does not apply to any equipment which has not been installed and used in accordance with the specifications recommended by **MKS** for the proper and normal use of the equipment. **MKS** shall not be liable under any circumstances for indirect, special, consequential, or incidental damages in connection with, or arising out of, the sale, performance, or use of the equipment covered by this warranty.

MKS recommends that all **MKS** pressure and flow products be calibrated periodically (typically every 6 to 12 months) to ensure accurate readings. When a product is returned to **MKS** for this periodic re-calibration it is considered normal preventative maintenance not covered by any warranty.

THIS WARRANTY IS IN LIEU OF ALL OTHER RELEVANT WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING THE IMPLIED WARRANTY OF MERCHANTABILITY AND THE IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, AND ANY WARRANTY AGAINST INFRINGEMENT OF ANY PATENT.

120714-P1
Rev A, 7/97

MKS Type 247D Four-Channel Readout

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Safety Information

Symbols Used in This Instruction Manual

Definitions of WARNING, CAUTION, and NOTE messages used throughout the manual.

Warning

The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.

Caution

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of all or part of the product.

Note

The NOTE sign denotes important information. It calls attention to a procedure, practice, condition, or the like, which is essential to highlight.

Symbols Found on the Unit

The following table describes symbols that may be found on the unit.

Definition of Symbols Found on the Unit			
On (Supply) IEC 417, No.5007	Off (Supply) IEC 417, No.5008	Earth (ground) IEC 417, No.5017	Protective earth (ground) IEC 417, No.5019
Frame or chassis IEC 417, No.5020	Equipotentiality IEC 417, No.5021	Direct current IEC 417, No.5031	Alternating Current IEC 417, No. 5032
Both direct and alternating Current IEC 417, No.5033-a	Class ll equipment IEC 417, No.5172-a	3~ Three phase alternating Current IEC 617-2 No. 020206	
Caution, refer to accompanying documents ISO 3864, No. B.3.1	Caution, risk of electric shock ISO 3864, No. B.3.6	Caution, hot surface IEC 417, No. 5041	

Table 1: Definition of Symbols Found on the Unit

Safety Procedures and Precautions

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of intended use of the instrument and may impair the protection provided by the equipment. MKS Instruments, Inc. assumes no liability for the customer's failure to comply with these requirements.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an MKS Calibration and Service Center for service and repair to ensure that all safety features are maintained.

SERVICE BY QUALIFIED PERSONNEL ONLY

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel only.

GROUNDING THE PRODUCT

This product is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting it to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

DANGER ARISING FROM LOSS OF GROUND

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electrical shock.

GROUND AND USE PROPER ELECTRICAL FITTINGS

Dangerous voltages are contained within this instrument. All electrical fittings and cables must be of the type specified, and in good condition. All electrical fittings must be properly connected and grounded.

USE THE PROPER POWER CORD

Use only a power cord that is in good condition and which meets the input power requirements specified in the manual.

Use only a detachable cord set with conductors that have a cross-sectional area equal to or greater than 0.75 mm^2. The power cable should be approved by a qualified agency such as VDE, Semko, or SEV.

USE THE PROPER POWER SOURCE

This product is intended to operate from a power source that does not apply more voltage between the supply conductors, or between either of the supply conductors and ground, than that specified in the manual.

USE THE PROPER FUSE

Use only a fuse of the correct type, voltage rating, and current rating, as specified for your product.

DO NOT OPERATE IN EXPLOSIVE ATMOSPHERES

To avoid explosion, do not operate this product in an explosive environment unless it has been specifically certified for such operation.

Sicherheitshinweise

In dieser Betriebsanleitung vorkommende Symbole

Definition der mit WARNUNG!, VORSICHT! und HINWEIS überschriebenen Abschnitte in dieser Betriebsanleitung.

Warnung!

Das Symbol WARNUNG! weist auf eine Gefahrenquelle hin. Es macht auf einen Arbeitsablauf, eine Arbeitsweise, einen Zustand oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. ungenügende Berücksichtigung zu Körperverletzung führen kann.

Vorsicht!

Das Symbol VORSICHT! weist auf eine Gefahrenquelle hin. Es macht auf einen Bedienungsablauf, eine Arbeitsweise oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. Ungenügende Berücksichtigung zu einer Beschädigung oder Zerstörung des Produkts oder von Teilen des Produkts führen kann.

Hinweis

Das Symbol HINWEIS weist auf eine wichtige Mitteilung hin, die auf einen Arbeitsablauf, eine Arbeitsweise, einen Zustand oder eine sonstige Gegebenheit von besonderer Wichtigkeit aufmerksam macht.

Am Gerät angebrachte Symbole

Der untenstehenden Tabelle sind die Bedeutungen der Symbole zu entnehmen, die an dem Gerät angebracht sind.

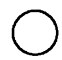
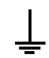
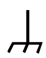
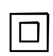
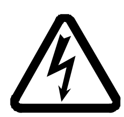
Definitionen der am Gerät angebrachten Symbole			
 Ein (Netz) IEC 417, Nr. 5007	 Aus (Netz) IEC 417, Nr. 5008	 Erde IEC 417, Nr. 5017	 Schutzleiter IEC 417, Nr. 5019
 Rahmen oder Chassis IEC 417, Nr. 5020	 Äquipotentialanschluß IEC 417, Nr. 5021	 Gleichstrom IEC 417, Nr. 5031	 Wechselstrom IEC 417, Nr. 5032
 Wechselstrom und Gleichstrom IEC 417, Nr. 5033-a	 Geräteklasse II IEC 417, Nr. 5172-a	 Drehstrom IEC 617-2 Nr. 020206	
 Vorsicht! Bitte Begleitdokumente lesen! ISO 3864, Nr. B.3.1	 Vorsicht! Stromschlaggefahr! ISO 3864, Nr. B.3.6	 Vorsicht! Heiße Fläche! IEC 417, Nr. 5041	

Tabelle 2: Definitionen der am Gerät angebrachten Symbole

Sicherheitsvorschriften und Vorsichtsmaßnahmen

Die untenstehenden allgemeinen Sicherheitsvorschriften sind bei allen Betriebs-phasen dieses Instruments zu befolgen. Jede Mißachtung dieser Sicherheits-vorschriften oder sonstiger spezifischer Warnhinweise in dieser Betriebsanleitung stellt eine Zuwiderhandlung der für dieses Instrument geltenden Sicherheits-standards dar und kann die an diesem Instrument vorgesehenen Schutzvor-richtungen unwirksam machen. MKS Instruments, Inc. haftet nicht für eine Mißachtung dieser Sicherheitsvorschriften seitens des Kunden.

Keine Teile austauschen und keine Veränderungen vornehmen!

Bauen Sie in das Instrument keine Ersatzteile ein, und nehmen Sie keine eigenmächtigen Änderungen am Gerät vor! Schicken Sie das Instrument zu Wartungs- und Reparatur-zwecken an einen MKS-Kalibrierungs- und -Kundendienst ein! Dadurch wird sicher-gestellt, daß alle Sicherheitseinrichtungen voll funktionsfähig bleiben.

Wartung nur durch qualifizierte Fachleute!

Das Gehäuse des Instruments darf vom Bedienpersonal nicht geöffnet werden. Das Auswechseln von Bauteilen und das Vornehmen von internen Einstellungen ist nur von qualifizierten Fachleuten durchzuführen.

Produkt erden!

Dieses Produkt ist mit einer Erdleitung und einem Schutzkontakt am Netzstecker versehen. Um der Gefahr eines elektrischen Schlages vorzubeugen, ist das Netzkabel an einer vorschriftsmäßig geerdeten Schutzkontaktsteckdose anzuschließen, bevor es an den Eingangs- bzw. Ausgangsklemmen des Produkts angeschlossen wird. Das Instrument kann nur sicher betrieben werden, wenn es über den Erdleiter des Netzkabels und einen Schutzkontakt geerdet wird.

Gefährdung durch Verlust der Schutzerdung!

Geht die Verbindung zum Schutzleiter verloren, besteht an sämtlichen zugänglichen Teilen aus stromleitendem Material die Gefahr eines elektrischen Schlages. Dies gilt auch für Knöpfe und andere Bedienelemente, die dem Anschein nach isoliert sind.

Erdung und Verwendung geeigneter elektrischer Armaturen!

In diesem Instrument liegen gefährliche Spannungen an. Alle verwendeten elektrischen Armaturen und Kabel müssen dem angegebenen Typ entsprechen und sich in einwand-freiem Zustand befinden. Alle elektrischen Armaturen sind vorschriftsmäßig anzubringen und zu erden.

Richtiges Netzkabel verwenden!

Das verwendete Netzkabel muß sich in einwandfreiem Zustand befinden und den in der Betriebsanleitung enthaltenen Anschlußwerten entsprechen.

Das Netzkabel muß abnehmbar sein. Der Querschnitt der einzelnen Leiter darf nicht weniger als 0,75 mm^2 betragen. Das Netzkabel sollte einen Prüfvermerk einer zuständigen Prüfstelle tragen, z.B. VDE, Semko oder SEV.

Richtige Stromquelle verwenden!

Dieses Produkt ist für eine Stromquelle vorgesehen, bei der die zwischen den Leitern bzw. zwischen jedem der Leiter und dem Masseleiter anliegende Spannung den in dieser Betriebsanleitung angegebenen Wert nicht überschreitet.

Richtige Sicherung benutzen!

Es ist eine Sicherung zu verwenden, deren Typ, Nennspannung und Nennstromstärke den Angaben für dieses Produkt entsprechen.

Gerät nicht in explosiver Atmosphäre benutzen!

Um der Gefahr einer Explosion vorzubeugen, darf dieses Gerät nicht in der Nähe explosiver Stoffe eingesetzt werden, sofern es nicht ausdrücklich für diesen Zweck zertifiziert worden ist.

Informations relatives à la sécurité

Symboles utilisés dans ce manuel d'utilisation

Définition des indications AVERTISSEMENT, ATTENTION et REMARQUE utilisées dans ce manuel.

Avertissement

L'indication AVERTISSEMENT signale un danger potentiel. Elle est destinée à attirer l'attention sur une procédure, une utilisation, une situation ou toute autre chose présentant un risque de blessure en cas d'exécution incorrecte ou de non-respect des consignes.

Attention

L'indication ATTENTION signale un danger potentiel. Elle est destinée à attirer l'attention sur une procédure, une utilisation, une situation ou toute autre chose présentant un risque d'endommagement ou de dégât d'une partie ou de la totalité de l'appareil en cas d'exécution incorrecte ou de non-respect des consignes.

Remarque

L'indication REMARQUE signale des informations importantes. Elle est destinée à attirer l'attention sur une procédure, une utilisation, une situation ou toute autre chose présentant un intérêt particulier.

Symboles apparaissant sur l'appareil

Le tableau suivant décrit les symboles apparaissant sur l'appareil.

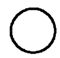
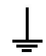
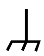
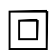
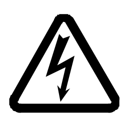
Définition des symboles apparaissant sur l'appareil			
 Marche (sous tension) IEC 417, No. 5007	 Arrêt (hors tension) IEC 417, No. 5008	 Terre (masse) IEC 417, No. 5017	 Terre de protection (masse) IEC 417, No. 5019
 Masse IEC 417, No. 5020	 Equipotentialité IEC 417, No. 5021	 Courant continu IEC 417, No. 5031	 Courant alternatif IEC 417, No. 5032
 Courant continu et alternatif IEC 417, No. 5033-a	 Matériel de classe II IEC 417, No. 5172-a	 Courant alternatif triphasé IEC 617-2 No. 020206	
 Attention : se reporter à la documentation ISO 3864, No. B.3.1	 Attention : risque de secousse électrique ISO 3864, No. B.3.6	 Attention : surface brûlante IEC 417, No. 5041	

Tableau 3 : Définition des symboles apparaissant sur l'appareil

Mesures de sécurité et mises en garde

Prendre toutes les précautions générales suivantes pendant toutes les phases d'utilisation de cet appareil. Le non-respect de ces précautions ou des avertissements contenus dans ce manuel entraîne une violation des normes de sécurité relatives à l'utilisation de l'appareil et le risque de réduire le niveau de protection fourni par l'appareil. MKS Instruments, Inc. ne prend aucune responsabilité pour les conséquences de tout non-respect des consignes de la part de ses clients.

NE PAS SUBSTITUER DES PIÈCES OU MODIFIER L'APPAREIL

Ne pas utiliser de pièces détachées autres que celles vendues par MKS Instruments, Inc. ou modifier l'appareil sans l'autorisation préalable de MKS Instruments, Inc. Renvoyer l'appareil à un centre d'étalonnage et de dépannage MKS pour tout dépannage ou réparation afin de s'assurer que tous les dispositifs de sécurité sont maintenus.

DÉPANNAGE EFFECTUÉ UNIQUEMENT PAR UN PERSONNEL QUALIFIÉ

L'opérateur de l'appareil ne doit pas enlever le capot de l'appareil. Le remplacement des composants et les réglages internes doivent être effectués uniquement par un personnel d'entretien qualifié.

MISE À LA TERRE DE L'APPAREIL

Cet appareil est mis à la terre à l'aide du fil de terre du cordon d'alimentation. Pour éviter tout risque de secousse électrique, brancher le cordon d'alimentation sur une prise de courant correctement câblée avant de le brancher sur les bornes d'entrée ou de sortie de l'appareil. Une mise à la terre de protection à l'aide du fil de terre du cordon d'alimentation est indispensable pour une utilisation sans danger de l'appareil.

DANGER LIÉ À UN DÉFAUT DE TERRE

En cas de défaut de terre, toutes les pièces conductrices accessibles (y compris les boutons de commande ou de réglage qui semblent être isolés) peuvent être source d'une secousse électrique.

MISE À LA TERRE ET UTILISATION CORRECTE D'ACCESSOIRES ÉLECTRIQUES

Des tensions dangereuses existent à l'intérieur de l'appareil. Tous les accessoires et les câbles électriques doivent être conformes au type spécifié et être en bon état. Tous les accessoires électriques doivent être correctement connectés et mis à la terre.

UTILISATION D'UN CORDON D'ALIMENTATION APPROPRIÉ

Utiliser uniquement un cordon d'alimentation en bon état et conforme aux exigences de puissance d'entrée spécifiées dans le manuel.

Utiliser uniquement un cordon d'alimentation amovible avec des conducteurs dont la section est égale ou supérieure à 0,75 mm^2. Le cordon d'alimentation doit être approuvé par un organisme compétent tel que VDE, Semko ou SEV.

UTILISATION D'UNE ALIMENTATION APPROPRIÉE

Cet appareil est conçu pour fonctionner en s'alimentant sur une source de courant électrique n'appliquant pas une tension entre les conducteurs d'alimentation, ou entre les conducteurs d'alimentation et le conducteur de terre, supérieure à celle spécifiée dans le manuel.

UTILISATION D'UN FUSIBLE APPROPRIÉ

Utiliser uniquement un fusible conforme au type, à la tension nominale et au courant nominal spécifiés pour l'appareil.

NE PAS UTILISER DANS UNE ATMOSPHÈRE EXPLOSIVE

Pour éviter tout risque d'explosion, ne pas utiliser l'appareil dans une atmosphère explosive à moins qu'il n'ait été approuvé pour une telle utilisation.

Información sobre seguridad

Símbolos usados en el manual de instrucciones

Definiciones de los mensajes de ADVERTENCIA, PRECAUCIÓN Y OBSERVACIÓN usados en el manual.

Advertencia

El símbolo de ADVERTENCIA indica un riesgo. Pone de relieve un procedimiento, práctica, condición, etc., que, de no realizarse u observarse correctamente, podría causar lesiones a los empleados.

Precaución

El símbolo de PRECAUCIÓN indica un riesgo. Pone de relieve un procedimiento, práctica, etc., de tipo operativo que, de no realizarse u observarse correctamente, podría causar desperfectos al instrumento, o llegar incluso a causar su destrucción total o parcial.

Observación

El símbolo de OBSERVACIÓN indica información de importancia. Pone de relieve un procedimiento, práctica, condición, etc., cuyo conocimiento resulta esencial.

Símbolos que aparecen en la unidad

En la tabla que figura a continuación se indican los símbolos que aparecen en la unidad.

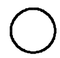
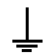
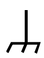
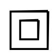
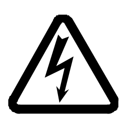
Definición de los símbolos que aparecen en la unidad			
 Encendido (alimentación eléctrica) IEC 417, N.° 5007	 Apagado (alimentación eléctrica) IEC 417, N.° 5008	 Puesta a tierra IEC 417, N.° 5017	 Protección a tierra IEC 417, N.° 5019
 Caja o chasis IEC 417, N.° 5020	 Equipotencialidad IEC 417, N.° 5021	 Corriente continua IEC 417, N.° 5031	 Corriente alterna IEC 417, N.° 5032
 Corriente continua y alterna IEC 417, N.° 5033-a	 Equipo de clase II IEC 417, N.° 5172-a	 Corriente alterna trifásica IEC 617-2 N.° 020206	
 Precaución. Consultar los documentos adjuntos ISO 3864, N.° B.3.1	 Precaución. Riesgo de descarga eléctrica ISO 3864, N.° B.3.6	 Precaución. Superficie caliente IEC 417, N.° 5041	

Tabla 4 : Definición de los símbolos que aparecen en la unidad

Procedimientos y precauciones de seguridad

Las precauciones generales de seguridad que figuran a continuación deben observarse durante todas las fases de funcionamiento del presente instrumento. La no observancia de dichas precauciones, o de las advertencias específicas a las que se hace referencia en el manual, contraviene las normas de seguridad referentes al uso previsto del instrumento y podría impedir la protección que proporciona el instrumento. MKS Instruments, Inc., no asume responsabilidad alguna en caso de que el cliente haga caso omiso de estos requerimientos.

NO UTILIZAR PIEZAS NO ORIGINALES NI MODIFICAR EL INSTRUMENTO

No se debe instalar piezas que no sean originales ni modificar el instrumento sin autorización. Para garantizar que las prestaciones de seguridad se observen en todo momento, enviar el instrumento al Centro de servicio y calibración de MKS cuando sea necesaria su reparación y servicio de mantenimiento.

REPARACIONES EFECTUADAS ÚNICAMENTE POR TÉCNICOS ESPECIALIZADOS

Los operarios no deben retirar las cubiertas del instrumento. El cambio de piezas y los reajustes internos deben efectuarlos únicamente técnicos especializados.

PUESTA A TIERRA DEL INSTRUMENTO

Este instrumento está puesto a tierra por medio del conductor de tierra del cable eléctrico. Para evitar descargas eléctricas, enchufar el cable eléctrico en una toma debidamente instalada, antes de conectarlo a las terminales de entrada o salida del instrumento. Para garantizar el uso sin riesgos del instrumento resulta esencial que se encuentre puesto a tierra por medio del conductor de tierra del cable eléctrico.

PELIGRO POR PÉRDIDA DE LA PUESTA A TIERRA

Si se pierde la conexión protectora de puesta a tierra, todas las piezas conductoras a las que se tiene acceso (incluidos los botones y mandos que pudieran parecer estar aislados) podrían producir descargar eléctricas.

PUESTA A TIERRA Y USO DE ACCESORIOS ELÉCTRICOS ADECUADOS

Este instrumento funciona con voltajes peligrosos. Todos los accesorios y cables eléctricos deben ser del tipo especificado y mantenerse en buenas condiciones. Todos los accesorios eléctricos deben estar conectados y puestos a tierra del modo adecuado.

USAR EL CABLE ELÉCTRICO ADECUADO

Usar únicamente un cable eléctrico que se encuentre en buenas condiciones y que cumpla los requisitos de alimentación de entrada indicados en el manual.

Usar únicamente un cable desmontable instalado con conductores que tengan un área de sección transversal equivalente o superior a 0,75mm². El cable eléctrico debe estar aprobado por una entidad autorizada como, por ejemplo, VDE, Semko o SEV.

USAR LA FUENTE DE ALIMENTACIÓN ELÉCTRICA ADECUADA

Este instrumento debe funcionar a partir de una fuente de alimentación eléctrica que no aplique más voltaje entre los conductores de suministro, o entre uno de los conductores de suministro y la puesta a tierra, que el que se especifica en el manual.

USAR EL FUSIBLE ADECUADO

Usar únicamente un fusible del tipo, clase de voltaje y de corriente adecuados, según lo que se especifica para el instrumento.

EVITAR SU USO EN ENTORNOS EXPLOSIVOS

Para evitar el riesgo de explosión, no usar este instrumento o en un entorno explosivo, a no ser que haya sido certificado para tal uso.

Chapter One: General Information

Introduction

The MKS Type 247D Four-Channel Mass Flow Controller Power Supply/Readout is designed as power supply/readout and set point source for four analog mass flow controllers (MFCs). The unit can also power and monitor the flow rate through analog mass flow meters (MFMs).

The 247 unit consists of a power supply, four signal conditioning channels, four set point circuits, and a digital panel meter (DPM) to display the flow rate of any single channel of a MFC or MFM. It may be used to monitor and provide set point levels for MFCs and to provide ratioed set points for multiple gas control.

The 247 unit is a versatile instrument that may be used separately or as part of a larger control system. The unit can be operated manually via the front panel controls, through an external controller, or through remote TTL logic control.

The 247 readout is primarily designed to interface with MKS analog mass flow controllers; however, with the proper interface cable, you can use most major MFCs. Refer to Table 5, page 20, for a list of MKS interface cables.

How This Manual is Organized

This manual is designed to provide instructions on how to set up and install a Type 247 unit.

Before installing your Type 247 unit in a system and/or operating it, carefully read and familiarize yourself with all precautionary notes in the *Safety Messages and Procedures* section at the front of this manual. In addition, observe and obey all WARNING and CAUTION notes provided throughout the manual.

Chapter One: General Information, (this chapter) introduces the product and describes the organization of the manual.

Chapter Two: Installation, explains the environmental requirements and describes how to mount the instrument in your system.

Chapter Three: Overview, gives a brief description of the instrument and its functionality.

Chapter Four: Operation, describes how to use the instrument and explains all the functions and features.

Chapter Five: Maintenance and Troubleshooting, describes basic maintenance procedures and troubleshooting procedures should the 247 unit malfunction.

Appendix A: Product Specifications, lists the specifications of the instrument.

Appendix B: Model Code Explanation, describes the instrument's ordering code.

Appendix C: Gas Correction Factors, lists the gas correction factors for some commonly used pure gases.

Customer Support

Standard maintenance and repair services are available at all of our regional MKS Calibration and Service Centers, listed on the back cover. In addition, MKS accepts the instruments of other manufacturers for recalibration using the Primary and Transfer Standard calibration equipment located at all of our regional service centers. Should any difficulties arise in the use of your Type 247 instrument, or to obtain information about companion products MKS offers, contact any authorized MKS Calibration and Service Center. If it is necessary to return the instrument to MKS, please obtain an ERA Number (Equipment Return Authorization Number) from the MKS Calibration and Service Center before shipping. The ERA Number expedites handling and ensures proper servicing of your instrument.

Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Warning

All returns to MKS Instruments must be free of harmful, corrosive, radioactive, or toxic materials.

Chapter Two: Installation

How To Unpack the Type 247 Unit

MKS has carefully packed the Type 247 unit so that it will reach you in perfect operating order. Upon receiving the unit, however, you should check for defects, cracks, broken connectors, etc., to be certain that damage has not occurred during shipment.

Note Do *not* discard any packing materials until you have completed your inspection and are sure the unit arrived safely.

If you find any damage, notify your carrier and MKS immediately. If it is necessary to return the unit to MKS, obtain an ERA Number (Equipment Return Authorization Number) from the MKS Service Center before shipping. Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Caution **Only qualified individuals should perform the installation and any user adjustments. They must comply with all the necessary ESD and handling precautions while installing and adjusting the instrument. Proper handling is essential when working with all highly sensitive precision electronic instruments.**

Unpacking Checklist

Standard Equipment

- Type 247 Unit
- Type 247 Instruction Manual (this book)
- Power cord

Optional Equipment

- Electrical Connector Accessories Kit:

  247D-K1 (includes an I/O connector for the rear panel of the unit, a cover for the I/O connector, and a screw lock assembly for the I/O connector cover)

- Power Supply:

  260 PS-1 (± 15 V, 1.5 Amps)
  260 PS-3 (± 15 V, 3.2 Amps)

- Rack Mount Kit:

  RM-6 (for mounting one or two units in a 19” rack)

Interface Cables

As of January 1, 1996, most products shipped to the European Community must comply with the EMC Directive 89/336/EEC, which covers radio frequency emissions and immunity tests. In addition, as of January 1, 1997, some products shipped to the European Community must also comply with the Product Safety Directive 92/59/EEC and Low-Voltage Directive 73/23/EEC, which cover general safety practices for design and workmanship. MKS products that meet these requirements are identified by application of the CE mark.

To ensure compliance with EMC Directive 89/336/EEC, an overall metal braided shielded cable, properly grounded at both ends, is required during use. No additional installation requirements are necessary to ensure compliance with Directives 92/59/EEC and 73/23/EEC.

Note

1. Overall metal braided shielded cables, properly grounded at both ends, are required to meet CE specifications.
2. To order metal braided shielded cables, add an “S” after the cable type designation. For example, to order a standard cable to connect the 247 unit to a Type 1679A MFC, use part number CB259-5-10; for a metal braided shielded cable, use part number CB259S-5-10.

System Interface Cables

The system interface cables include cables to connect the 247 unit to a mass flow device, an external controller, a power supply, or another 247 unit.

System Interface Cables		
To Connect the 247 Unit To...	**Use the MKS Cable...**	
	Standard	**Shielded**
Mass Flow Controllers/Meters 258, 358, 558, 1150*, 1151*, 1152*, 1159, 1162, 1259, 1261, 1359, 1449, 1559**, 1562, 1678, 1679A, 2159, 2162, 2259 1179A, 2179A, 1479A, and 1679B with 15-pin Type “D” connectors	CB259-5-10	CB259S-5-10
Mass Flow Controllers/Meters 1462, 1661 1179A, 2179A, 1479A, and 1679B with 9-pin Type “D” connectors	CB147-12-10	CB147S-12-10
1160, 1163, 1461, 2160, 2163 MFC	CB259-10-10	CB259S-10-10

Table 5: System Interface Cables
(Continued on next page)

System Interface Cables *(Continued)*		
To Connect the 247 Unit To...	**Use the MKS Cable...**	
	Standard	**Shielded**
250 Controller (PCS)	CB247-2-3	CB247S-2-3
1250 Controller (PCS)	CB247-9-3	CB247S-9-3
247 Readout	CB247-4-x***	CB247S-4-x***

* *To connect the 1150, 1151, or 1152 unit to a 260 PS-1, you must also use cable CB260(S)-3-10.*

** *An extra power supply is needed if using more than two 1559 MFCs with one 247 unit. Use cable CB1559(S)-1-10 to connect the 247 unit to a 260 PS-1 Power Supply.*

*** *x = length in feet.*

Table 5: System Interface Cables

Generic Shielded Cables

MKS offers a full line of cables for all MKS equipment. Should you choose to manufacture your own cables, follow the guidelines listed below:

1. The cable must have an overall metal *braided* shield, covering all wires. Neither aluminum foil nor spiral shielding will be as effective; using either may nullify regulatory compliance.
2. The connectors must have a metal case which has direct contact to the cable's shield on the whole circumference of the cable. The inductance of a flying lead or wire from the shield to the connector will seriously degrade the shield's effectiveness. The shield should be grounded to the connector before its internal wires exit.
3. With very few exceptions, the connector(s) must make good contact to the device's case (ground). "Good contact" is about 0.01 ohms; and the ground should surround all wires. Contact to ground at just one point may not suffice.
4. For shielded cables with flying leads at one or both ends; it is important at each such end, to ground the shield *before* the wires exit. Make this ground with absolute minimum length. (A ¼ inch piece of #22 wire may be undesirably long since it has approximately 5 nH of inductance, equivalent to 31 ohms at 1000 MHz). After picking up the braid's ground, keep wires and braid flat against the case. With very few exceptions, grounded metal covers are not required over terminal strips. If one is required, it will be stated in the Declaration of Conformity or in the instruction manual.
5. In selecting the appropriate type and wire size for cables, consider:
   A. The voltage ratings;
   B. The cumulative I^2R heating of all the conductors (keep them safely cool);
   C. The IR drop of the conductors, so that adequate power or signal voltage gets to the device;
   D. The capacitance and inductance of cables which are handling fast signals, (such as data lines or stepper motor drive cables); and
   E. That some cables may need internal shielding from specific wires to others; please see the instruction manual for details regarding this matter.

Product Location and Requirements

The Type 247 unit meets the following criteria:

- POLLUTION DEGREE 2 in accordance with IEC 664
- Transient overvoltages according to INSTALLATION CATEGORY II

Operating Environmental Requirements

- Ambient Operating Temperature: 15° to 40° C (59° to 104° F)
- Main supply voltage fluctuations must not exceed ±10% of the nominal voltage
- Ventilation requirements include sufficient air circulation
- Connect the power cord into a properly grounded outlet

Safety Conditions

The 247 unit poses no safety risk under the following environmental conditions.

- Altitude: up to 2000 m
- Maximum relative humidity: 80% for temperatures up to 31° C, decreasing linearly to 50% at 40° C

Setup

Dimensions

Note All dimensions are listed in inches with millimeters referenced in parentheses.

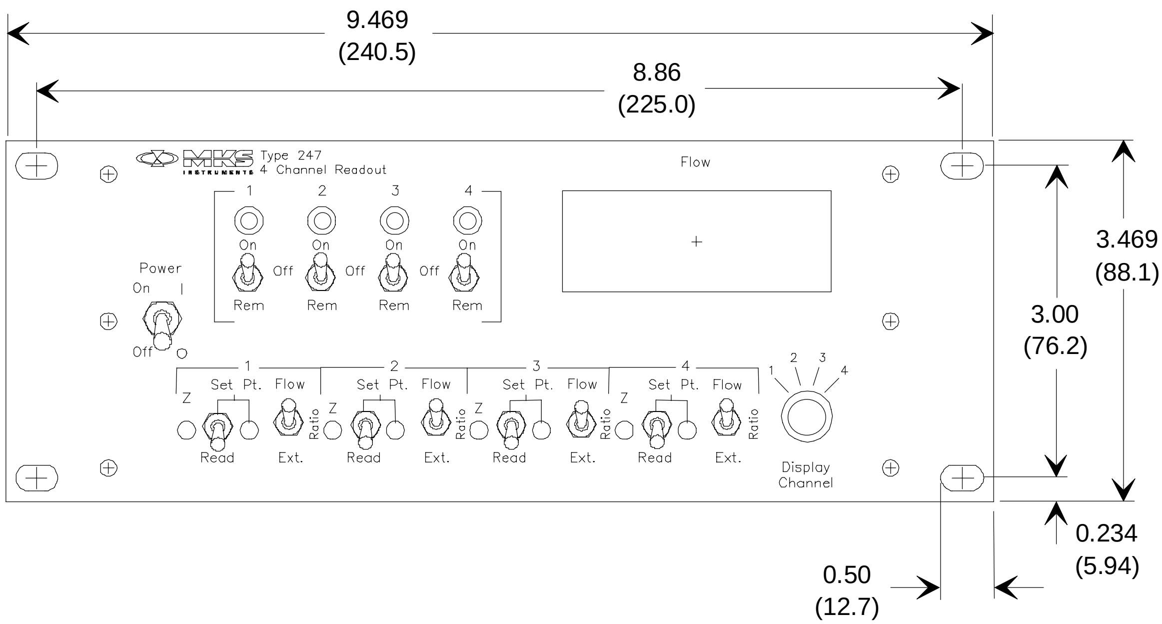


Figure 1: Front Panel Dimensions

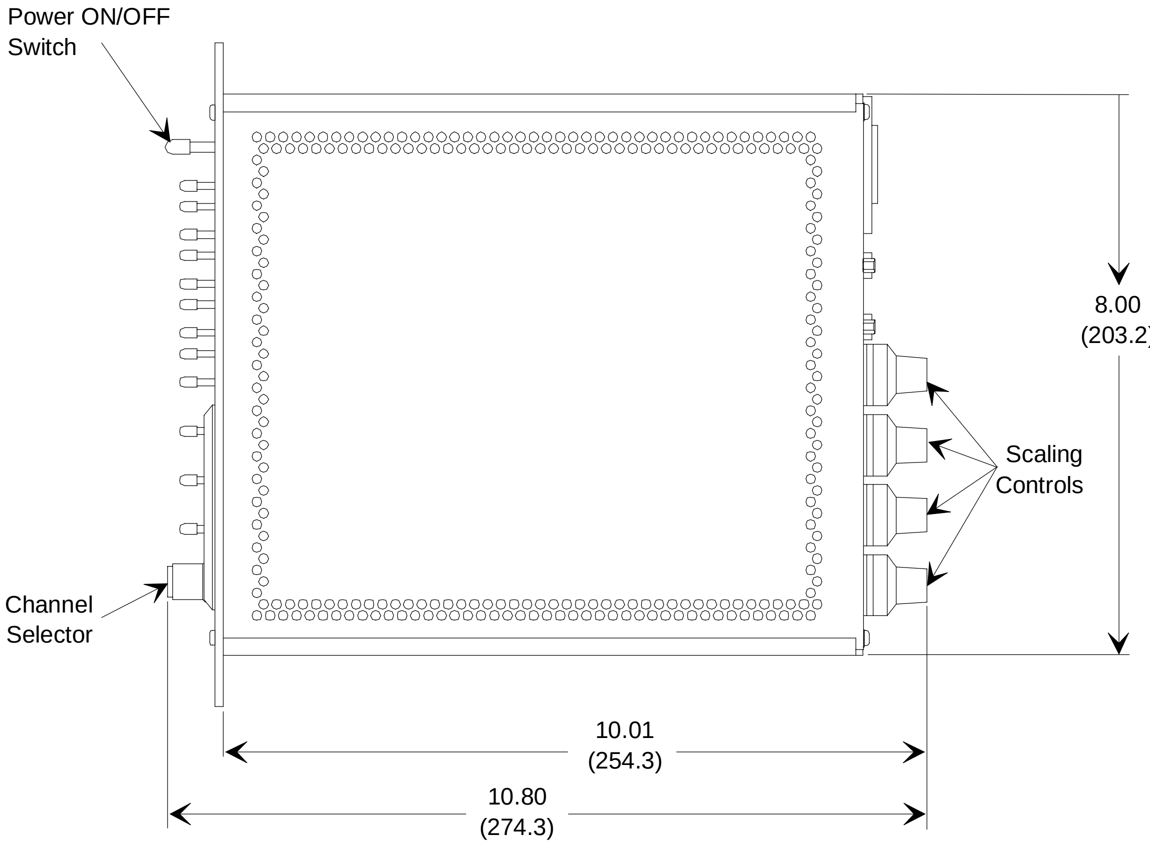


Figure 2: Top View Dimensions

Power Requirements

The power requirements for the 247 unit are:

- 115 VAC Setting 100 to 120 VAC nominal, 50/60 Hz
- 230 VAC Setting 200 to 240 VAC nominal, 50/60 Hz

The power consumption for the 247 unit is:

- 19 VA @ 115 VAC 60 Hz with *no* MFCs attached
- Additional 15 VA for start-up
- Additional 10 VA operational for *each* MFC attached

Mounting Instructions

247 Unit

The 247 unit can be used as a bench top instrument, or can be mounted through a panel or in a standard 19” rack. However the unit is mounted, leave adequate space around it for proper ventilation. Refer to *Dimensions*, page 24, for dimensional drawings of the 247 unit.

Note

1. When used with three or more MFCs, the 247 unit may become quite warm to the touch, especially when used with higher than nominal (115 VAC) line voltage.
2. An extra power supply is needed if using more than two 1559 MFCs with one 247 unit.

MFCs

Caution

Install the MFCs in the gas stream so that the flow direction corresponds to the flow marking on the base of the equipment.

Allow enough space for connector clearance, access to zero adjustments, and access to the seat adjustment in the control valve. This adjustment is below the external control valve on the 1259/2259 MFCs and on the top of the case on the 1159/1160 MFCs.

Refer to the appropriate instruction manual as needed for complete installation instructions.

System Configurations

The 247 unit can be configured for manual, external set point, or remote operation. The various system configurations and the required cabling are shown in Figure 3, page 27, and Figure 4, page 28. The system interface cables are listed in Table 5, page 20.

Refer to *Chapter Four: Operation*, page 55, for information on the setup and operation of these systems.

Manual Flow Control

Figure 3 illustrates a simple manual control system which requires only the use of the MFC interface cables.

With this configuration, the flow rate for each gas can be individually controlled with a front panel SET POINT CONTROL, or Channels 2 to 4 can be ratioed to the flow in Channel 1. Another four channels may be additionally ratioed to Channel 1 by adding a second 247 unit to the system.

Note

An extra power supply is needed if using more than two 1559 MFCs with one 247 unit.

Figure 3: Manual Flow Control

External Flow Control

Flow control can be accomplished using a set point signal from an external controller only, or ratioed using an external controller and a pressure transducer.

Figure 4 illustrates pressure control with an external controller; the gas flow into a chamber is controlled to maintain a constant pressure. This system configuration requires the 247 unit, a controller, and a pressure transducer. More than four gases may be controlled by adding a second 247 unit to the system.

Note

Any controller and pressure transducer may be used provided the signal that enters the 247 unit goes *positive* with increasing flow (correct polarity). Throughout this manual, the MKS Type 250 Pressure/Flow Controller and Type 127/227 Baratron® Pressure Transducers are used for example only.

Figure 4: Pressure Control with an External Controller

Remote Flow Control

Remote flow control can be accomplished using TTL logic control. Interface connector P6 provides the means to remotely turn the flow on/off and to adjust and monitor the flow rate in any channel using a set point signal from a voltage applied to P6. Refer to Table 7, page 32, for the pinout for Interface connector P6.

Electrical Information

Fuses

The line fuses protect the internal circuitry; both sides of the line are fused. The fuse values are listed in Table 6.

Fuse Information		
Voltage Setting	**Fuse Type**	**MKS Part Number**
115 VAC	0.8 A (T) / 250 V	024-5693
230 VAC	0.4 A (T) / 250 V	024-5811

Table 6: Fuse Information

Caution

Disconnect the power cord from the 247 unit *before* you replace the fuse, to avoid any damage.

Grounding

For protective earthing, plug the power cord into a properly grounded outlet.

How To Set the Line Voltage

The Line Voltage Selector configures the 247 unit to accept either 115 or 230 VAC input voltage. The value of the selected line voltage is visible through the window in the cover when it is closed.

Caution

The Line Voltage Selector on the 247 unit must be set to the proper input voltage *before* you connect the power cord and turn on the power. Otherwise, the unit will be severely damaged.

To change the line voltage:

1. Ensure that the power cord and all interface cables are disconnected from the 247 instrument.
2. Use a blunt instrument, such as a flat head screw driver, under the left hand side of the cover to the line voltage selector, and firmly pull towards you to unsnap the cover.

   The cover is attached firmly, so it requires a strong force from the screwdriver to loosen it. The cover will flip open, from left to right, to expose the line voltage selector drum.
3. Grasp the line voltage selector drum carefully and pull it out of its position.
4. Turn the selector drum to the appropriate line voltage.
5. Replace the line voltage selector drum into the 247 unit so that the voltage value can be read from bottom to top.

   The top and bottom of the voltage selector drum are shaped differently so that the drum will only fit into position in the correct orientation. The value of the selected line voltage is visible through the window in the cover when it is closed.

Connectors and Cables

The 247 unit's two Interface connectors and four MFC connectors are located on the rear panel of the unit (refer to Figure 6, page 43).

When the 247 is purchased as part of a complete system including MFCs, all of the required interface cables are supplied. When purchased separately, the interface cables must be specifically ordered. The system interface cables are listed in Table 5, page 20.

Interface Connector P6 (Channels 1 to 4)

The 25-pin male Type "D" connector, located on the rear panel (refer to Figure 6, page 43) provides the communications link to and from the unit, including the connection to the scaled transducer outputs, the lines to turn the flow on and off, and the set point input lines which remotely set the flow rate of the MFCs.

Interface Connector P6 (Channels 1 to 4) Pinout			
Pin	**Assignment**	**Pin**	**Assignment**
1	Signal Ground	14	Ch. 2 Transducer Output
2	Ch. 1 Transducer Output	15	Ch. 2 Scaled Output
3	Ch. 1 Scaled Output	16	Ch. 3 Transducer Output
4	Ch. 1 Set Point Input	17	Ch. 3 Scaled Output
5	Ch. 2 Set Point Input	18	Ch. 4 Transducer Output
6	Ch. 3 Set Point Input	19	Ch. 4 Scaled Output
7	Ch. 4 Set Point Input	20	No Connection
8	Digital Ground	21	No Connection
9	Power Ground	22	No Connection
10	Ch. 2 Flow ON/OFF Input	23	No Connection
11	Ch. 3 Flow ON/OFF Input	24	No Connection
12	Ch. 1 Flow ON/OFF Input	25	Chassis Ground
13	Ch. 4 Flow ON/OFF Input		

Table 7: Interface Connector P6 (Channels 1 to 4) Pinout

Note The "No Connection" pin assignment refers to a pin with no internal connection.

Interface Connector P5 (Channel 1)

The 9-pin Type “D” connector, located on the rear panel (refer to Figure 6, page 43), is used to join two 247 units, or to connect a 247 unit to an external controller which provides the external ratio signal interface.

Interface Connector P5 (Channel 1) Pinout	
Pin	**Assignment**
1	Signal Ground
2	Ch. 1 Scaled Output
3	Digital Ground
4	Power Ground
5	No Connection
6	Ch. 1 Transducer Output
7	External Ratio Set Point Input
8	Ratio Output Voltage
9	Chassis Ground

Table 8: Interface Connector P5 (Channel 1) Pinout

Note The “No Connection” pin assignment refers to a pin with no internal connection.

MFC Connectors (J1 - J4)

The four 15-pin Type "D" connectors (J1 through J4), located on the rear panel (refer to Figure 6, page 43), provide the connection for the mass flow controllers. Each connector provides the necessary power and set point voltages, and receives the flow output signal.

MFC Interface Connectors (J1 - J4) Pinout	
Pin	**Assignment**
1	No Connection
2	Flow Input Signal
3	No Connection
4	No Connection
5	Power Ground
6	-15 Volts
7	+15 Volts
8	Set Point Output Signal
9	No Connection
10	Input Stage Output
11	No Connection
12	Signal Ground
13	No Connection
14	No Connection
15	Chassis Ground

Table 9: MFC Interface Connectors (J1 - J4) Pinout

Note

1. The "No Connection" pin assignment refers to a pin with no internal connection.
2. An extra power supply is needed if using more than two 1559 MFCs with one 247 unit.

Chapter Three: Overview

General Information

The 247 power supply/readout can be connected to as many as four MFCs through connectors J1 to J4 on the rear panel (refer to Figure 6, page 43). Communication to and from the unit occurs through connector P6. Connector P5 is used to join two 247 units or to connect a 247 unit to an external controller.

The main power supply provides ±15 Volts to power the MFCs. The voltage corresponding to the flow rate, +5 VDC at full rated flow, is received at the input amplifier where the fine zero correction is made. The output from this amplifier is referred to as the *transducer output*.

This signal is amplified times two and applied to a scaling control, the output of which is buffered to become the scaled output. This signal is applied to the Digital Panel Meter on the front panel (refer to Figure 5, page 40) and to the *scaled output* on the rear panel connectors P5 and P6.

The MFCs set point signal is applied through a switch circuit which is controlled from a front panel switch or a TTL logic level on connector P6. When the circuit is turned ON, the set point signal is applied to the MFC and flow begins. When the switch circuit is turned OFF, flow will stop.

The flow rate is determined by the magnitude of the set point signal with +5 V corresponding to full flow. The source of this signal is selected by the Set Point Source Switch on the front panel (refer to *Set Point Signal Source*, page 36, for additional information).

Flow Signal Path

The flow signal from the MFC (0 to 5 V) enters the 247 unit at pin 2 in Connectors J1 to J4. The signal is buffered and the system injects a zero correction signal, if necessary, using the front panel ZERO CONTROL. This signal goes to an output pin of the Interface connector P6 and to the spring loaded READ/SET POINT switch. The *READ* position is the default; the up or *SET POINT* position is a momentary condition which allows the flow signal to be amplified times two and scaled by the scaling control. Refer to *Front Panel Controls*, page 40, for more information.

The zeroed and scaled signal is sent to P6 and the Channel Selector Switch, which routes the signal to the Digital Panel Meter where it is read directly in flow engineering units (sccm or slm).

Set Point Signal

The set point signal that is sent to each MFC through connectors J1 to J4 may be generated in a variety of ways:

- *Manually* using independent gas flows or by ratioing the gas flows for one to three channels to the flow in Channel 1
- *Externally* using a set point signal from an external controller, or by ratioing gas flows based on the set point signal from an external controller and measurements from a pressure transducer
- *Remotely* using TTL logic control

Set Point Signal Source

The flow rate is determined by the magnitude of the set point signal with +5 V corresponding to full scale flow. The set point signal can be generated by:

- An internal +5 V reference
- A ratio signal from Channel 1 or an external controller
- An externally applied voltage

The source of the set point signal is selected by the three position SET POINT SOURCE SWITCH on the front panel (refer to Figure 5, page 40), as either FLOW, RATIO, or EXT. The FLOW and RATIO positions of this switch are driven by the output of the SET POINT CONTROL; the EXT position is driven by an externally applied voltage.

The output of the SET POINT CONTROL is driven by an internal dipswitch (S15), located on the rear of the Main PC board. The 247 unit is initially configured so that the ratio set point signal is based on the Transducer Output of Channel 1 (the internal reference). To change the configuration so that the source of the set point signal is based on the External Ratio Amplifier, you must change the dipswitch settings in S15. Refer to *How To Change the Dipswitch Settings*, page 64, for more information.

Set Point Function with Manual Flow Control

Individual Gas Flows

The SET POINT SOURCE SWITCH must be set to the FLOW position, when manually controlling individual gas flows.

In this mode of operation, a precise 5.000 VDC signal is generated from the power supply, and flows through the SET POINT SOURCE SWITCH to the SET POINT CONTROL attenuator. The signal then flows to the buffer amplifier, and can be read on the Digital Panel Meter by pressing the READ/SET POINT SWITCH. If necessary, the set point signal can be adjusted using the SET POINT CONTROL.

The set point signal is finally sent to the MFC by placing the front panel FLOW CONTROL SWITCH to the ON position. This switch activates the output switch which allows the set point signal to flow through it, through the unity gain buffer amplifier, and on to the MFC.

When the FLOW CONTROL SWITCH is in the OFF position, the switch places a small negative voltage on the set point output line so that the control valve will be closed positively. When the FLOW CONTROL SWITCH is in the REMOTE position, a logic signal coming in through Interface connector P6 may be used to gate the set point signal to the MFC. A logic low turns the flow ON; a logic high turns the flow OFF.

Ratioed Gas Flows

The SET POINT SOURCE SWITCH must be set to the FLOW position for Channel 1, and the RATIO position for Channels 2 to 4, when manually controlling ratioed gas flows.

In this mode of operation, one to three channels of flow are ratioed from Channel 1. A fraction of the actual flow of Channel 1 is used as the source for the set points of Channels 2 to 4.

The flow of Channel 1 is established using the set point routing described in *Individual Gas Flows,* page 37. To derive the set point signals for Channels 2 to 4, the SET POINT SOURCE SWITCHES for Channels 2 to 4 are placed in the RATIO position.

The zeroed flow signal of Channel 1 passes through a dipswitch inside of the unit and into the SET POINT CONTROL SWITCHES. This signal is attenuated by the SET POINT CONTROL pot and is sent on to the MFC by placing the front panel FLOW CONTROL SWITCH to the ON position (in the same way as described in *Individual Gas Flows,* page 37).

Since the flow in Channels 2 to 4 is ratioed to Channel 1, the percent of full scale flow in these channels may not exceed the percent of full scale flow in Channel 1. For example, with 75% of flow in Channel 1, Channels 2 to 4 may not exceed 75% of their rated flow.

The ratio is based on voltage, therefore, when full scales are mixed, built-in ratio factors exist. For example, if you are using two channels where the full scale is 10 sccm for Channel 1 and 1000 sccm for Channel 2, with Channel 1 set for 100% (10 sccm) and Channel 2 set for 50% (500 sccm), the flow ratio will be 10:500.

Set Point Function with External Flow Control

The SET POINT SOURCE SWITCH must be set to the RATIO position, when using an external set point source.

Individual Gas Flows

This mode of operation enables you to control individual gas flows using a set point signal from an external command. A 0 to 5 VDC signal from an external source is received at Interface Connector P6, where it is routed by the SET POINT SOURCE SWITCH to each MFC. Its application to the MFC is the same as that described in *Individual Gas Flows*, page 37.

Note that each channel has its own external set point line. Any or all channels may have their set points or flow driven from the external source. Those that are not may be adjusted using the controls on the 247 unit, as described in *How To Manually Control Individual Gas Flows,* page 59.

Pressure Control with Ratioed Gas Flows

In this type of operation, the pressure in a chamber is maintained by controlling the ratio of gas flows, based on a set point signal from an external controller and measurements from a pressure transducer. This system configuration requires the 247 unit, an external controller, and a pressure transducer, as shown in Figure 4, page 28. More than four gases may be controlled by adding a second 247 unit to the system.

Note that any or all channels may be used to flow gas to maintain pressure with a preset ratio of flows. Any channel that is not used in this way may be used independently.

Note

Any controller and pressure transducer may be used provided the signal that enters the 247 unit goes *positive* with increasing flow (correct polarity). Throughout this manual, the MKS Type 250 Pressure/Flow Controller and Type 127/227 Baratron Pressure Transducers are used for example only.

In this mode of operation, the 247 unit receives a signal from the controller called a pressure control signal (PCS). This signal goes to an appropriate level from 0 to 10 VDC to drive the pressure signal to equal its set point signal (within the 250 controller). The PCS voltage enters the 247 unit at Interface Connector P5, is buffered and amplified, and routed to the RATIO position of the SET POINT SOURCE SWITCH. From this point the paths are the same as those described in *Ratioed Gas Flows*, page 37.

Set Point Function with Remote Flow Control

The SET POINT SOURCE SWITCH must be set to the EXT position, when using remote flow control.

Interface connector P6 provides the means to remotely turn the flow on/off and to adjust and monitor the flow rate in any channel using a set point signal from a voltage applied to P6.

Refer to *How To Control Gas Flow with TTL Logic*, page 69, for more information.

Front Panel Controls

Figure 5 shows the location of the controls on the front panel of the 247 controller.

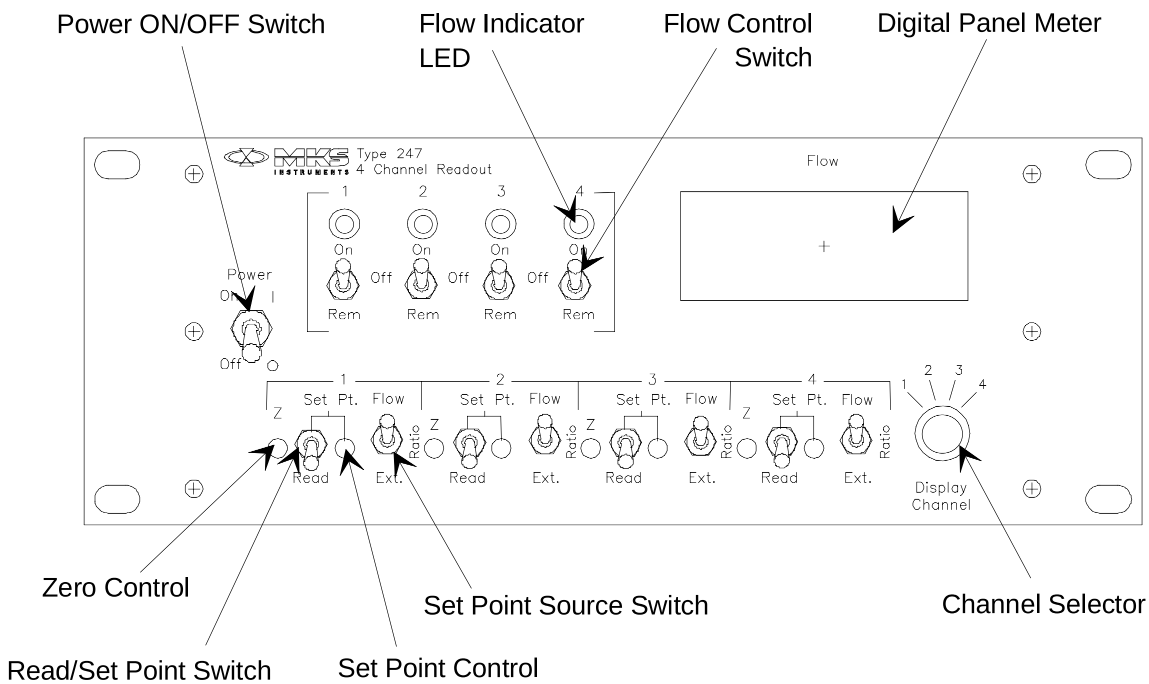


Figure 5: Front Panel Controls

Power ON/OFF Switch

The Power switch controls power to the 247 unit and all attached MFCs.

Flow Indicator LED

This green LED indicates that the set point signal has been applied to the MFC. It does not mean that flow is occurring or that its value is correct.

Flow Control Switch

This switch controls the circuit which applies the set point signal to the MFC as follows:

ON: The switch activates the output switch which allows the set point signal to flow through it, through the unity gain buffer amplifier, and on to the MFC.

OFF: The switch places a small negative voltage on the set output line so that the control valve will be closed positively.

REMOTE: A logic signal coming in through Interface connector P6 may be used to gate the set point signal to the MFC. Flow may be turned ON/OFF by an external TTL signal; a logic low turns the flow ON, a logic high or open turns the flow OFF.

Digital Panel Meter

The Digital Panel Meter (DPM) is a 3½ digit, 2 V full scale device. The DPM—set to read 1 VDC as 1000 counts full scale—displays the flow rate of the channel selected by the Channel Selector. The DPM also displays the set point signal for an MFC when its READ/SET POINT switch is held in the SET POINT position.

The Scaling Controls on the rear panel (refer to Figure 6, page 43) must be properly set for the meter to display a *direct* flow or set point reading, in sccm or slm. Refer to *Scaling Controls*, page 46, for more information.

Channel Selector

The Channel Selector switch controls input to the Digital Panel Meter.

Set Point Source Switch

This 3-position switch selects the source of the set point signal to be sent to the MFC. The FLOW and RATIO positions are driven by the output of the SET POINT CONTROL; the EXT position is driven by an externally applied voltage level. Refer to *Set Point Signal*, page 36, for more information.

FLOW Position: Selects the set point signal from the front panel Set Point Control, which is driven from the + 5 V internal reference. *The switch must be in this position when using Manual Flow Control.*

RATIO Position: Selects the set point signal from the front panel Set Point Control, which is driven from the Channel 1 Transducer Output or the External Ratio Amplifier, driven by an external controller (external set point input at Interface connector P5). *The switch must be in this position when using External Ratio Flow Control.*

EXT Position: Selects the set point signal from a pin on Interface connector P6, allowing the flow rate to be controlled directly from an external 0 to +5 V signal. *The switch must be in this position when using TTL logic control.*

Set Point Control

This 20-turn potentiometer sets the set point level when the Set Point Source Switch is in the FLOW or RATIO position. The ranges are:

FLOW Position: ± 0.1 to 100% of Full Rated Flow

RATIO Position: ± 0.1 to 100% of Channel 1 Flow/Ext. Ratio Signal

Read / Set Point Switch

This spring loaded switch allows you to read, from the Digital Panel Meter, either the flow rate or the set point value (which may be going to the MFC through the front panel flow switch). This allows you to check or set the MFCs zero, check or set the set point level, and check for an agreement between flow and set point when the MFC is so commanded.

The Scaling Controls on the rear panel (refer to Figure 6, page 43) must be properly set for the meter to display a *direct* set point reading, in sccm or slm. Refer to *Scaling Controls*, page 46, for more information.

Zero Control

This 20-turn potentiometer is used for fine zero adjustment. It has a limited range of ±3% of FS; therefore, larger adjustments must be made with the zero control on the MFC.

Rear Panel Controls

Figure 6 shows the location of the controls on the rear panel of the 247 controller.

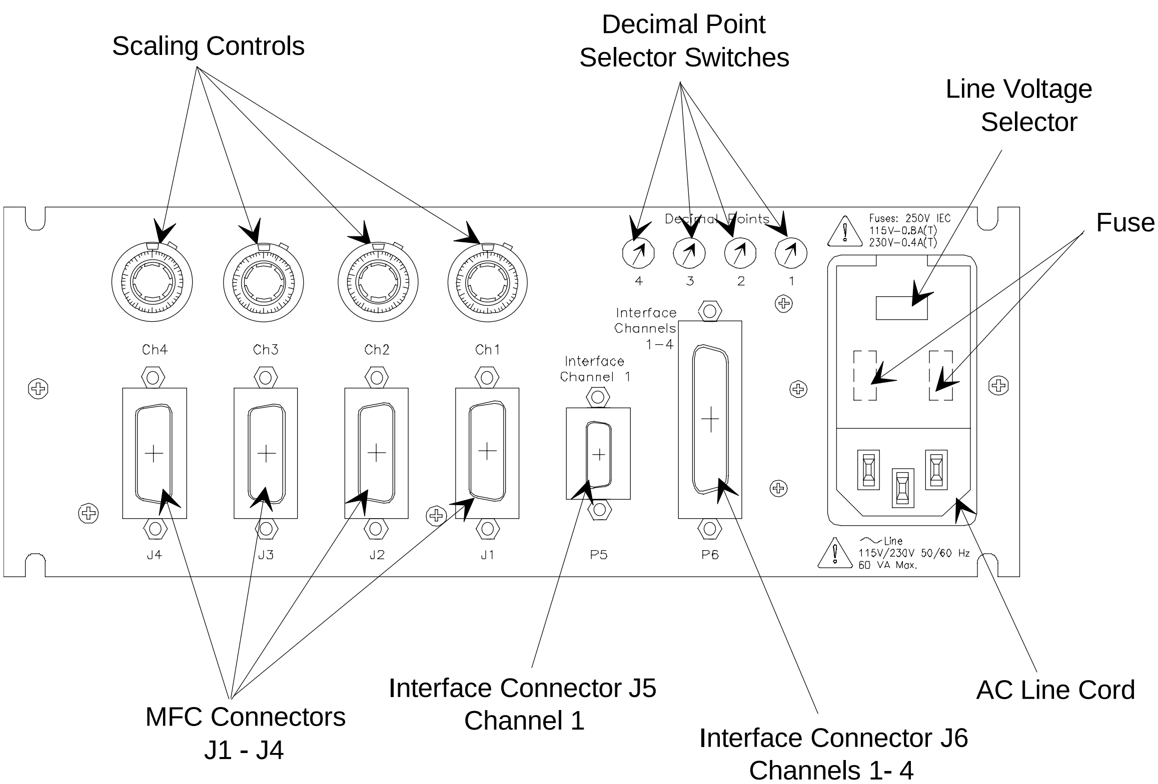


Figure 6: Rear Panel Controls

Scaling Control Potentiometers

These four 10-turn potentiometers are used to enter the scaling factor, which scales down the +5 VDC transducer output signal so that the Digital Panel Meter displays the flow rate and set point directly in sccm or slm.

Note It is ***critical*** for proper system operation that the scaling factors are calculated properly and that the potentiometers are set correctly. Refer to *Scaling Controls*, page 46, for more information.

Decimal Point Selector Switches

These switches, one for each channel, set the decimal point for the Digital Panel Meter on the front panel.

The position of the decimal point is determined by the full scale range of the MFC in use. A 100 sccm mass flow controller requires the decimal point to be positioned as “100.0” (display at full rated flow).

Line Voltage Selector

The Line Voltage Selector configures the 247 unit to accept either 115 or 230 VAC input voltage. The voltage selected is visible in the panel cutout. Refer to *How To Set the Line Voltage*, page 31, for more information.

Caution

The Line Voltage Selector on the 247 unit must be set to the proper input voltage *before* you connect the power cord and turn on the power. Otherwise, the unit will be severely damaged.

Fuse

The fuse protects the internal circuitry of the 247 unit; both sides of the line are fused. The fuse values are listed in Table 6, page 30.

Caution

Disconnect the power cord from the 247 unit *before* you replace the fuse, to avoid any damage.

AC Line Cord

The AC Line Cord provides 115 or 230 VAC power to the 247 unit. For protective earthing, plug the power cord into a properly grounded outlet.

Interface Connector J6 - Channels 1 to 4

This 25-pin male Type “D” connector provides the communications link to and from the unit, including the connection to the scaled transducer outputs, the lines to turn the flow on and off, and the (external) set point input lines which remotely set the flow rate of the MFCs.

Refer to Table 7, page 32, for the Interface Connector J6 pinout.

Interface Connector J5 - Channel 1

This 9-pin Type “D” connector is used to connect two 247 units or to connect a 247 unit to an external pressure controller.

Individual flow rates are set, using the front panel Set Point Controls, as a fraction of Channel 1 of the first 247 unit; this ratio is maintained while the total flow is adjusted to maintain the desired pressure. When two 247 units are attached, four additional MFCs can be ratioed to Channel 1 of the first 247 unit.

When a 247 unit is connected to an external pressure controller, the controller provides the pressure control signal (PCS) that can be applied to all set point controls on the 247 unit.

Refer to Table 8, page 33, for the Interface Connector J5 pinout.

Note The MFC that is set to control at the highest percentage of its rated flow should be connected to Channel 1.

MFC Connectors

These 15-pin Type “D” connectors (J1 through J4) provide the connection for the mass flow controllers. Each connector provides the necessary power and set point voltages, and receives the flow output signal.

Refer to Table 9, page 34, for the MFC Connector pinout.

Scaling Controls

There are four *Scaling Control Potentiometers* on the rear panel of the 247 unit; one for each channel (refer to Figure 6, page 43). These 10-turn potentiometers are used to adjust the full scale voltage signals from the MFCs, which correspond to the flow rate, to a level that enables the digital panel meter (DPM) to display the flow rate and set point directly, in sccm or slm.

The 247 unit uses a digital panel meter that reads 1 VDC as 1000 counts full scale (FS). Although the DPM can accommodate a *maximum* of 2 VDC and can read up to 1999 counts, it cannot be adjusted to the 5000 counts needed to accommodate the +5 VDC full scale output signals from the MFCs. Therefore, the +5 VDC output voltage from each MFC must be scaled down so that the full scale counts (1000) read on the meter represent the full scale voltage from the MFCs. When the adjustment is properly made, flow can be read directly from the meter.

The amount by which the +5 VDC output signal is scaled down, the *Scaling Control Factor,* is application dependent and must be calculated for each MFC in use. The Scaling Control Factor for the MFCs is set with the *Scaling Control Potentiometers*.

Note

It is ***critical*** for proper system operation that the Scaling Control Factors are calculated properly and that the Scaling Control Potentiometers are set correctly.

Scaling Control Factor

The Scaling Control Factor is the *product* of the Gauge Factor for the MFC in use and the Gas Correction Factor for the gas in use:

SCALING CONTROL FACTOR = GAUGE FACTOR x GAS CORRECTION FACTOR

Gauge Factor

The Gauge Factor is a factory set value which scales the +5 VDC output signal to the appropriate full scale range for the MFC, so that the digital panel meter reads 1000 counts. The gauge factors for various flow ranges are listed in Table 10.

MFC Gauge Factors	
MFC Flow Range (sccm)	**Gauge Factor**
1, 10, 100, 1000, 10K	100
2, 20, 200, 2000, 2K	200
5, 50, 500, 5000, 50K	50

Table 10: MFC Gauge Factors

Gas Correction Factor

A Gas Correction Factor (GCF) is used to indicate the ratio of flow rates of different gases which will produce the same output voltage from a mass flow controller. The GCF is a function of specific heat, density, and the molecular structure of the gases. Since flow controllers are usually calibrated with nitrogen, nitrogen is used as the baseline gas (GCF = 1).

Refer to Table 17, page 83, for a list of GCFs for commonly used pure gases. If the pure gas you are using is not listed in Table 17, page 83, or you are using a gas mixture, you must calculate its GCF. Refer to *How To Calculate the GCF for Pure Gases*, page 50, and *How To Calculate the GCF for Gas Mixtures*, page 51, for more information.

Note Refer to *How To Setup the System*, step 6, page 56, for more information and an example Scaling Control Factor calculation.

Scaling Control Potentiometer

The Scaling Control (refer to Figure 7) is a 10-turn potentiometer that serves as a voltage divider for the +5 VDC output signals from the MFCs; the control has a full scale setting of 1000.

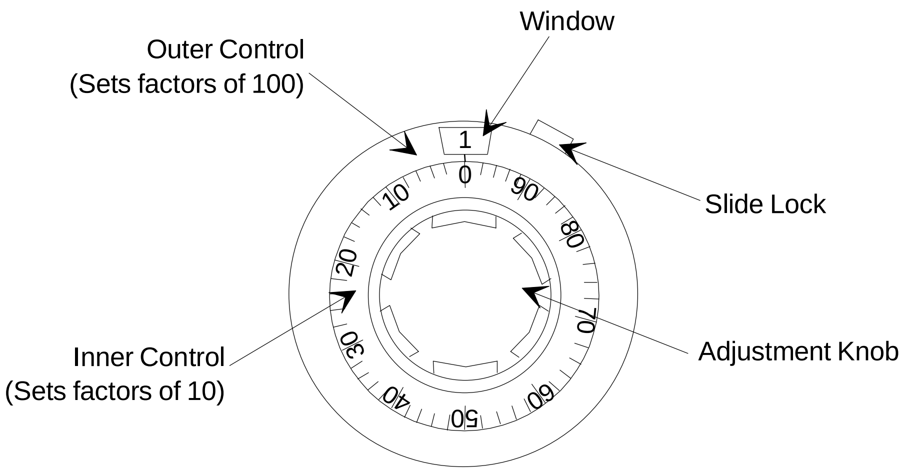


Figure 7: Scaling Control Potentiometer - Initial Setting

The outer control represents factors of 100; indicated by the numbers 0 to 10 which display in the window at the top of the potentiometer. The inner control represents factors of 10, in divisions of 2; these values are set when the appropriate value is aligned with the vertical line beneath the window. The adjustment knob cannot be turned below 0 or above the full scale setting of 1000.

Note Since the maximum number of counts the digital panel meter can read is 1999, the voltage cannot exceed 2 VDC. That is, the maximum value that can be displayed in the scaling potentiometer window is 2.

To adjust the Scaling Control Potentiometer:

- Unlock the slide lock on the right side of the control by pushing it up (counterclockwise)
- Turn the adjustment knob *clockwise* to increase the value represented on the control

  The 147 unit is typically shipped with the control set to “100”, as shown in Figure 7.
- Turn the adjustment knob *counterclockwise* to decrease the value represented on the control
- Lock the position of the control by pushing the slide lock on the right side of the control down (clockwise)

Note Refer to *How To Setup the System*, step 7, page 57, for more information and an example Scaling Control Potentiometer adjustment.

Gas Correction Factor (GCF)

A Gas Correction Factor (GCF) is used to indicate the ratio of flow rates of different gases which will produce the same output voltage from a mass flow controller. The GCF is a function of specific heat, density, and the molecular structure of the gases. Since flow controllers are usually calibrated with nitrogen, nitrogen is used as the baseline gas (GCF = 1).

Table 17, page 83, lists the gas correction factors for some commonly used pure gases. If the gas you are using is not listed in Table 17, you must calculate its GCF. The equations for calculating gas correction factors are listed in *How To Calculate the GCF for Pure Gases*, page 50, and *How To Calculate the GCF for Gas Mixtures*, page 51.

The equations for calculating the GCF assume that the MFC was calibrated at a reference temperature of 0° C (~273° K). If you want the 247 unit to read the mass flow as if the MFC was calibrated at a different reference temperature, adjust the calculated GCF value using the following equation:

$$\text{Temperature Corrected GCF} = \text{GCF} \times \frac{T_x}{T_s}$$

where:

T_X = Reference temperature (° K)

T_S = 273.15° K (~ equal to 0° C)

Note

1. When using the GCF, the accuracy of the flow reading may vary by ±5%, however, the repeatability will remain ±0.2% of FS.
2. All MKS readouts have Gas Correction Adjustment controls to provide direct readout.

How To Calculate the GCF for Pure Gases

To calculate the Gas Correction Factor for *pure* gases, use the following equation:

$$GCF_x = \frac{(0.3106)\ (s)}{(d_x)\ (cp_x)}$$

where:

GCF_X = Gas Correction Factor for gas X

0.3106 = (Standard Density of nitrogen) (Specific Heat of nitrogen)

s = Molecular Structure correction factor where S equals:

1.030 for Monatomic gases

1.000 for Diatomic gases

0.941 for Triatomic gases

0.880 for Polyatomic gases

d_X = Standard Density of gas X, in g/l (at 0° C and 760 mm Hg)

cp_X = Specific Heat of gas X, in cal/g° C

How To Calculate the GCF for Gas Mixtures

For gas mixtures, the calculated Gas Correction Factor is not simply the weighted average of each component's GCF. Instead, the GCF (relative to nitrogen) is calculated by the following equation:

$$GCF_M = \frac{(0.3106)\ (a_1 s_1 + a_2 s_2 + \ldots a_n s_n)}{(a_1 d_1 cp_1 + a_2 d_2 cp_2 + \ldots a_n d_n cp_n)}$$

where:

GCF_M = Gas Correction Factor for a gas mixture

0.3106 = (Standard Density of nitrogen) (Specific Heat of nitrogen)

a_1 and a_2 = Fractional Flow of gases 1 and 2
Note: a_1 and a_2 must add up to 1.0

s_1 and s_2 = Molecular Structure correction factor for gases 1 and 2
where S equals:

1.030 for Monatomic gases

1.000 for Diatomic gases

0.941 for Triatomic gases

0.880 for Polyatomic gases

d_1 and d_2 = Standard Densities for gases 1 and 2, in g/l
(at 0° C and 760 mm Hg)

cp_1 and cp_2 = Specific Heat of gas 1 and gas 2, cal/g° C

Note

The values for s, d, and cp_x are available for most gases, refer to Table 17, page 83.

The values for a_1 and a_2 (which must add up to 1.0) are application dependent.

Example:

Calculate the GCF for a gas mixture of argon (gas 1) flowing at 150 sccm and nitrogen (gas 2) flowing at 50 sccm, where:

$$a_1 = \frac{150}{200} = 0.75 \qquad a_2 = \frac{50}{200} = 0.25$$

$$s_1 = 1.030 \qquad s_2 = 1.000$$

$$d_1 = 1.782 \text{ g/l} \qquad d_2 = 1.250 \text{ g/l}$$

$$cp_1 = 0.1244 \text{ cal/g } ^\circ \text{C} \qquad cp_2 = 0.2485 \text{ cal/g } ^\circ \text{C}$$

then:

$$GCF_M = \frac{(0.3106)\ [(0.75)(1.030) + (0.25)(1.000)]}{(0.75)(1.782)(0.1244)\ + (0.25)(1.250)(0.2485)}$$

$$= \frac{(0.3106)\ [(0.7725) + (0.25)]}{(0.1663)\ + (0.0777)}$$

$$= \frac{(0.3106)\ (1.0225)}{0.244}$$

$$= \frac{0.3176}{0.244}$$

$$GCF_M = 1.302$$

Labels

Serial Number Label

The Serial Number Label, located on the side of the instrument, lists the serial number and the product model number, and displays the CE mark signifying compliance with the European CE regulations.

Figure 8: Serial Number Label

The instrument model code is identified as "247D." Refer to *Appendix B: Model Code Explanation*, page 81, for more information.

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Chapter Four: Operation

How To Setup the System

1. Ensure that the MFCs and the 247 unit are properly installed.

   Refer to *Mounting Instructions*, page 26.

2. Set the FRONT PANEL CONTROLS (refer to Figure 5, page 40) as listed in Table 11.

Manual Flow Control - 247 Unit Front Panel Controls	
Control	**Switch Position**
Power ON/OFF Switch	OFF
Flow Control Switch (1 - 4)	OFF
Set Point Source Switch (1 - 4)	FLOW
Channel Selector	Channel 1

Table 11: Manual Flow Control - 247 Unit Front Panel Controls

3. Verify that the LINE VOLTAGE SELECTOR on the rear panel of the 247 unit is set to the proper voltage.

   Refer to *How To Set the Line Voltage*, page 31, for more information.

Caution **The Line Voltage Selector on the 247 unit must be set to the proper input voltage *before* you connect the power cord and turn on the power. Otherwise, the unit will be severely damaged.**

4. Plug the AC LINE CORD into the power line.

   For protective earthing, plug the power cord into a properly grounded outlet.

5. Connect the MFCs to the MFC Input Connectors (J1 to J4) on the rear panel (refer to Figure 6, page 43) using the proper interface cables. If more than 4 channels are required, add an additional 247 unit to your system.

   The system interface cables are listed in Table 5, page 20.

Note An extra power supply is needed if using more than two 1559 MFCs with one 247 unit.

6. Calculate the SCALING CONTROL FACTOR for *each* MFC in use.

   The Scaling Control Factor specifies how much the +5 VDC output signal from the MFC will be scaled down so that the flow rate can be read directly from the Digital Panel Meter, which reads 1 VDC as 1000 counts full scale.

Note

It is ***critical*** for proper system operation that the Scaling Control Factors are calculated properly. Refer to *Scaling Controls,* page 46, for more information.

a. The *Scaling Control Factor* is the product of the Gauge Factor for the MFC in use and the Gas Correction Factor for the gas in use:

   SCALING CONTROL FACTOR = GAUGE FACTOR x GAS CORRECTION FACTOR

b. The *Gauge Factor* is a factory set value which scales the 5 VDC signal to the appropriate full scale range for the MFC, so that the digital panel meter reads 1000 counts. The gauge factors for various flow ranges are listed in Table 10, page 47.

c. The *Gas Correction Factor (GCF)* is used to indicate the ratio of flow rates of different gases which will produce the same output voltage from a mass flow controller. The GCF is a function of specific heat, density, and the molecular structure of the gases. Since flow controllers are usually calibrated with nitrogen, nitrogen is used as the baseline gas (GCF = 1). Refer to Table 17, page 83, for a list of GCFs for commonly used pure gases.

   If the pure gas you are using is not listed in Table 17, page 83, or you are using a gas mixture, you must calculate its GCF. Refer to *Gas Correction Factor (GCF),* page 49, for more information.

Example:

To calculate the Scaling Control Factor for a 20 sccm MFC, which is flowing pure argon gas, multiply the Gauge Factor for argon (200), listed in Table 10, page 47, times the Gas Correction Factor for argon (1.44), listed in Table 17, page 83:

SCALING CONTROL FACTOR = GAUGE FACTOR x GAS CORRECTION FACTOR

= 200 x 1.44

= 288

Since the full scale setting of the Scaling Control Potentiometer is 1000, the Scaling Control Factor of 288 is 28.8% of FS.

7. Adjust the SCALING CONTROL POTENTIOMETER for *each* MFC in use.

   The Scaling Control Potentiometers set the values of the Scaling Control Factors.

Note It is ***critical*** for proper system operation that the Scaling Control Potentiometers are set correctly. Refer to *Scaling Controls*, page 46, for more information.

The outer control represents factors of 100; indicated by the numbers 0 to 10 which display in the window at the top of the potentiometer. The inner control represents factors of 10, in divisions of 2; these values are set when the appropriate value is aligned with the vertical line beneath the window. The adjustment knob cannot be turned below 0 or above the full scale setting of 1000.

To adjust the Scaling Control Potentiometer to the setting of "288" calculated in the example in step 6, page 56:

a. Unlock the slide lock on the right side of the control by pushing it up (counterclockwise).

b. Turn the adjustment knob clockwise until the "2" appears in the window.

c. Continue turning the adjustment knob until the line on the inner control which represents "88" is aligned with the vertical line beneath the window, as shown in Figure 9.

d. Lock the position of the control by pushing the slide lock on the right side of the control down (clockwise).

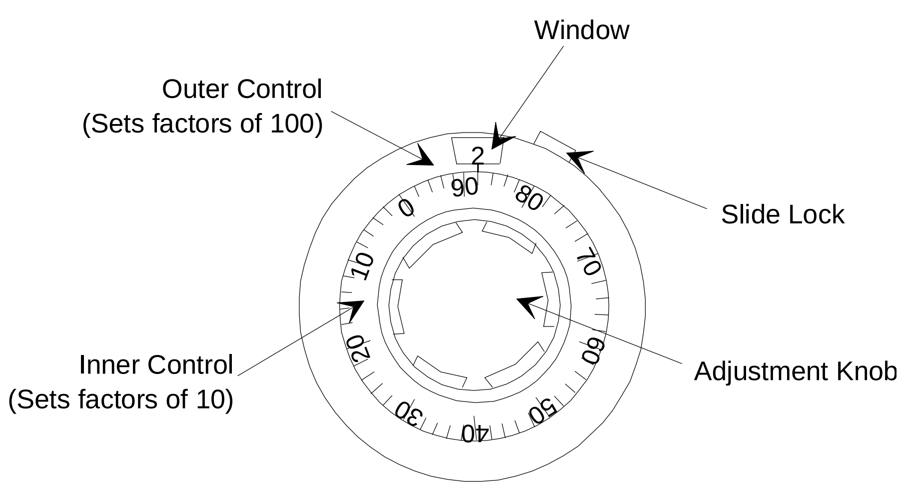

Figure 9: Scaling Control Potentiometer - Example Setting
(Set to "288")

8. Turn the POWER SWITCH ON to apply power to the 247 unit and the attached MFCs.

Note Allow the MFCs to warm up for a period of 1 hour prior to any zero adjustments. Best performance is achieved when the MFCs are powered continuously.

9. Set the DECIMAL POINT for Channel 1.

   Insert a screwdriver blade into the slot of the DECIMAL POINT SELECTOR SWITCH for Channel 1 and rotate it clockwise (CW) until the desired decimal point is illuminated on the Digital Meter Display.

   The Decimal Point Selector Switches are mounted on the rear panel (refer to Figure 6, page 43); the channels that they control are screened below the switch. The position of the decimal point is determined by the full scale range of the MFC in use. For example, a 100 sccm mass flow controller requires the decimal point to be positioned as “100.0” (display at full rated flow).

10. Adjust the ZERO CONTROL for each MFC until the Digital Panel Meter displays a reading of ± 000.

    If the zero control lacks the range for this adjustment, center it and use the zero control on the MFC to bring the reading within the range of the 247 unit’s zero control.

Manual Flow Control

Manual control of the flow rate through MFCs in an *individual* or *ratioed* mode is accomplished using the system configuration shown in Figure 3, page 27.

Note Ensure the MFCs and the 247 unit are properly configured as described in *How To Setup the System*, page 55.

How To Manually Control Individual Gas Flows

This mode of operation enables you to control individual gas flows using an internal set point signal.

1. Move the CHANNEL SELECTOR to position 1.

2. Ensure the SET POINT SOURCE SWITCH is set to the FLOW position.

   This connects an internal +5 V reference to the top of the SET POINT CONTROL. Since the +5 V corresponds to full rated flow, each Set Point Control can be adjusted up to a maximum of 100% for the attached MFCs rated flow.

3. Adjust the SET POINT for the MFC.

   Hold the READ/SET POINT SWITCH in the SET POINT position and turn the SET POINT CONTROL to the desired level as displayed on the Digital Panel Meter. When the adjustment is complete, release the READ/SET POINT SWITCH; it is spring loaded and will return to the READ (Flow) position.

   Since the Digital Panel Meter is driven from the scaled output, the displayed value has the Gas Correction and Gauge Factors applied. *Therefore, it represents the actual set point in sccm for the attached MFC*. Refer to *Scaling Controls*, page 46, for more information.

4. Move the CHANNEL SELECTOR to the next channel position that has an MFC connected to it, and repeat steps 2 and 3 until the set points for all channels with MFCs attached have been properly set.

5. Return the CHANNEL SELECTOR to the channel that you wish to monitor.

   The system is now completely adjusted to set the flow of each MFC.

6. Turn the flow ON by placing the FLOW CONTROL SWITCH to the ON position.

   The set point signal is applied to the MFC, the Flow Indicator LED illuminates, and flow begins after a slight delay. The correct flow is realized within approximately 1.5 seconds, depending on the type of MFC being used.

Note The flow through any channel can be displayed on the Digital Panel Meter by placing the Channel Selector Switch to that channel.

7. Turn the flow OFF by placing the FLOW CONTROL SWITCH to the OFF position.

How To Manually Control Ratioed Gas Flows

This mode of operation enables you to control the individual flow rates of Channels 2 to 4 as a fraction of the flow of Channel 1, using an internal set point signal. The set point signal is controlled by the Transducer Output of Channel 1.

If more than three channels are to be ratioed to Channel 1, a second 247 unit is required. The second 247 unit must be connected to Channel 1 of the first 247 unit, and its S15 dipswitch must be set for External Ratio Control. Refer to *How To Change the Dipswitch Settings*, page 64, for more information.

Note The MFC that is set to control at the highest percentage of its rated flow should be connected to Channel 1.

In the following example, we will assume a system with four 100 sccm MFCs flowing nitrogen (N_2) gas. Channels 2 to 4 will be set to a ratio of 75, 50, and 25% of the flow in Channel 1.

1. Set the SET POINT SOURCE SWITCHES for Channels 1 to 4 to the FLOW position.

   This connects an internal +5 V reference to the top of the SET POINT CONTROL. Since the +5 V corresponds to full rated flow, each Set Point Control can be adjusted up to a maximum of 100% for the attached MFCs rated flow.

2. Adjust the SET POINT for *each* MFC.

   Hold the READ/SET POINT SWITCH in the SET POINT position and turn the SET POINT CONTROL for each MFC to the level shown in Table 12, as displayed on the Digital Panel Meter.

Ratio Control Set Point Levels	
Set Point Control	**Level (SCCM)**
Channel 1	0 to 100
Channel 2	75
Channel 3	50
Channel 4	25

Table 12: Ratio Control Set Point Levels

   When the adjustment is complete, release the READ/SET POINT SWITCH; it is spring loaded and will return to the READ (Flow) position.

   Since the Digital Panel Meter is driven from the scaled output, the displayed value has the Gas Correction and Gauge Factors applied. *Therefore, it represents the actual set point in sccm for the attached MFC*. Refer to *Scaling Controls*, page 46, for more information.

3. Leave the SET POINT SOURCE SWITCH for Channel 1 in the FLOW position and move the switches for Channels 2 to 4 to the RATIO position.

   The 247 unit is now adjusted to control the MFCs connected to Channels 2 through 4 to 75, 50, and 25% of the flow rate through Channel 1.

4. Turn the flow on by placing the FLOW CONTROL SWITCH for all channels to the ON position.

   The set point signal is applied to the MFC, the Flow Indicator LED illuminates, and flow begins after a slight delay. The correct flow is realized within approximately 1.5 seconds, depending on the type of MFC being used.

Note The flow through any channel can be displayed on the Digital Panel Meter by placing the Channel Selector Switch to that channel.

5. Turn the flow off by placing the FLOW CONTROL SWITCH for all channels to the OFF position.

External Flow Control

External control of the flow rate through MFCs in either an individual or ratioed mode is accomplished using the system configuration shown in Figure 4, page 28.

Note Ensure the MFCs and the 247 unit are properly configured as described in *How To Setup the System*, page 55.

This mode of operation enables you to control individual gas flows using a set point signal from an external controller, or to ratio gas flows based on a set point signal from an external controller and measurements from a pressure transducer. In either case, the set point signal is controlled by the output of the external controller signal, the *External Ratio Amplifier*, rather than the Transducer Output of Channel 1.

The 247 unit is initially configured so that the set point signal is based on the Transducer Output of Channel 1. In order to use external flow control, you must change the source of the set point signal to the External Ratio Amplifier by changing the settings in the 4-position dipswitch (S15) located at the rear of the Main PC board. The External Ratio Amplifier will accept signals corresponding to a full scale voltage of +5 V or +1 V, depending on the configuration of the dipswitch. Refer to *How To Change the Dipswitch Settings*, page 64, for more information.

If more than three channels are to be ratioed to Channel 1, a second 247 unit is required. The second 247 unit must be connected to Channel 1 of the first 247 unit, and its S15 dipswitch must also be set for External Ratio Control.

Note Any controller and pressure transducer may be used provided the signal that enters the 247 unit goes *positive* with increasing flow (correct polarity). Throughout this manual, the MKS Type 250 Pressure/Flow Controller and Type 127/227 Baratron Pressure Transducers are used for example only.

How To Change the Dipswitch Settings

The External Ratio Amplifier will accept signals corresponding to a full scale voltage of +5 V or +1 V. Configuring dipswitch S15 to the settings listed in Table 14, page 64, or Table 15, page 65, configures the RATIO position on all of the SET POINT SOURCE SWITCHES to be driven by the output of the External Ratio Amplifier, rather than the +5 V internal reference.

The 247 unit is initially configured so that the set point signal is based on the Transducer Output of Channel 1, with dipswitch S15 set as listed in Table 13.

Dipswitch S15 Initial Settings	
Dipswitch	**Position**
1	Closed (On)
2	Open (Off)
3	Open (Off)
4	Open (Off)

Table 13: Dipswitch S15 Initial Settings

To change the dipswitch settings for external set point control:

1. Remove the retaining screws and the top cover of the 247 unit.

2. Locate the Main PC board.

3. Locate the 4-position dipswitch (S15) at the rear of the Main PC board.

4. To configure the 247 unit to accept +5 V full scale input, set dipswitch S15 to the positions listed in Table 14.

Dipswitch S15 Settings for +5 V Full Scale Input	
Dipswitch	**Position**
1	Open (Off)
2	Closed (On)
3	Open (Off)
4	Open (Off) (amplifier is set to unity gain)

Table 14: Dipswitch S15 Settings for +5 V Full Scale Input.

5. To configure the 247 unit to accept +1 V full scale input, set dipswitch S15 to the settings listed in Table 15.

Dipswitch S15 Settings for +1 V Full Scale Input	
Dipswitch	**Position**
1	Open (Off)
2	Closed (On)
3	Open (Off)
4	Closed (On) (amplifier is set to a gain of 5)

Table 15: Dipswitch S15 Settings for +1 V Full Scale Input.

6. Replace the top cover and the retaining screws.

7. Connect the pressure transducer to the controller using the proper cable.

   The system interface cables are listed in Table 5, page 20.

8. Perform the steps described in *How To Setup the System,* page 55, to prepare the 247 unit and MFCs for flow control.

How To Control Individual Gas Flows with an External Controller

This mode of operation enables you to control individual gas flows using a set point signal from an external controller. The 0 to 5 VDC set point signal is received at Interface Connector P6, and is routed by the SET POINT SOURCE SWITCH to each MFC. Its application to the MFC is the same as that described in *How To Manually Control Individual Gas Flows,* page 59.

Note that each channel has its own external set point line. Any or all channels may have their set points or flow driven from the external source.

How To Control Pressure with Ratioed Gas Flows

In this type of operation, the pressure in a chamber is maintained by controlling the ratio of gas flows, based on a set point signal from an external controller and measurements from a pressure transducer. More than four gases may be controlled by adding a second 247 unit to the system.

The pressure in the chamber is measured by the transducer which produces a DC output which is proportional to the pressure. This output is applied to the controller where it is compared with the pressure set point level. The 247 unit receives the pressure control signal (PCS) from the controller as an external ratio signal to produce the gas flow necessary to achieve the required pressure.

The PCS voltage enters the 247 unit through Interface Connector P5. It is routed to the RATIO position of the SET POINT SOURCE SWITCH, where it functions the same as that described in *How To Manually Control Ratioed Gas Flows,* page 61.

Note that any or all channels may be used to flow gas to maintain pressure with a preset ratio of flows. Any channel that is not used this way may be used independently.

How To Setup the Controller for Pressure Control

Any controller that provides a positive signal with increasing flow (correct polarity) may be used; the MKS Type 250 Pressure/Flow Controller is used for example only.

1. Verify that the LINE VOLTAGE SELECTOR SWITCH on the 250 controller is set to the proper voltage.

2. Set the FRONT PANEL CONTROLS on the 250 controller as listed in Table 16.

External Controller - Front Panel Controls	
Control	**Position**
Power Switch	OFF
INT/EXT	INT
10V/1V/.1V	10V
Phase Lead	1.5 SEC
Gain	20%
Bias	Fully CCW
CMAE	Manual
Manual Control	500 out of 1000
Set Point Level	Required pressure level

Table 16: External Controller - Front Panel Controls

The settings in Table 16 configure the controller to deliver a constant Pressure Control Signal (PCS) of approximately +5 V to the 247 unit's External Ratio Amplifier. This manually produced signal is used to determine if the required pressure and flow rates can be achieved using a PCS with a nominal value of +5 V. *Best control performance is achieved when the PCS is kept high for a good signal to noise ratio.*

3. Plug the AC LINE CORD into the power line and turn on the power switch.

Note Allow the controller to warm-up for at least 1½ hours before adjusting the zero.

4. Pump the chamber down below the resolution of the transducer and adjust the zero for a reading of ±0000 on the controller's Digital Panel Meter.

   On controllers without a DPM, adjust the Set Point Control to zero and adjust for a zero reading on the Error Meter.

How To Setup the 247 Unit for Pressure Control

1. Place the SET POINT SOURCE SWITCHES on all channels of the 247 unit with an MFC attached to the RATIO position.

2. Place the FLOW CONTROL SWITCHES on all channels with an MFC attached to the ON position.

   This produces flow through all the MFCs.

3. Adjust the flow rate for each channel with the 247 unit's SET POINT CONTROL to achieve the desired flow rate and ratio between the channels and the desired pressure (within a factor of 2) in the chamber.

   The flow rate displays on the Digital Panel Meter which is controlled with the CHANNEL SELECTOR SWITCH.

4. Read the chamber pressure on the controller's Digital Panel Meter.

   To read pressure on a controller without a meter, adjust the controller's set point until the error meter reads zero, then multiply the Set Point reading times the Full Scale of the transducer (1000 counts = full scale). When the pressure is within the desired 2 to 1 range, the system is ready for automatic control.

   If the pressure cannot be adjusted to within the factor of 2, then modification of the system may be necessary.

   - Too high of a pressure requires increased pumping capacity or smaller MFCs for less total flow
   - Too low of a pressure requires reduced pumping capacity or larger MFCs for greater total flow

5. Move the CMAE switch on the controller to the AUTO position.

Note The controller will vary the pressure control signal to adjust the total flow to achieve the control pressure. Although the total flow rate will change, the *ratio* between the gases will remain constant.

6. Adjust the controller's GAIN and PHASE LEAD settings as needed.

   The controller settings listed in Table 16, page 67, are used as a starting point for control. These settings should be properly tuned to provide accurate control, free from oscillations. Refer to the appropriate instruction manual for complete tuning information.

Remote Flow Control

Note Ensure the MFCs and the 247 unit are properly configured as described in *How To Setup the System*, page 55.

Interface connector P6 provides the means to remotely turn the flow on/off and to adjust and monitor the flow rate in any channel using a set point signal from a voltage applied to P6. Refer to Table 7, page 32, for the pinout for Interface connector P6.

How To Control Gas Flow with TTL Logic

TTL logic control provides a way to use only a simple voltage level to control the flow rate. You can create a custom interface by wiring the required control signals to the appropriate pins on Connector P6. Refer to Table 7, page 32, for the Interface connector P6 pinout.

When the FLOW CONTROL SWITCH (refer to Figure 5, page 40) is placed in the REMOTE position, a logic signal coming in through the Interface connector P6 may be used to gate the set point signal to the MFC. A logic low turns the flow on; a logic high turns the flow off.

To use TTL logic control:

1. Follow the instructions in *How To Setup the System,* page 55, to prepare the 247 and the MFCs for flow control.

2. Place the SET POINT SOURCE switches on all channels with a MFC attached to the EXT position.

3. Place the FLOW CONTROL SWITCHES on all channels with a MFC attached to the REM position.

4. Apply the control signals through Interface connector P6.

   For example:

   a. To produce a flow of 50 sccm through a 100 sccm MFC connected to Channel 1, apply a +2.5 V signal to pin 4 on connector P6. Reference this voltage to pin 1 on connector P6.

   b. Attach a TTL signal to pin 12 on connector P6. Reference this signal to pin 8 on connector P6.

   c. Turn on the flow by applying a TTL low (0.4 to 0.8 V) to pin 12 on connector P6.

   d. Turn off the flow by applying a TTL high (2.4 to 5 V) to pin 12 on connector P6 or an open circuit.

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Chapter Five: Maintenance and Troubleshooting

General Information

If the 247 controller fails to operate properly upon receipt, check for shipping damage, and check the cables for proper continuity. Any damage should be reported to the carrier and MKS Instruments immediately. If it is necessary to return the unit to MKS, obtain an ERA number (Equipment Return Authorization Number) from a MKS Service Center before shipping. Please refer to the inside back cover of this manual for a list of MKS Calibration and Service Centers.

Maintenance

Periodically check for wear on the cables and inspect the enclosure for visible signs of damage.

How To Clean the Unit

Periodically wipe down the unit with a damp cloth.

How To Replace the Fuses

The line fuses protect the internal circuitry; both sides of the line are fused.

Caution

Disconnect the power cord from the 247 unit *before* you replace the fuse, to avoid any damage.

1. Select the proper fuses. Refer to Table 6, page 30, for the fuse values.

2. Disconnect the power cord from the 247 instrument.

Warning

To avoid an electrical shock, be sure to disconnect the power cord *before* proceeding.

3. Disconnect all cables from the connectors located at the back of the unit.

4. Insert a small, flat head screw driver under the top side of the black plastic cover and firmly pull towards you to unsnap the cover.

   The cover is attached firmly, so it requires a strong force on the screw driver to loosen it. The cover will flip open to expose the line voltage selector drum and the two fuse carriers. The two fuse carriers are marked with arrows (➡).

5. Carefully slide the fuse carrier out and remove the fuse.

6. Insert the new fuse into the fuse carrier.

   Be certain that the new fuse is the appropriate type for the line voltage selection.

7. Slide the fuse carrier back into the Power Entry module.

8. Close the Power Entry module cover.

9. Connect any cables removed from the back of the 247 instrument in step 3 above.

10. Connect the power cord.

Troubleshooting

The first approach when dealing with a problem with the 247 unit is to isolate the section of the instrument where the fault lies. The 247 readout can be separated into the following sections:

- Power Supply
- Channel Amplifiers
- Internal +5 V Voltage Reference
- External Ratio Amplifier
- Digital Panel Meter
- Set Point Buffer and Flow Switching Circuit

Since a problem in the Power Supply will effect the performance of all sections, it is important to begin troubleshooting at this location.

Power Supply

1. Measure the ± supplies at the power supply jumpers on the PC board; reference to the TP1 ground, located in the center of the Main PC board.

   The voltages should be within the range of 14.8 to 15.2 Volts and the AC ripple should be < 10 mV P-P. If the voltages are within range, proceed to step 4. If the voltages are not within the acceptable range, proceed to step 2.

2. Disconnect the MFCs from the rear panel, one at a time.

   Should the supplies recover when an MFC is removed, then either the cable or the MFC is defective.

3. Isolate the power supply jumpers from the circuits in the 247 unit by disconnecting the power supply jumpers and measuring the supplies on the supply side.

Caution ***Disconnect BOTH SUPPLIES*** **to perform this test. Do not run the circuits with only one supply operative.**

4. If the power supply is operating normally, proceed to *Channel Amplifiers*, page 74, to examine the signal path through the channel amplifiers.

Channel Amplifiers

To test a channel:

1. Plug an external connector with a jumper wire connected between pins 2 and 8, into the appropriate Channel Input Connector.

   This connects the output of the set point buffer to the input of the channel.

2. Connect a voltmeter to the jumper wire and reference the meter to the TP1 ground, located in the center of the Main PC board.

3. Ensure that the channel's FLOW CONTROL SWITCH is on.

4. Place the SET POINT SOURCE SWITCH to the FLOW position.

5 Adjust the SET POINT CONTROL to produce a +5 V reading on the voltmeter.

   If you cannot adjust the SET POINT CONTROL to produce a + 5V reading, proceed to *Internal +5 V Voltage Reference*, page 75.

6. Turn the Zero Pot 25 turns counterclockwise (CCW) and then 12 turns clockwise (CW) to center it.

7. Set the SCALING CONTROL to 100 (10% of FS).

   The DPM should display +1000, ±15 counts.

Internal +5 V Voltage Reference

In the event that the voltage output from the internal +5 V source is not correct, measure the input to the source.

1. Connect the high side of the voltmeter to the junction of R67 and VR1, located on the rear of the Main PC board.

2. Reference the meter to the TP1 ground, located in the center of the Main PC board.

   The proper input voltage is +1.23 to +1.25 Volts. With this input, the potentiometer R66, located on the rear of the Main PC board, can be adjusted to produce a +5 V output (actually, factory set to +5.1 V).

An incorrect input voltage may be caused by a defective reference VR1. An incorrect output may be caused by a defective amplifier U9A, also located on the rear of the Main PC board. Contact MKS Instruments for assistance.

External Ratio Amplifier

Failure of the 247 unit to work properly with an external voltage being used as a ratio signal may be caused by a defective amplifier or by an incorrect setting on dipswitch S15.

The external ratio amplifier accepts signals corresponding to a full scale voltage of +5 V or +1 V, controlled by the settings in dipswitch S15 on the Main PC board. For a +5 V full scale input, ensure that dipswitch S15 is configured as listed in Table 14, page 64. For a +1 V full scale input, ensure that dipswitch S15 is configured as listed in Table 15, page 65. Refer to *How To Change the Dipswitch Settings*, page 64, for more information.

The input voltage required to produce the +5 V or +1 V output is applied to the 247 unit through pin 7 on Interface connector P5. Both the input voltage and the meter measuring the output should be referenced to pin 1 on Interface connector P5. Refer to Table 8, page 33, for the complete pinout of Interface connector P5.

Digital Panel Meter

The Digital Panel Meter (DPM) is a 3½ digit, 2 V full scale device. The meter is powered by a +5 V supply located on the Main PC board.

To measure the supply voltage to the meter:

1. Connect a voltmeter to the +5 V supply jumper on the Main PC board.

2. Reference the meter to the TP1 ground, located on the center of the Main PC board.

   The voltage should be between +4.7 and +5.3 Volts.

3. Setup Channel 1 for +1 V output.

   Refer to *How To Change the Dipswitch Settings*, page 64.

4. Ensure that the CHANNEL SELECTOR is on position 1.

5. Measure the output of the channel on pin 2 of Interface connector P5.

   The voltage on the DPM should match the voltmeter reading from pin 2 of Interface connector P5, ±1 count. If it does not, you must adjust the span pot on the right rear of the DPM until the readings agree. To access the span pot you must remove the top cover of the 247 unit; proceed to step 6.

6. Remove the two screws on the top corners of the rear panel of the 247 unit and slide the top cover towards the back of the unit until the entire digital panel meter box is visible.

7. Adjust the span pot on the rear of the DPM with a small flathead screwdriver until the meter reading agrees with the voltmeter reading from pin 2 of Interface connector P5, ±1 count.

   If the range of this adjustment is insufficient to bring the two meter readings into agreement, the DPM must be replaced.

8. Slide the top cover back into position and replace the two screws on the rear panel to secure it in place.

Set Point Buffer and Flow Switching Circuit

The buffer amplifier prevents the Flow Controller from loading the set point signal. The voltage at the output of the second set point buffer should track the voltage on the arm of the Set Point Control by ±2 mV when the flow is on. If this signal is incorrect at the Channel Input Connector, trace the signal back to the Set Point Control to determine where the fault lies.

A negative voltage (approximately - 0.1 V) at the Channel Input Connector indicates that the field effect transistor (FET) is ON. If the Flow Lamp is on, then the FET is defective or the drive to the gate is incorrect. The drive under these conditions should be -15 V ±1 V.

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Appendix A: Product Specifications

CE Compliance Electromagnetic Compatibility[1] Low-Voltage Requirements Installation Category Pollution Degree Product Safety and Liability	 EMC Directive 89/336/EEC Low-Voltage Directive 73/23/EEC II, according to EN 61010-1 2, according to IEC 664 Product Safety Directive 92/59/EEC
Display Accuracy	±0.1% ± 1 digit
Flow Display	3 ½ Digit Display (+1.999 maximum)
Fuse Ratings 115 VAC 230 VAC	 0.8 A (T) / 250 V 0.4 A (T) / 250 V
MFC Capacity	4; 1 MFC per channel, sequentially selectable
Operating Temperature	15° to 40° C (59° to 104° F)
Package	½ Rack (9.5" W x 3.5" H x 9" D)
Power Consumption	19 VA @ 115 VAC 60 Hz with no MFCs attached *Additional* 15 VA for start-up and 10 VA operational for *each* MFC attached
Power Requirement 115 VAC Setting 230 VAC Setting	 100 to 120 VAC nominal, 50/60 Hz 200 to 240 VAC nominal, 50/60 Hz
Power Supply Output Capacity	±15 VDC @ 1 Ampere Maximum ripple < 10 mV P-P
Set Point Adjust *(each channel)*	0.1 to 100% of Full Scale (flow) 0.1 to 100% of Input level (ratio)

[1]An overall metal braided shielded cable, properly grounded at both ends, is required during use.

Signal Inputs *(each channel)*	
MFC	0 to +5 VDC (5.5 V maximum)
Scaling (GCF)	0.1 to 4.0
External Set Point (bypasses on-board set point controls)	0 to 5 VDC
External ON/OFF	TTL Compatible
Signal Outputs *(each channel)*	
MFC Output(s)	Minimum load impedance; 10K ohm/channel
Unscaled Transducer Output	0 to +5 VDC
Scaled (Corrected) Transducer Output	0 to +1 VDC Nominal (scaled with a rear panel scaling control); 0 to 2 VDC maximum
Weight	8.5 lbs. (3.85 kg)
Zero Correction *(each channel)*	± 3% of Full Scale

Due to continuing research and development activities, these product specifications are subject to change without notice.

Appendix B: Model Code Explanation

Model Code

The model code is identified as follows:

247D

Type Number (247D)

The type number 247D designates the model number of the instrument.

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Appendix C: Gas Correction Factors for Commonly Used Pure Gases

Table 17 lists the gas correction factors for some commonly used pure gases. If the GCF for your gas is not listed, or you are using a gas mixture, you must calculate the GCF. Refer to Gas Correction Factor (GCF), page 49, for more information.

Gas Correction Factors for Pure Gases				
GAS	**SYMBOL**	**SPECIFIC HEAT, Cp cal/g^{o}C**	**DENSITY g/l @ 0^{o}C**	**CONVERSION FACTOR**
Air	- - -	0.240	1.293	1.00
Ammonia	NH_3	0.492	0.760	0.73
Argon	Ar	0.1244	1.782	1.39[1]
Arsine	AsH_3	0.1167	3.478	0.67
Boron Trichloride	BCl_3	0.1279	5.227	0.41
Bromine	Br_2	0.0539	7.130	0.81
Carbon Dioxide	CO_2	0.2016	1.964	0.70[1]
Carbon Monoxide	CO	0.2488	1.250	1.00
Carbon Tetrachloride	CCl_4	0.1655	6.86	0.31
Carbon Tetraflouride (Freon - 14)	CF_4	0.1654	3.926	0.42
Chlorine	Cl_2	0.1144	3.163	0.86
Chlorodifluoromethane (Freon - 22)	$CHClF_2$	0.1544	3.858	0.46
Chloropentafluoroethane (Freon - 115)	C_2ClF_5	0.164	6.892	0.24
Chlorotrifluoromethane (Freon - 13)	$CClF_3$	0.153	4.660	0.38
Cyanogen	C_2N_2	0.2613	2.322	0.61
Deuterium	D_2	1.722	0.1799	1.00
Diborane	B_2H_6	0.508	1.235	0.44
Dibromodifluoromethane	CBr_2F_2	0.15	9.362	0.19
Dichlorodifluoromethane (Freon - 12)	CCl_2F_2	0.1432	5.395	0.35

Table 17: Gas Correction Factors for Pure Gases
(Continued on next page)

Gas Correction Factors for Pure Gases *(Continued)*				
GAS	**SYMBOL**	**SPECIFIC HEAT, Cp cal/g^{o}C**	**DENSITY g/l @ 0^{o}C**	**CONVERSION FACTOR**
Dichlorofluoromethane (Freon - 21)	$CHCl_2F$	0.140	4.592	0.42
Dichloromethysilane	$(CH_3)_2SiCl_2$	0.1882	5.758	0.25
Dichlorosilane	SiH_2Cl_2	0.150	4.506	0.40
1,2-Dichlorotetrafluoroethane (Freon - 114)	$C_2Cl_2F_4$	0.160	7.626	0.22
1,1-Difluoroethylene (Freon - 1132A)	$C_2H_2F_2$	0.224	2.857	0.43
2,2-Dimethylpropane	C_5H_{12}	0.3914	3.219	0.22
Ethane	C_2H_6	0.4097	1.342	0.50
Fluorine	F_2	0.1873	1.695	0.98
Fluoroform (Freon - 23)	CHF_3	0.176	3.127	0.50
Freon - 11	CCl_3F	0.1357	6.129	0.33
Freon - 12	CCl_2F_2	0.1432	5.395	0.35
Freon - 13	$CClF_3$	0.153	4.660	0.38
Freon - 13 B1	$CBrF_3$	0.1113	6.644	0.37
Freon - 14	CF_4	0.1654	3.926	0.42
Freon - 21	$CHCl_2F$	0.140	4.592	0.42
Freon - 22	$CHClF_2$	0.1544	3.858	0.46
Freon - 23	CHF_3	0.176	3.127	0.50
Freon - 113	$C_2Cl_3F_3$	0.161	8.360	0.20
Freon - 114	$C_2Cl_2F_4$	0.160	7.626	0.22
Freon - 115	C_2ClF_5	0.164	6.892	0.24
Freon - 116	C_2F_6	0.1843	6.157	0.24
Freon - C318	C_4F_8	0.185	8.397	0.17
Freon - 1132A	$C_2H_2F_2$	0.224	2.857	0.43
Helium	He	1.241	0.1786	.- - -2
Hexafluoroethane (Freon - 116)	C_2F_6	0.1843	6.157	0.24

Table 17: Gas Correction Factors for Pure Gases

(Continued on next page)

Gas Correction Factors for Pure Gases *(Continued)*				
GAS	**SYMBOL**	**SPECIFIC HEAT, Cp cal/g^{o}C**	**DENSITY g/l @ 0^{o}C**	**CONVERSION FACTOR**
Hydrogen	H_2	3.419	0.0899	.- - -[2]
Hydrogen Bromide	HBr	0.0861	3.610	1.00
Hydrogen Chloride	HCl	0.1912	1.627	1.00
Hydrogen Fluoride	HF	0.3479	0.893	1.00
Isobutylene	C_4H_8	0.3701	2.503	0.29
Krypton	Kr	0.0593	3.739	1.543
Methane	CH_4	0.5328	0.715	0.72
Methyl Fluoride	CH_3F	0.3221	1.518	0.56
Molybdenum Hexafluoride	MoF_6	0.1373	9.366	0.21
Neon	Ne	0.246	0.900	1.46
Nitric Oxide	NO	0.2328	1.339	0.99
Nitrogen	N_2	0.2485	1.250	1.00
Nitrogen Dioxide	NO_2	0.1933	2.052	- -[2]
Nitrogen Trifluoride	NF_3	0.1797	3.168	0.48
Nitrous Oxide	N_2O	0.2088	1.964	0.71
Octafluorocyclobutane (Freon - C318)	C_4F_8	0.185	8.937	0.17
Oxygen	O_2	0.2193	1.427	1.00[3]
Pentane	C_5H_{12}	0.398	3.219	0.21
Perfluoropropane	C_3F_8	0.194	8.388	0.17
Phosgene	$COCl_2$	0.1394	4.418	0.44
Phosphine	PH_3	0.2374	1.517	0.76
Propane	C_3H_8	0.3885	1.967	0.36
Propylene	C_3H_6	0.3541	1.877	0.41
Silane	SiH_4	0.3189	1.433	0.60
Silicon Tetrachloride	$SiCl_4$	0.1270	7.580	0.28
Silicon Tetrafluoride	SiF_4	0.1691	4.643	0.35
Sulfur Dioxide	SO_2	0.1488	2.858	0.69

Table 17: Gas Correction Factors for Pure Gases
(Continued on next page)

Gas Correction Factors for Pure Gases *(Continued)*				
GAS	**SYMBOL**	**SPECIFIC HEAT, Cp cal/g°C**	**DENSITY g/l @ 0°C**	**CONVERSION FACTOR**
Sulfur Hexafluoride	SF_6	0.1592	6.516	0.26
Trichlorofluoromethane (Freon - 11)	CCl_3F	0.1357	6.129	0.33
Trichlorosilane	$SiHCl_3$	0.1380	6.043	0.33
1,1,2-Trichloro - 1,2,2-Trifluoroethane (Freon - 113)	CCl_2FCClF_2 or ($C_2Cl_3F_3$)	0.161	8.360	0.20
Tungsten Hexafluoride	WF_6	0.0810	13.28	0.25
Xenon	Xe	0.0378	5.858	1.32

[1]Empirically defined.

[2]Consult MKS Instruments, Inc. for special applications.

[3]The GCF for Oxygen is 0.993 when using *thermal* MFCs such as the Type 1179, 1479, 1679, 1159, and 1259 units, and related products. The GCF for Oxygen is 1.000, as listed in the table, for pressure based MFCs such as the Type 1640, 1150, 1151, 1152, and 1153 units.

NOTE: Standard Pressure is defined as 760 mmHg (14.7 psia).
Standard Temperature is defined as 0°C

Table 17: Gas Correction Factors for Pure Gases

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Rev F, 10/97
Instruction Manual

MKS Type 651C
Pressure Controller

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(800) 227-8766 or (978) 975-2350

Fax: (978) 975-0093
E-mail: mks@mksinst.com
Web site: http://www.mksinst.com

WARRANTY

Type 651C Equipment

MKS Instruments, Inc. (**MKS**) warrants that the equipment described above (the "equipment") manufactured by **MKS** shall be free from defects in materials and workmanship for a period of one year from date of shipment and will for a period of two years from the date of shipment, correctly perform all date-related operations, including without limitation accepting data entry, sequencing, sorting, comparing, and reporting, regardless of the date the operation is performed or the date involved in the operation, provided that, if the equipment exchanges data or is otherwise used with equipment, software, or other products of others, such products of others themselves correctly perform all date-related operations and store and transmit dates and date-related data in a format compatible with **MKS** equipment. THIS WARRANTY IS **MKS'** SOLE WARRANTY CONCERNING DATE-RELATED OPERATIONS.

For the period commencing with the date of shipment of this equipment and ending one year later in the case of defects in materials and workmanship, but two years later in the case of failure to comply with the date-related operations warranty, **MKS** will, at its option, either repair or replace any part which is defective in materials or workmanship or with respect to the date-related operations warranty without charge to the purchaser. The foregoing shall constitute the exclusive and sole remedy of the purchaser for any breach by **MKS** of this warranty.

The purchaser, before returning any equipment covered by this warranty, which is asserted to be defective by the purchaser, shall make specific written arrangements with respect to the responsibility for shipping the equipment and handling any other incidental charges with the **MKS** sales representative or distributor from which the equipment was purchased or, in the case of a direct purchase from **MKS**, with the **MKS** home office in Andover, Massachusetts, USA.

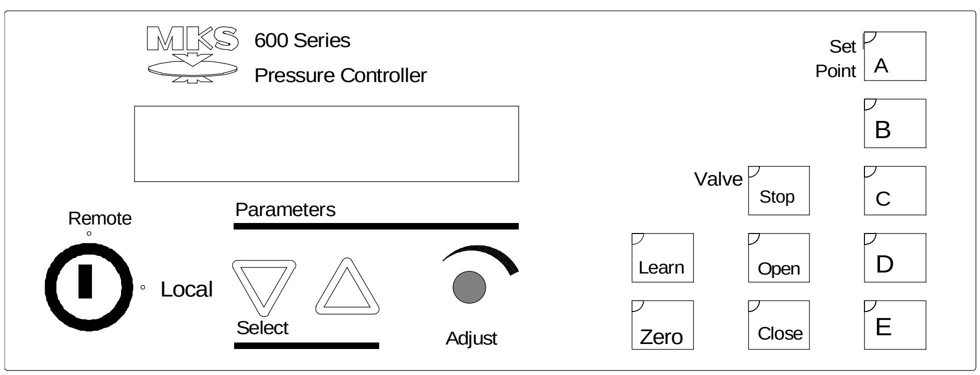
This warranty does not apply to any equipment which has not been installed and used in accordance with the specifications recommended by **MKS** for the proper and normal use of the equipment. **MKS** shall not be liable under any circumstances for indirect, special, consequential, or incidental damages in connection with, or arising out of, the sale, performance, or use of the equipment covered by this warranty.

MKS recommends that all **MKS** pressure and flow products be calibrated periodically (typically every 6 to 12 months) to ensure accurate readings. When a product is returned to **MKS** for this periodic re-calibration it is considered normal preventative maintenance not covered by any warranty.

THIS WARRANTY IS IN LIEU OF ALL OTHER RELEVANT WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING THE IMPLIED WARRANTY OF MERCHANTABILITY AND THE IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, AND ANY WARRANTY AGAINST INFRINGEMENT OF ANY PATENT.

115605-P1
Rev F, 10/97

MKS Type 651C
Pressure Controller



Please Note:
MKS Instruments provides these documents as the latest version for the revision indicated. The material is subject to change without notice, and should be verified if used in a critical application.

This manual is for firmware version 1.8x

Table of Contents

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List of Tables

Safety Information

Symbols Used in This Instruction Manual

Definitions of WARNING, CAUTION, and NOTE messages used throughout the manual.

Warning

The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.

Caution

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of all or part of the product.

Note

The NOTE sign denotes important information. It calls attention to a procedure, practice, condition, or the like, which is essential to highlight.

Symbols Found on the Unit

The following table describes symbols that may be found on the unit.

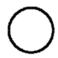
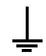
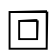
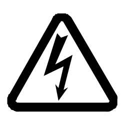
Definition of Symbols Found on the Unit			
 On (Supply) IEC 417, No.5007	 Off (Supply) IEC 417, No.5008	 Earth (ground) IEC 417, No.5017	 Protective earth (ground) IEC 417, No.5019
 Frame or chassis IEC 417, No.5020	 Equipotentiality IEC 417, No.5021	 Direct current IEC 417, No.5031	 Alternating current IEC 417, No.5032
 Both direct and alternating current IEC 417, No.5033-a	 Class ll equipment IEC 417, No.5172-a	 Three phase alternating current IEC 617-2 No.020206	
 Caution, refer to accompanying documents ISO 3864, No.B.3.1	 Caution, risk of electric shock ISO 3864, No.B.3.6	 Caution, hot surface IEC 417, No.5041	

Table 1: Definition of Symbols Found on the Unit

Safety Procedures and Precautions

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of intended use of the instrument and may impair the protection provided by the equipment. MKS Instruments, Inc. assumes no liability for the customer's failure to comply with these requirements.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an MKS Calibration and Service Center for service and repair to ensure that all safety features are maintained.

SERVICE BY QUALIFIED PERSONNEL ONLY

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel only.

GROUNDING THE PRODUCT

This product is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting it to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

DANGER ARISING FROM LOSS OF GROUND

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electrical shock.

GROUND AND USE PROPER ELECTRICAL FITTINGS

Dangerous voltages are contained within this instrument. All electrical fittings and cables must be of the type specified, and in good condition. All electrical fittings must be properly connected and grounded.

USE THE PROPER POWER CORD

Use only a power cord that is in good condition and which meets the input power requirements specified in the manual.

Use only a detachable cord set with conductors that have a cross-sectional area equal to or greater than 0.75 mm^2. The power cable should be approved by a qualified agency such as VDE, Semko, or SEV.

USE THE PROPER POWER SOURCE

This product is intended to operate from a power source that does not apply more voltage between the supply conductors, or between either of the supply conductors and ground, than that specified in the manual.

USE THE PROPER FUSE

Use only a fuse of the correct type, voltage rating, and current rating, as specified for your product.

DO NOT OPERATE IN EXPLOSIVE ATMOSPHERES

To avoid explosion, do not operate this product in an explosive environment unless it has been specifically certified for such operation.

HIGH VOLTAGE DANGER

High voltage is present in the cable, and in the sensor when the controller is turned on.

Sicherheitshinweise

In dieser Betriebsanleitung vorkommende Symbole

Definition der mit WARNUNG!, VORSICHT! und HINWEIS überschriebenen Abschnitte in dieser Betriebsanleitung.

Warnung!

Das Symbol WARNUNG! weist auf eine Gefahrenquelle hin. Es macht auf einen Arbeitsablauf, eine Arbeitsweise, einen Zustand oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. ungenügende Berücksichtigung zu Körperverletzung führen kann.

Vorsicht!

Das Symbol VORSICHT! weist auf eine Gefahrenquelle hin. Es macht auf einen Bedienungsablauf, eine Arbeitsweise oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. Ungenügende Berücksichtigung zu einer Beschädigung oder Zerstörung des Produkts oder von Teilen des Produkts führen kann.

Hinweis

Das Symbol HINWEIS weist auf eine wichtige Mitteilung hin, die auf einen Arbeitsablauf, eine Arbeitsweise, einen Zustand oder eine sonstige Gegebenheit von besonderer Wichtigkeit aufmerksam macht.

Am Gerät angebrachte Symbole

Der untenstehenden Tabelle sind die Bedeutungen der Symbole zu entnehmen, die an dem Gerät angebracht sind.

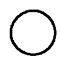
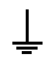
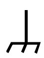
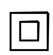
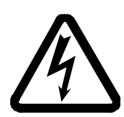
Definitionen der am Gerät angebrachten Symbole			
 Ein (Netz) IEC 417, Nr. 5007	 Aus (Netz) IEC 417, Nr. 5008	 Erde IEC 417, Nr. 5017	 Schutzleiter IEC 417, Nr. 5019
 Rahmen oder Chassis IEC 417, Nr. 5020	 Äquipotentialanschluß IEC 417, Nr. 5021	 Gleichstrom IEC 417, Nr. 5031	 Wechselstrom IEC 417, Nr. 5032
 Wechselstrom und Gleichstrom IEC 417, Nr. 5033-a	 Geräteklasse II IEC 417, Nr. 5172-a	 Drehstrom IEC 617-2 Nr. 020206	
 Vorsicht! Bitte Begleitdokumente lesen! ISO 3864, Nr. B.3.1	 Vorsicht! Stromschlaggefahr! ISO 3864, Nr. B.3.6	 Vorsicht! Heiße Fläche! IEC 417, Nr. 5041	

Tabelle 2: Definitionen der am Gerät angebrachten Symbole

Sicherheitsvorschriften und Vorsichtsmaßnahmen

Die untenstehenden allgemeinen Sicherheitsvorschriften sind bei allen Betriebs-phasen dieses Instruments zu befolgen. Jede Mißachtung dieser Sicherheits-vorschriften oder sonstiger spezifischer Warnhinweise in dieser Betriebsanleitung stellt eine Zuwiderhandlung der für dieses Instrument geltenden Sicherheits-standards dar und kann die an diesem Instrument vorgesehenen Schutzvor-richtungen unwirksam machen. MKS Instruments, Inc. haftet nicht für eine Mißachtung dieser Sicherheitsvorschriften seitens des Kunden.

Keine Teile austauschen und keine Veränderungen vornehmen!

Bauen Sie in das Instrument keine Ersatzteile ein, und nehmen Sie keine eigenmächtigen Änderungen am Gerät vor! Schicken Sie das Instrument zu Wartungs- und Reparatur-zwecken an einen MKS-Kalibrierungs- und -Kundendienst ein! Dadurch wird sicher-gestellt, daß alle Sicherheitseinrichtungen voll funktionsfähig bleiben.

Wartung nur durch qualifizierte Fachleute!

Das Gehäuse des Instruments darf vom Bedienpersonal nicht geöffnet werden. Das Auswechseln von Bauteilen und das Vornehmen von internen Einstellungen ist nur von qualifizierten Fachleuten durchzuführen.

Produkt erden!

Dieses Produkt ist mit einer Erdleitung und einem Schutzkontakt am Netzstecker versehen. Um der Gefahr eines elektrischen Schlages vorzubeugen, ist das Netzkabel an einer vorschriftsmäßig geerdeten Schutzkontaktsteckdose anzuschließen, bevor es an den Eingangs- bzw. Ausgangsklemmen des Produkts angeschlossen wird. Das Instrument kann nur sicher betrieben werden, wenn es über den Erdleiter des Netzkabels und einen Schutzkontakt geerdet wird.

Gefährdung durch Verlust der Schutzerdung!

Geht die Verbindung zum Schutzleiter verloren, besteht an sämtlichen zugänglichen Teilen aus stromleitendem Material die Gefahr eines elektrischen Schlages. Dies gilt auch für Knöpfe und andere Bedienelemente, die dem Anschein nach isoliert sind.

Erdung und Verwendung geeigneter elektrischer Armaturen!

In diesem Instrument liegen gefährliche Spannungen an. Alle verwendeten elektrischen Armaturen und Kabel müssen dem angegebenen Typ entsprechen und sich in einwand-freiem Zustand befinden. Alle elektrischen Armaturen sind vorschriftsmäßig anzubringen und zu erden.

Richtiges Netzkabel verwenden!

Das verwendete Netzkabel muß sich in einwandfreiem Zustand befinden und den in der Betriebsanleitung enthaltenen Anschlußwerten entsprechen.

Das Netzkabel muß abnehmbar sein. Der Querschnitt der einzelnen Leiter darf nicht weniger als 0,75 mm^2 betragen. Das Netzkabel sollte einen Prüfvermerk einer zuständigen Prüfstelle tragen, z.B. VDE, Semko oder SEV.

Richtige Stromquelle verwenden!

Dieses Produkt ist für eine Stromquelle vorgesehen, bei der die zwischen den Leitern bzw. zwischen jedem der Leiter und dem Masseleiter anliegende Spannung den in dieser Betriebsanleitung angegebenen Wert nicht überschreitet.

Richtige Sicherung benutzen!

Es ist eine Sicherung zu verwenden, deren Typ, Nennspannung und Nennstromstärke den Angaben für dieses Produkt entsprechen.

Gerät nicht in explosiver Atmosphäre benutzen!

Um der Gefahr einer Explosion vorzubeugen, darf dieses Gerät nicht in der Nähe explosiver Stoffe eingesetzt werden, sofern es nicht ausdrücklich für diesen Zweck zertifiziert worden ist.

Hochspannungsgefahr!

Bei eingeschaltetem Steuerteil liegt im Kabel und im Sensor Hochspannung an.

Informations relatives à la sécurité

Symboles utilisés dans ce manuel d'utilisation

Définition des indications AVERTISSEMENT, ATTENTION et REMARQUE utilisées dans ce manuel.

Avertissement

L'indication AVERTISSEMENT signale un danger potentiel. Elle est destinée à attirer l'attention sur une procédure, une utilisation, une situation ou toute autre chose présentant un risque de blessure en cas d'exécution incorrecte ou de non-respect des consignes.

Attention

L'indication ATTENTION signale un danger potentiel. Elle est destinée à attirer l'attention sur une procédure, une utilisation, une situation ou toute autre chose présentant un risque d'endommagement ou de dégât d'une partie ou de la totalité de l'appareil en cas d'exécution incorrecte ou de non-respect des consignes.

Remarque

L'indication REMARQUE signale des informations importantes. Elle est destinée à attirer l'attention sur une procédure, une utilisation, une situation ou toute autre chose présentant un intérêt particulier.

Symboles apparaissant sur l'appareil

Le tableau suivant décrit les symboles apparaissant sur l'appareil.

Définition des symboles apparaissant sur l'appareil			
Marche (sous tension) IEC 417, No. 5007	Arrêt (hors tension) IEC 417, No. 5008	Terre (masse) IEC 417, No. 5017	Terre de protection (masse) IEC 417, No. 5019
Masse IEC 417, No. 5020	Equipotentialité IEC 417, No. 5021	Courant continu IEC 417, No. 5031	Courant alternatif IEC 417, No. 5032
Courant continu et alternatif IEC 417, No. 5033-a	Matériel de classe II IEC 417, No. 5172-a	Courant alternatif triphasé IEC 617-2 No. 020206	
Attention : se reporter à la documentation ISO 3864, No. B.3.1	Attention : risque de secousse électrique ISO 3864, No. B.3.6	Attention : surface brûlante IEC 417, No. 5041	

Tableau 3 : Définition des symboles apparaissant sur l'appareil

Mesures de sécurité et mises en garde

Prendre toutes les précautions générales suivantes pendant toutes les phases d'utilisation de cet appareil. Le non-respect de ces précautions ou des avertissements contenus dans ce manuel entraîne une violation des normes de sécurité relatives à l'utilisation de l'appareil et le risque de réduire le niveau de protection fourni par l'appareil. MKS Instruments, Inc. ne prend aucune responsabilité pour les conséquences de tout non-respect des consignes de la part de ses clients.

NE PAS SUBSTITUER DES PIÈCES OU MODIFIER L'APPAREIL

Ne pas utiliser de pièces détachées autres que celles vendues par MKS Instruments, Inc. ou modifier l'appareil sans l'autorisation préalable de MKS Instruments, Inc. Renvoyer l'appareil à un centre d'étalonnage et de dépannage MKS pour tout dépannage ou réparation afin de s'assurer que tous les dispositifs de sécurité sont maintenus.

DÉPANNAGE EFFECTUÉ UNIQUEMENT PAR UN PERSONNEL QUALIFIÉ

L'opérateur de l'appareil ne doit pas enlever le capot de l'appareil. Le remplacement des composants et les réglages internes doivent être effectués uniquement par un personnel d'entretien qualifié.

MISE À LA TERRE DE L'APPAREIL

Cet appareil est mis à la terre à l'aide du fil de terre du cordon d'alimentation. Pour éviter tout risque de secousse électrique, brancher le cordon d'alimentation sur une prise de courant correctement câblée avant de le brancher sur les bornes d'entrée ou de sortie de l'appareil. Une mise à la terre de protection à l'aide du fil de terre du cordon d'alimentation est indispensable pour une utilisation sans danger de l'appareil.

DANGER LIÉ À UN DÉFAUT DE TERRE

En cas de défaut de terre, toutes les pièces conductrices accessibles (y compris les boutons de commande ou de réglage qui semblent être isolés) peuvent être source d'une secousse électrique.

MISE À LA TERRE ET UTILISATION CORRECTE D'ACCESSOIRES ÉLECTRIQUES

Des tensions dangereuses existent à l'intérieur de l'appareil. Tous les accessoires et les câbles électriques doivent être conformes au type spécifié et être en bon état. Tous les accessoires électriques doivent être correctement connectés et mis à la terre.

UTILISATION D'UN CORDON D'ALIMENTATION APPROPRIÉ

Utiliser uniquement un cordon d'alimentation en bon état et conforme aux exigences de puissance d'entrée spécifiées dans le manuel.

Utiliser uniquement un cordon d'alimentation amovible avec des conducteurs dont la section est égale ou supérieure à 0,75 mm^2. Le cordon d'alimentation doit être approuvé par un organisme compétent tel que VDE, Semko ou SEV.

UTILISATION D'UNE ALIMENTATION APPROPRIÉE

Cet appareil est conçu pour fonctionner en s'alimentant sur une source de courant électrique n'appliquant pas une tension entre les conducteurs d'alimentation, ou entre les conducteurs d'alimentation et le conducteur de terre, supérieure à celle spécifiée dans le manuel.

UTILISATION D'UN FUSIBLE APPROPRIÉ

Utiliser uniquement un fusible conforme au type, à la tension nominale et au courant nominal spécifiés pour l'appareil.

NE PAS UTILISER DANS UNE ATMOSPHÈRE EXPLOSIVE

Pour éviter tout risque d'explosion, ne pas utiliser l'appareil dans une atmosphère explosive à moins qu'il n'ait été approuvé pour une telle utilisation.

DANGER DE HAUTE TENSION

Une haute tension est présente dans le câble et dans le capteur lorsque le contrôleur est sous tension.

Información sobre seguridad

Símbolos usados en el manual de instrucciones

Definiciones de los mensajes de ADVERTENCIA, PRECAUCIÓN Y OBSERVACIÓN usados en el manual.

Advertencia

El símbolo de ADVERTENCIA indica un riesgo. Pone de relieve un procedimiento, práctica, condición, etc., que, de no realizarse u observarse correctamente, podría causar lesiones a los empleados.

Precaución

El símbolo de PRECAUCIÓN indica un riesgo. Pone de relieve un procedimiento, práctica, etc., de tipo operativo que, de no realizarse u observarse correctamente, podría causar desperfectos al instrumento, o llegar incluso a causar su destrucción total o parcial.

Observación

El símbolo de OBSERVACIÓN indica información de importancia. Pone de relieve un procedimiento, práctica, condición, etc., cuyo conocimiento resulta esencial.

Símbolos que aparecen en la unidad

En la tabla que figura a continuación se indican los símbolos que aparecen en la unidad.

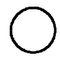
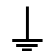
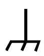
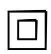
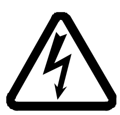
Definición de los símbolos que aparecen en la unidad			
 Encendido (alimentación eléctrica) IEC 417, N.° 5007	 Apagado (alimentación eléctrica) IEC 417, N.° 5008	 Puesta a tierra IEC 417, N.° 5017	 Protección a tierra IEC 417, N.° 5019
 Caja o chasis IEC 417, N.° 5020	 Equipotencialidad IEC 417, N.° 5021	 Corriente continua IEC 417, N.° 5031	 Corriente alterna IEC 417, N.° 5032
 Corriente continua y alterna IEC 417, N.° 5033-a	 Equipo de clase II IEC 417, N.° 5172-a	 Corriente alterna trifásica IEC 617-2 N.° 020206	
 Precaución. Consultar los documentos adjuntos ISO 3864, N.° B.3.1	 Precaución. Riesgo de descarga eléctrica ISO 3864, N.° B.3.6	 Precaución. Superficie caliente IEC 417, N.° 5041	

Tabla 4 : Definición de los símbolos que aparecen en la unidad

Procedimientos y precauciones de seguridad

Las precauciones generales de seguridad que figuran a continuación deben observarse durante todas las fases de funcionamiento del presente instrumento. La no observancia de dichas precauciones, o de las advertencias específicas a las que se hace referencia en el manual, contraviene las normas de seguridad referentes al uso previsto del instrumento y podría impedir la protección que proporciona el instrumento. MKS Instruments, Inc., no asume responsabilidad alguna en caso de que el cliente haga caso omiso de estos requerimientos.

NO UTILIZAR PIEZAS NO ORIGINALES NI MODIFICAR EL INSTRUMENTO

No se debe instalar piezas que no sean originales ni modificar el instrumento sin autorización. Para garantizar que las prestaciones de seguridad se observen en todo momento, enviar el instrumento al Centro de servicio y calibración de MKS cuando sea necesaria su reparación y servicio de mantenimiento.

REPARACIONES EFECTUADAS ÚNICAMENTE POR TÉCNICOS ESPECIALIZADOS

Los operarios no deben retirar las cubiertas del instrumento. El cambio de piezas y los reajustes internos deben efectuarlos únicamente técnicos especializados.

PUESTA A TIERRA DEL INSTRUMENTO

Este instrumento está puesto a tierra por medio del conductor de tierra del cable eléctrico. Para evitar descargas eléctricas, enchufar el cable eléctrico en una toma debidamente instalada, antes de conectarlo a las terminales de entrada o salida del instrumento. Para garantizar el uso sin riesgos del instrumento resulta esencial que se encuentre puesto a tierra por medio del conductor de tierra del cable eléctrico.

PELIGRO POR PÉRDIDA DE LA PUESTA A TIERRA

Si se pierde la conexión protectora de puesta a tierra, todas las piezas conductoras a las que se tiene acceso (incluidos los botones y mandos que pudieran parecer estar aislados) podrían producir descargar eléctricas.

PUESTA A TIERRA Y USO DE ACCESORIOS ELÉCTRICOS ADECUADOS

Este instrumento funciona con voltajes peligrosos. Todos los accesorios y cables eléctricos deben ser del tipo especificado y mantenerse en buenas condiciones. Todos los accesorios eléctricos deben estar conectados y puestos a tierra del modo adecuado.

USAR EL CABLE ELÉCTRICO ADECUADO

Usar únicamente un cable eléctrico que se encuentre en buenas condiciones y que cumpla los requisitos de alimentación de entrada indicados en el manual.

Usar únicamente un cable desmontable instalado con conductores que tengan un área de sección transversal equivalente o superior a 0,75mm². El cable eléctrico debe estar aprobado por una entidad autorizada como, por ejemplo, VDE, Semko o SEV.

USAR LA FUENTE DE ALIMENTACIÓN ELÉCTRICA ADECUADA

Este instrumento debe funcionar a partir de una fuente de alimentación eléctrica que no aplique más voltaje entre los conductores de suministro, o entre uno de los conductores de suministro y la puesta a tierra, que el que se especifica en el manual.

USAR EL FUSIBLE ADECUADO

Usar únicamente un fusible del tipo, clase de voltaje y de corriente adecuados, según lo que se especifica para el instrumento.

EVITAR SU USO EN ENTORNOS EXPLOSIVOS

Para evitar el riesgo de explosión, no usar este instrumento o en un entorno explosivo, a no ser que haya sido certificado para tal uso.

PELIGRO POR ALTO VOLTAJE

Cuando el controlador está encendido, se registra alto voltaje en el cable y en el sensor.

Chapter One: General Information

Introduction

The Type 651C instrument is a self-tuning pressure controller for throttle valves. It can supply ±15 Volts to power and provide a readout for an attached capacitance manometer. The self-tuning feature of the Type 651 unit determines system characteristics necessary for control. This feature takes into account time constants, transfer functions of the valve and plumbing, valve gain, pump speed, and many other important parameters when determining the system characteristics. The 651 unit also includes an adjustable softstart function (to minimize turbulence in the chamber and contamination of the process), Local/Remote transducer zeroing capability, and two process limit relays to indicate if the pressure deviates from the desired trip points.

Located on the front panel is a Key Lock switch used to select front panel or rear panel control. The switch can lock the front panel controls as a safety measure to prevent accidental command entries. The default window display on the front panel shows the pressure readout and the valve position (% open). The pressure readout can be displayed in units of Torr, mTorr, mbar, μbar, Pascal, kPa, cmH_2O, or inH_2O. Five reprogrammable set points are provided, each one having the option of being setup for pressure or position control. Valve open, close, and stop functions are also provided on the front panel for use in system setup and diagnostics.

The 651 instrument has a high-powered driver to operate most MKS type throttle valves, including valves up to 100 mm (4”) with vacuum shut-off capability, giving the unit a control range from 10^{-4} to 760 Torr with the appropriate pressure transducers *Appendix C: Product Compatibility*, page 117, lists all MKS products that are compatible with the 651 controller. All MKS unheated and 45° C temperature-controlled, linear Baratron® transducers are compatible with the 651 controller, which is equipped with a low-capacity power supply. The 651 unit can be optionally equipped with a high-capacity power supply, enabling compatibility with 100° C temperature-controlled, linear Baratron transducers. The 651 unit contains a battery-backed memory module which stores configuration and *learned* system information while power is off. There is also an optional valve failsafe battery backup available. The optional battery backup allows user-configuration of the 651 instrument to drive a valve open or closed upon an AC power failure.

How This Manual is Organized

This manual is designed to provide instructions on how to set up, install and operate a Type 651 unit.

Before installing your Type 651 unit in a system and/or operating it, carefully read and familiarize yourself with all precautionary notes in the *Safety Messages and Procedures* section at the front of this manual. In addition, observe and obey all WARNING and CAUTION notes provided throughout the manual.

Chapter One, *General Information*, (this chapter) introduces the product.

Chapter Two, *Installation*, explains environmental requirements and practical considerations to take into account when selecting the proper setting for the pressure control instrument.

Chapter Three, *Overview*, reviews the 651 pressure controller. It describes the components on both the front and rear panels and describes the electrical connections.

Chapter Four, *System Setup*, explains how to connect a valve and set up the 651 pressure controller using the menu selection prompts displayed on the front panel.

Chapter Five, *Local Operation*, describes how to operate the instrument from the front panel and includes detailed instructions for using each of the functions available in Local mode.

Chapter Six, *Remote Operation*, describes RS-232 control and the digital logic operation.

Chapter Seven, *Battery-Backed Memory Module*, provides instructions on how to replace the battery-backed memory module.

Chapter Eight, *Valve Failsafe Battery Backup Option*, provides information on the optional valve failsafe battery backup.

Chapter Nine, *Maintenance*, provides general maintenance procedures.

Appendix A, *Product Specifications*, lists product specifications for the 651 instrument.

Appendix B, *Model Code Explanation*, describes the instrument’s ordering code.

Appendix C, *Products Compatibility* supplies information about MKS compatible products.

Appendix D, *Displayless Version*, describes the displayless version and how it differs from the standard 651 unit.

Appendix E, *Initial Settings*, lists the initial settings for the controller.

Appendix F, *Command and Request Reference*, is a summary of the RS-232 commands and responses.

Customer Support

Standard maintenance and repair services are available at all of our regional MKS Calibration and Service Centers, listed on the back cover. In addition, MKS accepts the instruments of other manufacturers for recalibration using the Primary and Transfer Standard calibration equipment located at all of our regional service centers. Should any difficulties arise in the use of your Type 651 instrument, or to obtain information about companion products MKS offers, contact any authorized MKS Calibration and Service Center. If it is necessary to return the instrument to MKS, please obtain an ERA Number (Equipment Return Authorization Number) from the MKS Calibration and Service Center before shipping. The ERA Number expedites handling and ensures proper servicing of your instrument.

Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Warning

All returns to MKS Instruments must be free of harmful, corrosive, radioactive, or toxic materials.

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Chapter Two: Installation

How To Unpack the Type 651 Unit

MKS has carefully packed the Type 651 unit so that it will reach you in perfect operating order. Upon receiving the unit, however, you should check for defects, cracks, broken connectors, etc., to be certain that damage has not occurred during shipment.

Note Do *not* discard any packing materials until you have completed your inspection and are sure the unit arrived safely.

If you find any damage, notify your carrier and MKS immediately. If it is necessary to return the instrument to MKS, obtain an ERA Number (Equipment Return Authorization Number) from the MKS Service center before shipping. Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Caution **Only qualified individuals should perform the installation and any user adjustments. They must comply with all the necessary ESD and handling precautions while installing and adjusting the instrument. Proper handling is essential when working with all highly sensitive precision electronic instruments.**

Unpacking Checklist

Standard Equipment:

- Type 651 Pressure Controller
- Type 651 Instruction Manual (this book)
- Key for the front panel Key Lock switch
- Power Cable

Optional Equipment:

- 651-K1 accessory kit (includes an I/O connector for the rear panel of the unit, a connector cover for the I/O connector, and a screwlock assembly for the I/O connector cover)
- Cables for supported sensors and the MKS Types 253 or 653 valves
- RM-13 or RM-14 rack mount option
- Valve failsafe battery backup (installed in the unit at the factory)
- MKS RS-232 Serial Communications Cable (CB651-10-10)

Note

1. An overall metal braided shielded cable, properly grounded at both ends, is required to meet CE specifications.
2. To order a metal braided shielded cable, add an "S" after the cable type designation. For example, to order a standard cable to connect the 651 controller to a Type 627 transducer, use part number CB259-5-10; for a metal braided, shielded cable use part number CB259S-5-10.

Product Location and Requirements

The Type 651 unit meets the following criteria:

- POLLUTION DEGREE 2 in accordance with IEC 664
- Transient overvoltages according to INSTALLATION CATEGORY II

Operating Environmental Requirements

- Ambient Operating Temperature: 15° to 40° C (60° to 104° F)
  15° to 35° C (60° to 95° F) with optional valve failsafe battery back-up
- Main supply voltage fluctuations must not exceed ±10% of the nominal voltage
- Ventilation requirements include sufficient air circulation
- Connect the power cord into a grounded outlet

Safety Conditions

The 651 controller poses no safety risk under the following environmental conditions:

- Altitude: up to 2000 m
- Maximum relative humidity: 80% for temperatures up to 31 °C, decreasing linearly to 50% at 40° C

Setup

Environmental Requirements

Follow these requirements when installing and using a 651 pressure controller.

1. Operating ambient temperature must be in the range of 15° to 40° C (15° to 35° C when equipped with the optional valve failsafe battery backup).

2. Humidity must be kept between 0 and 95%, non-condensing.

3. Position the unit with proper clearance, to allow air cooling, so that the unit can operate within the product temperature specifications listed above.

4. The 651 unit can be mounted in a panel cutout or in either a 9-inch deep or 12-inch deep rack. (The optional valve failsafe battery backup requires 12 inches).

   A. The RM-13 rack mount option supports a 9-inch deep rack.

   B. The RM-14 rack mount option supports a 12-inch deep rack.

5. Power and fuse requirements for both the low power and high power units are listed in *Checking the Fuses and Line Voltage Selector Switch*, page 24.

Caution

A. Check to make sure the voltage setting is correct for your local electrical source.

B. Check to make sure the fuse type is appropriate for your voltage setting.

6. A solid system ground should be maintained for proper operation and safety to personnel.

For additional Type 651 controller requirements refer to *Appendix A: Product Specifications*, page 113.

Checking the Fuses and Line Voltage Selector Switch

The 651 unit is shipped with the line voltage set for 115 VAC. If you need to operate the unit with a 230 VAC line voltage, follow the instructions in this section. Refer Table 5 for information on the fuse types.

Fuse Information			
Power Supply Option	**Nominal Line**	**Line Voltage Range**	**Fuse Type**
Low power	115 VAC	90-132 VAC @50/60 Hz 75 VA (max)	0.63A (T), 250V, 5 x 20 mm
	230 VAC	180-264 VAC @50/60 Hz 75 VA (max)	0.315A (T), 250V, 5 x 20 mm
High power	115 VAC	90-132 VAC @48/62 Hz 150 VA (max)	1.25A (T), 250V, 5 x 20 mm
	230 VAC	180-264 VAC @48/62 Hz 150 VA (max)	0.63A (T), 250V, 5 x 20 mm

Table 5: Fuse Information

Note

The fuses are IEC rated (where the name plate value is the expected current *carrying* rating) and not UL or CSA rated (where the name plate value is nearly the current *blowing* rating). Use of UL or CSA rated fuses will cause unnecessary blowing at high loads.

Appropriate replacement fuses include:

- Bussmann GDC-T315 mA or equivalent for the 0.315 A fuse
- Bussmann GDC-T630 mA or equivalent for the 0.63 A fuse
- Bussmann GDC-T1.25 A or equivalent for the 1.25 A fuse

How To Change the Line Voltage

1. Check the current line voltage setting.

   Refer to Figure 1 for the location of the voltage selector switch on the *low power* unit, or to Figure 2, page 26, for the location of the switch on the *high power* unit. The label above the switch (on either unit) shows the corresponding voltage range and fuse requirements for either voltage setting.

2. Use a small device, for example, a screwdriver, to set the switch to the left position for operation in the 115 V range, or to the right position for operation in the 230 V range.

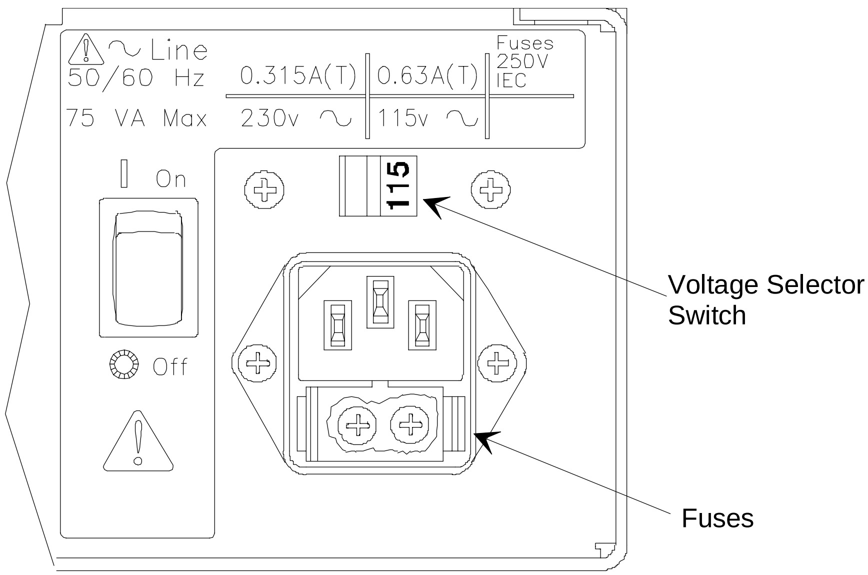

Figure 1: Voltage and Fuse Data for the Low Power Unit

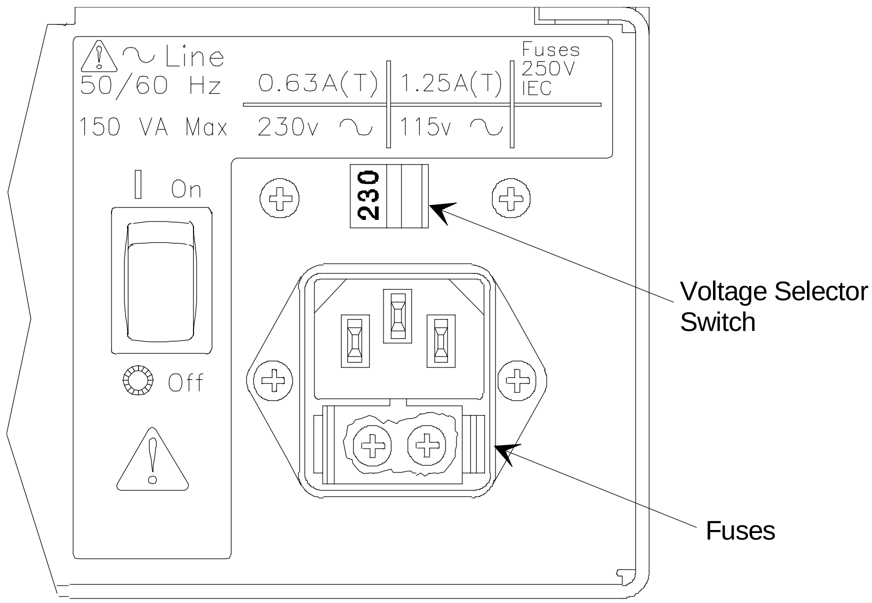

Figure 2: Voltage and Fuse Data for the High Power Unit

The 651 pressure controller is now ready for valve connection and system setup. Refer to *Chapter Three: Overview*, page 27, for an overview of the controller and to *Chapter Four: System Setup*, page 39, for instructions on how to setup and operate the unit.

Chapter Three: Overview

Front Panel

Front Panel Components

Figure 3 labels all the components located on the front panel of the 651 instrument. Table 6, page 28, summarizes the functions of the front panel components.

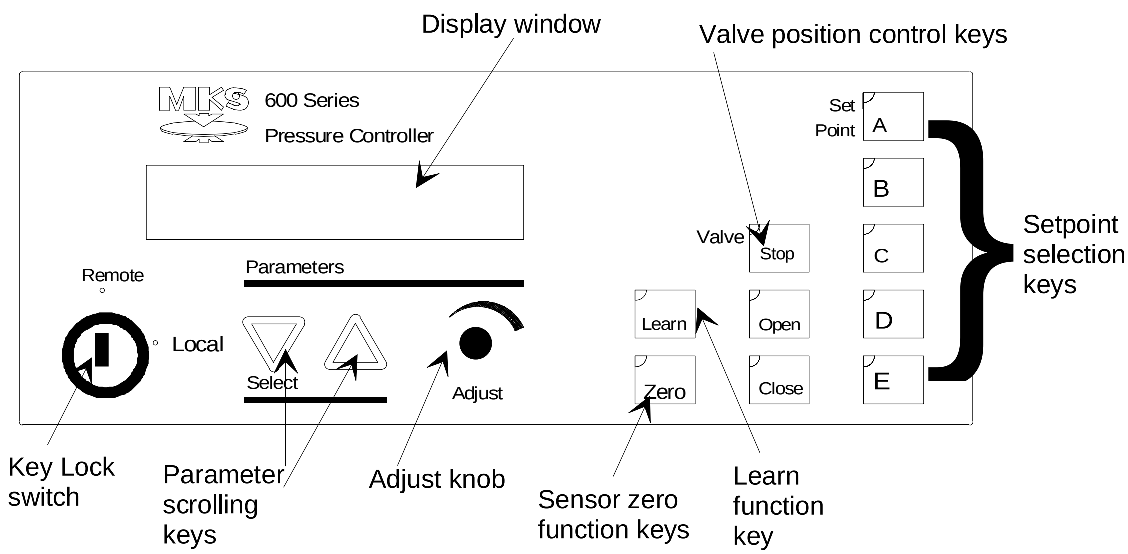

Figure 3: Front Panel of the 651 Instrument

Front Panel Display

The front panel display shows pressure and valve position by default. The down scrolling key, [▽] selects the previous display in the display list. The up scrolling key, [△] scrolls to the next display in the display sequence.

Summary of Front Panel Components	
Front Panel Component	**Function**
Key Lock switch	Switches between Local (front panel), and Remote (rear panel), control. The switch must be set to Remote to remove the key.
Display window	Displays pressure and the valve position by default. Other displays include information such as set points, trip limits, battery voltage, and softstart rate (depending on how the unit is configured).
Parameter scrolling keys	Used to scroll through displays: [▽] down, and [△] up.
Adjust knob	Used to enter parameter values.
Learn function key	Used to enable the learn function within the 651 unit. In a control system with a positive flow rate, the 651 learn function determines the system characteristics necessary for self-tuning control.
Sensor zero function key	Used to zero an attached sensor.
Valve position control keys	Used to select the valve position. The possibilities are open, close, and stop.
Set point selection keys	Used to select which set point (A through E), is the active set point.
Lights	The lights on the front panel are not visible unless lit. They indicate which parameter(s) (ex. set point A), or function(s) (ex. learn) is currently active.

Table 6: Summary of Front Panel Components

Local and Remote Operation

The Key Lock switch is used to select front panel control (Local) or rear panel control (Remote). When set to Local, control command input and set point parameter modification must be entered via the front panel. Information *requests* (not commands) and 651 unit *responses*, however, may still be sent through the Serial Interface connector on the rear panel. Refer to Table 26, page 128, and Table 27, page 134, for a listing of the request and return message protocol.

When the Key Lock switch is set to Remote, the front panel becomes locked out. This is a useful feature for preventing accidental command entries. It is still possible, however, to scroll through the displays to view existing parameters using the [▽] and [△] keys. When in Remote mode, control command input and set point parameter modification must be entered via the rear panel either by RS-232 command protocol at the Serial Interface connector or through digital logic levels at the I/O connector. Refer to Figure 4, page 31, for the location of the connectors, to Table 8, page 32, for the Serial RS-232 Interface connector pinout, and to Table 10, page 34, for the I/O connector pinout. *Chapter Six: Remote Operation*, page 61, contains more detailed information about RS-232 control and digital logic operation.

Command Priority

The 651 pressure controller responds to the most recent command, whether it is issued in Local mode or Remote mode. In switching from Remote to Local, the 651 instrument will respond to the last command issued in Remote until a new command is issued in Local. In switching from Local to Remote, the 651 instrument will continue to respond to the last command issued in Local until a new command is issued in Remote.

Control Mode: Self-Tuning or PID Control

The 651 instrument can control a vacuum system in one of two ways. When used in the *Self-Tuning* control mode, the 651 instrument determines control parameters based upon the system's characteristics using a unique control algorithm, and does not require the input of lead or gain values. To activate this feature from the front panel, be sure the Key Lock switch is set to Local, and hold down both scrolling keys simultaneously for approximately three seconds, to enter the Setup menu. Scroll through the Setup menu until the Control mode entry appears. The Control mode screen is shown on page 41. To change from PID to Self-Tuning, turn the Adjust knob counterclockwise. Then press the [Learn] key for about three seconds. Once the unit has *learned* the system characteristics, it can operate with the Key Lock switch set to either Local or Remote. Refer to *How To Activate the Learn Function*, page 70, for more information about the [Learn] key.

When used in the *PID* control mode, the 651 unit employs a **P**roportional, **I**ntegral, and **D**erivative (PID) algorithm for control. PID control requires the input of user-defined lead and gain values. Each set point uses its own lead and gain values to optimize response from set point to set point. Although there are default values for lead and gain, you should enter the values for optimum control. To enter lead and gain parameters from the front panel, the Key Lock switch must be set to Local. Select PID Pressure control from the Setup menu to set the lead and gain values. (To enter the Setup menu, hold down both scrolling keys simultaneously for approximately three seconds. Scroll through the Setup menu until the Control mode entry appears. To change from Self-Tuning to PID, turn the Adjust knob clockwise.) Once the lead and gain parameters have been entered, the 651 unit can operate with the Key Lock switch set to either Local or Remote. Refer to *How To Set the Lead and Gain Parameters*, page 81, for instructions on setting lead and gain parameters.

The control mode selection applies to the five internal set points (A through E) and the analog set point.

Softstart Control

The softstart feature is used to reduce the rate at which a control valve moves toward set point. The rate is given as a percent of full speed and can be used on either a pressure or position set point. Once set point is achieved under softstart control, the valve is free to move at full speed. Softstart control can be applied to set points A through E, analog set point, valve open, and valve close. Refer to *Chapter Four: System Setup*, page 39, for instructions on how to set softstart rates from the front panel.

If a set point is established via RS-232 input, the softstart rate for that set point is selected through use of the **I6** *value* RS-232 command. If an analog set point is established via digital logic input, the softstart rate for the analog set point is controlled by digital logic on pin 7 of the I/O connector. To achieve softstart control of digital logic or analog set points, the *softstart line must be held low*. If the line is *not* held low, the valve will move at 100% full speed. Refer to *Chapter Six: Remote Operation*, page 61, for additional information about softstart control via the rear panel.

Battery Backups

There are two types of batteries used in the 651 instrument: a lithium battery and an optional lead-acid battery. The lithium battery is included inside each 651 unit and is used to power memory for storage of configuration and learned system information while power is off. The optional lead-acid battery allows user-configuration of the 651 instrument to drive a valve open or closed upon an AC power failure.

Rear Panel

Rear Panel Components

Figure 4 labels all the components located on the rear panel of the 651 instrument. The power On/Off switch and the line voltage selector switch are on the back of the 651 unit. The four Type "D" connectors are also located on the rear panel.

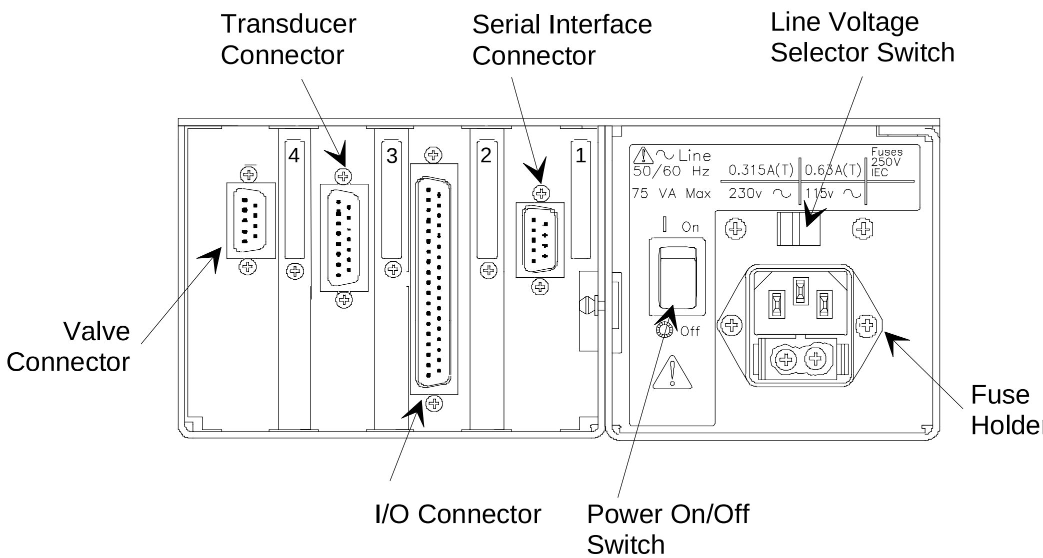

Figure 4: Rear Panel of the 651 Instrument

The connectors are numbered on the rear panel, as listed in Table 7.

Slot Labels	
Slot	**Label**
Serial Interface connector	1
I/O connector	2
Transducer connector	3
Valve connector	4

Table 7: Slot Labels

Electrical Connections

Tables 8 through 14, on the following pages, list each connector's pinout as well as corresponding MKS cable numbers.

Note

1. An overall metal braided shielded cable, properly grounded at both ends, is required to meet CE specifications.
2. To order a metal braided shielded cable, add an "S" after the cable type designation. For example, to order a standard cable to connect the 651 controller to a Type 627 transducer, use part number CB259-5-10; for a metal braided, shielded cable use part number CB259S-5-10.

<table>
<tr><th colspan="2">Serial RS-232 Interface Connector Pinout</th></tr>
<tr><th>Pin Number</th><th>Function</th></tr>
<tr><td>1</td><td>No connection</td></tr>
<tr><td>2</td><td>Transmit data</td></tr>
<tr><td>3</td><td>Receive data</td></tr>
<tr><td>4</td><td>No connection</td></tr>
<tr><td>5</td><td>Digital ground</td></tr>
<tr><td>6</td><td>Reserved</td></tr>
<tr><td>7</td><td>Reserved</td></tr>
<tr><td>8</td><td>No connection</td></tr>
<tr><td>9</td><td>No connection</td></tr>
<tr><td colspan="2">A Reserved pin assignment means that the pin has an internal connection and may be assigned a function in the future. The No Connection pin assignment refers to a pin with no internal connection.</td></tr>
</table>

Table 8: Serial RS-232 Interface Connector Pinout

RS-232 Serial Communication Cables	
Serial Interface Cable	**Cable Number**
651 Serial Communications to 9-pin serial port (pins 2 and 3 straight through)	CB651-10-10
651 Serial Communications to 25-pin serial port (pins 2 and 3 reversed)	CB651-11-10

Table 9: RS-232 Serial Communication Cables

Caution

The MKS RS-232 Serial Communications cable (CB651-10-10) *must* be used for the 9-pin, Serial Interface connector. Unlisted pins on this connector are not compatible with the current Type "D" 9-pin, industry-standard cable.

I/O Connector Pinout	
Pin Number	**Function**
1	PLO relay #1 - NC contact
2	PLO relay #1 - NO contact
3	PLO relay #2 - NC contact
4	Digital ground
5	Learn system (low)
6	Hold *both* pin 6 and pin 11 low to select analog set point with position control
7	Softstart (low)
8	Close valve (low)
9	Reserved
10	Analog set point ÷ 10
11	Hold *only* pin 11 low to select analog set point with pressure control Hold *both* pin 6 and pin 11 low to select analog set point with position control
12	Select set point E (low)
13	Select set point D (low)
14	Select set point C (low)
15	Select set point B (low)
16	Select set point A (low)
17	Reserved
18	Reserved
19	Valve open status (hi = open)
20	PLO relay 1 - common contact
21	PLO relay 2 - common contact
22	PLO relay 2 - NO contact
23	Valve closed status (hi = closed)
24	Reserved

Table 10: I/O Connector Pinout
(Continued on next page)

I/O Connector Pinout *(Continued)*	
Pin Number	**Function**
25	Remote zero (low)
26	Stop valve (low)
27	Open valve (low)
28	PLO #2 status (low = out of limit)
29	PLO #1 status (low = out of limit)
30	+15V Output
31	-15V Output
32	Power ground
33	+ Set point input
34	- Set point input
35	Analog ground
36	Pressure output voltage
37	Position output voltage
A *Reserved* pin assignment means that the pin has an internal connection and may be assigned a function in the future. The *No Connection* pin assignment refers to a pin with no internal connection.	

Table 10: I/O Connector Pinout

Transducer Connector Pinout	
Pin Number	**Function**
1	+15V Supply
2	+ Pressure input
3	Reserved
4	Reserved
5	Power ground
6	-15 V Supply
7	+15 V Supply
8	Reserved
9	-15 V Supply
10	Reserved
11	Digital ground
12	- Pressure input
13	Reserved
14	Reserved
15	Chassis ground

Table 11: Transducer Connector Pinout

System Interface Cables for MKS Transducers	
Transducer Type Number	**Cable Numbers**
122/124/223/225/622/623	CB112-2-10
127/128/624/625/626/627/628	CB259-5-10
120	CB120-1-10
220	CB112-10-10
121/221	CB112-14-10

Table 12: System Interface Cables for MKS Transducers

Valve Connector Pinout	
Pin Number	**Function**
1	Motor winding A low
2	Motor winding A high
3	Limit switch ground
4	Open limit switch signal
5	Closed limit switch signal
6	Motor winding B high
7	Motor winding B low
8	+15 V @25 mA (for Opto switches)

Table 13: Valve Connector Pinout

System Interface Cables for MKS Throttle Valves	
Valve Type Number	**Cable Number**
253A	CB652-2-10
653A	CB652-1-10

Table 14: System Interface Cables for MKS Throttle Valves

Labels

Serial Number Label

The Serial Number Label, located on the side of the instrument, lists the serial number and the product model number, and displays the CE mark signifying compliance with the European CE regulations.

Figure 5: Serial Number Label

The product model number (code) is identified as “651CXYZCD”, where:

651C	=	Type number
X	=	Display
Y	=	Interface
Z	=	Valve Driver
C	=	Power Supply
D	=	Option

Refer to *Appendix B: Model Code Explanation*, page 115, for more information.

Chapter Four: System Setup

Overview

The 651 pressure controller is configured entirely through menu selection via display lists that appear on the front panel. It is not necessary to open the unit to set any switches. Valve connection and calibration, sensor range and pressure units, etc. are selected by scrolling through the display lists and making adjustments using the controls on the front panel. At initial power up the display screen, listing the current software/firmware version, appears for about five seconds.

The system then defaults to its *pressure and position* display and is ready for valve connection and setup (or normal operation once the system has been configured).

```
PRES  4.90 Torr
POS    35.0  %
```

RS-232 Commands and Requests

System setup and control can also be accomplished through RS-23 communications. Refer to Table 26, page 128, for a list of RS-232 commands, and Table 27, page 134, for a list of RS-232 requests and responses.

Valve Selection and Calibration

Prior to its use, the appropriate valve must be connected and identified by the 651 controller. The 651 controller is initially configured to work with a 653 valve. Follow the steps below to select another valve.

Caution

This procedure involves cycling the valve from the open to the close position. Be certain that the system can withstand valve cycling *before* proceeding. This test can be performed prior to installing the 651 controller and the valve in the system.

1. Be sure that the valve is connected to the 651 unit and the Key Lock switch is set to Local.
2. Press the [△] and the valve [CLOSE] key simultaneously for about three seconds.

```
VALVE TYPE:
653
```

3. Use the Adjust knob to scroll through the display list until the type of valve connected to your unit appears.

   The display list includes the following valves:

   253 STD

   253 FAST

   653

4. With the correct valve type displayed, press the [STOP] key to select and calibrate the appropriate valve. The valve will move (open and close) as it is being calibrated, then stop at completion.

Note

Be sure to select the correct valve, otherwise the 651 pressure controller will not function properly.

Setup Menu

The Setup menu enables you to change the configuration of the 651 controller. The initial configuration is listed in *Appendix E: Initial Settings*, page 125. The instructions in this section assume that you will enter the commands from the front panel, so be sure that the key lock switch is set to local.

The Setup menu includes display lists from which selections can be made under the following topics:

- Control mode - PID or Self-Tuning
- Baud rate, parity, and delimiter
- Sensor range and pressure units of measure
- Sensor signal and type
- Analog set point input range and valve signal output
- Set point types A through E, pressure or valve position
- Softstart rates for set points A through E, analog set point, valve open, and valve close
- Direction of valve control

It is possible to exit the Setup menu and return to the system's default display, *pressure and position,* by pressing any key at any time. The Setup menu input can be resumed or restarted by pressing [▽] and [△] simultaneously for about three seconds. Press [▽] or [△] to scroll to the previous or next topic in the Setup menu and use the Adjust knob to select the desired parameters.

Control Mode

The 651 controller is initially configured for PID control. Follow the steps below to change the control mode setting to Self-Tuning control.

1. Press [▽] and [△] simultaneously for about three seconds. The following display appears.

```
CONTROL
MODE:     PID
```

2. Use the Adjust knob to choose either *PID* or *Self-Tuning* control.

3. If you choose Self-Tuning control, press the [LEARN] key for roughly three seconds.

   The 651 unit will "learn" the characteristics of your valve. Once the learn process is complete, you can operate the 651 unit in either the Local or Remote mode.

RS-232 Communications

The 651 controller is initially configured with a baud rate of 9600, no parity, 8 data bits, and CRLF delimiter. Follow the steps below to change any of the RS-232 communication parameters.

1. From the *control mode* display, scroll to the next topic in the Setup menu.

```
BAUD RATE:  9600
```

2. Select the desired baud rate. The display list includes the following baud rate settings:

   300

   1200

   2400

   4800

   9600*

   ** initial setting*

3. Scroll to the next topic.

```
PARITY:  NONE
```

4. Choose either *none* (8 data bits, no parity) or *even* (7 data bits, even parity) and scroll to the next topic. The initial setting is 8 data bits, no parity.

```
DELIMITER:  CRLF
```

5. Choose either CRLF (carriage return/line feed), or CR (carriage return). The initial delimiter is CRLF.

Sensor Setup

The 651 controller is initially configured to use Torr as the pressure units, 100 Torr as the sensor full scale range, 0 to 10 Volts for the sensor input signal, and 0 to 5 Volts for the analog set point input. Follow the steps below to change any of these parameters.

1. Be sure that the sensor is connected to the 651 unit.

2. From the *delimiter* display, scroll to the next topic.

```
SENSOR RANGE:
10.000
```

3. Scroll through the display list until the range of the sensor connected to the unit appears.

Note

To view the range of a sensor in pressure units of *mbar* for a sensor calibrated in *Torr*, select the equivalent mbar unit of measure. For example, select 13.332 for a sensor calibrated to 10.000 Torr.

To display a 1 Torr sensor in *mTorr*, the appropriate sensor range and pressure unit must be entered during setup. For example, 1000 *mTorr* must be entered to display a 1 Torr sensor in *mTorr*.

The display list includes the following sensor ranges:

.10000	
.20000	
.5000	
1.0000	1.3332
2.0000	2.6664
5.000	
10.000	13.332
50.00	
100.00*	133.32
500.0	
1000.0	1333.2
5000	6666
10000	13332

** initial value*

4. Scroll to the next topic.

PRESSURE UNITS:
Torr

5. Scroll through the display list until the unit of measure that the sensor has been calibrated to, appears. The display list includes the following pressure units:

Torr*	kPa
mTorr	Pa
mbar	cmH_2O
µbar	inH_2O

** initial setting*

6. Scroll to the next topic.

SENSOR SIGNAL:
10 VOLTS

7. Scroll through the display list until the sensor full scale voltage appears. The display list includes the following selections:

1 Volt

5 Volts

10 Volts*

** initial value*

8. Scroll to the next topic.

SENSOR TYPE:
ABSOLUTE

9. Choose either *absolute* or *differential*.

Analog Set Point

1. From the *sensor type* display, scroll to the next topic in the Setup menu.

```
ANALOG SETPT RANGE:
10 VOLTS
```

2. Choose either 5 Volts or 10 Volts full scale signal.

   The initial setting is 0 to 5 Volts. Refer to *How To View and Adjust the Analog Set Point*, page 56, or *How To Adjust the Analog Set Point Value*,page 76, for more information.

Valve Position Output

1. From the *analog setpt range* display, scroll to the next topic in the Setup menu.

```
VALVE SIGNAL OUTPUT:
10 VOLTS
```

2. Choose either 5 Volts or 10 Volts full scale for valve position output. The 651 controller is initially configured for 0 to 10 Volts.

Set Points A Through E, Pressure/Position Selection

The 651 controller is initially configured to use *pressure* control for all set points, A through E. Follow the steps below to change configuration of any of the set points.

1. From the *valve signal output* display, scroll to the next topic in the menu selection.

```
SETPOINT A TYPE:
PRESSURE
```

2. Choose either *pressure* or *position* for set point A and scroll to the next topic.

```
SETPOINT B TYPE:
POSITION
```

3. Choose either *pressure* or *position* for set point B.

4. Continue to scroll through the menus in the manner just described, until set points A through E have each been set at either *pressure* or *position*. Refer to *How To View and Adjust Set Points*, page 50.

Note The function of the analog set point, *pressure* or *position*, is controlled by the digital logic level on Pin 6 of the I/O connector. Refer to *Digital Logic Control*, page 90, for information about establishing the analog set point.

Softstart Rates

Softstart rates for set points A through E, analog set point, valve open, and valve close can be established via the Setup menu. If it is not necessary to utilize softstart control in your process, the softstart rate should be left at 100% (of F.S.).

1. From the set point E *pressure* or *position* display, scroll to the next topic in the menu selection.

```
SOFT START RATE
SETPT A:  100.0 %
```

2. Select the softstart rate (between 0.1 and 100%) desired for set point A, then scroll to the next topic.

```
SOFT START RATE
SETPT B:  100.0 %
```

3. Select the softstart rate (between 0.1 and 100%) desired for set point B.

4. Continue to scroll through the menus in the manner just described, until set points A through E have each been set at the desired softstart rates.

5. From the *softstart rate* selected for set point E display, scroll to the next topic in the menu selection.

```
SOFT START RATE
ANLG SETPT:  100%
```

6. Select the softstart rate (between 0.1 and 100%) desired for analog set point.

7. Continue to scroll through the menus in the manner just described, to set the softstart rates for valve open and valve close.

Valve Control

A valve can be controlled to open and close in a *direct* or *reverse* direction. *Direct* action of valve control is defined as valve open at 100% of the valve position's full scale. and valve close at 0%. *Reverse* action of valve control is defined as valve open at 0% of the valve position's full scale and valve close at 100%. The 651 controller is initially configured to use direct action to control the valve.

1. From the valve close *softstart rate* display, scroll to the next topic in the menu selection.

```
VALVE DIRECTION:
DIRECT
```

2. Choose either *direct* or *reverse* direction.

System setup is now complete. Press the [STOP] key to exit the Setup menu and return to the default display, *pressure* and *position*. *Chapter Five: Local Operation,* page 49, discusses *Local Operation* via the front panel and *Chapter Six: Remote Operation,* page 61, provides information about *Remote Operation* of the 651 pressure controller.

Chapter Five: Local Operation

Overview

Local operation of the 651 Pressure Controller is similar to *System Setup* outlined in the previous chapter, in that all functions of the controller can be accessed via display lists, and they respond according to information entered at the front panel. The system software includes display lists from which selections can be made under the following topics:

- How to view and adjust set points, as well as how to activate set points
- How to identify an out-of-range condition
- How to control the valve
- How to activate and stop the learn function
- How to zero a sensor, use special zero, and remove zero
- How to view and adjust process limit relays, as well as how to enable and disable them
- How to view the analog set point, how to zero it, and how to calibrate it to full scale span
- How to view and adjust lead and gain parameters

Be sure the Key Lock switch is set to Local and use [▽] or [△] to scroll to the appropriate function.

How To View and Adjust Set Points

The 651 instrument provides five user-definable set points (set point A through set point E). Each set point can be configured as a *pressure* set point or a valve *position* set point. Pressure set points are displayed in units of Torr, mTorr, mbar, μbar, Pascal, or kPa. Position set points are displayed in % open of F.S., where 0 = closed, and 100 = open.

Only one set point can be designated as the active set point. The active set point (or valve position) is indicated by a light in the appropriate set point key.

1. Hold down both arrow keys, [▽] and [△] for approximately three seconds to enter the Setup menu.

2. Scroll until the Control mode screen appears and verify that PID is selected.

3. If Self-Tuning is selected, turn the Adjust knob clockwise to select PID control.

4. Scroll to the set point A screen.

   A sample display of set point A (SP A) is shown below. In this example, set point A is defined as 100 mTorr, and the system *pressure* at this time is also 100 mTorr.

```
SP A   100 mTorr
PRES   100 mTorr
```

5. Adjust the displayed set point with the Adjust knob on the front panel.

   The system responds by immediately storing the set point value. The system pressure does not change however, unless the displayed set point is the active set point.

The display shown below provides another example of a set point display. In this case, set point D (SP D) is configured as a valve *position* set point. The valve position is indicated in % open of F.S., where 0 = closed, and 100 = open. In this example, set point D is configured for a valve position of 60.0% open of F.S., and the system pressure is shown as 2.000 Torr.

```
SP D     60.0   %
PRES    2.000   Torr
```

How To Activate Set Points

Activating a set point causes the 651 unit to control to that set point. To activate a set point, press the appropriate set point key (A through E).

The system responds by illuminating a light in the set point key and controlling according to the selected set point. The front panel display changes to reflect the activated set point. That is, the display at the top shows the actual pressure and the display at the bottom shows the valve position.

The light remains lit in the set point key until another set point (or valve function), is chosen.

How To Identify an Out-of-Range Condition

An out-of-range condition occurs at ±105% of F.S. (±10.5 Volts at sensor input) and is displayed as a positive or negative polarity. An example of a positive out-of-range condition for a set point is shown below.

SP A	3.000 Torr
PRES	+++++++

An example of a negative out-of-range condition displayed on the default screen is shown below.

PRES	- - - - - - Torr
POS	0.0 %

How To Control the Valve

The 651 unit can drive the throttle valve to full open or full close, or halt it at its current position.

How To Open the Valve

To drive the valve to full open, press the [OPEN] key. The system responds by turning a light on in the [OPEN] key, and driving the throttle valve to full open. The front panel window returns to the default display of pressure and valve position, if it is not already showing the default display.

The open command overrides the active set point. Pressing any other key on the front panel (except [ZERO] or [LEARN]), cancels the open command.

How To Close the Valve

To drive the valve to full close, press the [CLOSE] key. The system responds by turning a light on in the [CLOSE] key, and driving the throttle valve to full close. The front panel window returns to the default display of pressure and valve position, if it is not already showing the default display.

The close command overrides the active set point. Pressing any other key on the front panel (except [ZERO] or [LEARN]), cancels the close command.

How To Halt the Valve

To stop the valve in its current position, press the [STOP] key. The system responds by illuminating a light in the [STOP] key, and halting the throttle valve in its current position. The front panel window returns to the default display of pressure and valve position, if it is not already showing the default display.

The stop command overrides the active set point. Pressing any other key on the front panel (except [ZERO] or [LEARN]), cancels the stop command.

How To Activate the Learn Function

The learn function, activated by pressing the [LEARN] key, enables the 651 unit to identify important system characteristics for Self-Tuning control. Use the learn function whenever the 651 controller is used in a new vacuum system or when processing conditions are changed (such as changed flow rate, new or refurbished pump, or piping modifications). The learning process may take several minutes to complete.

Note

The system pressure will vary during the learn cycle to as low and high as is possible for the current flow rate.

1. Initiate the proper gas flow into the system.

   The Gas flow rate should be close to that used for the actual process (use the maximum flow rate if several flow rates are used in the process).

   Do not vary the gas flow rate during learning.

2. Press the [LEARN] key for about three seconds.

   The system responds by illuminating a light in the [LEARN] key, and initiating the learning process. The front panel window displays the changing values of pressure and position as the instrument learns the system. The light stays on until the learn function is complete.

How To Stop the Learn Function

It is recommended that the learn function go through to completion. However, if your process is slow to reach its highest pressures *and* your process will not be operating at those pressures, it is possible to stop the learn function early.

Caution

Do not stop the learn function until it is well above the highest pressure at which the process will be operating.

Press the [LEARN] key and the [STOP] key simultaneously for about three seconds. The system responds by stopping the learn function and returning to its prior operation. For example, if the valve was closed before the [LEARN] key was pressed, the valve will now close.

How To Zero a Sensor

Zeroing a sensor is performed to correct sensor zero offsets.

1. Turn the gas flow off.

2. Fully open the control valve.

3. Wait until the system is pumped down to base pressure.

   In order to achieve a proper zero, the pressure of the system must be *lower* than the resolution of the Baratron used to measure system pressure. If the pressure reading (at base pressure) is greater than 4% of full range, the sensor will not be zeroed.

4. Press the [ZERO] key for at least three seconds.

   The system responds by flashing on a light in the [ZERO] key, and zeroing the sensor. The front panel window shows a pressure reading of zero.

   The front panel display changes to reflect a change in system pressure as soon as a change occurs.

How To Use Special Zero

The special zero function is used to zero base pressure in systems where the known pressure is not *at*, but *near* zero (displayed on another readout in the system).

1. Press [△] and the [ZERO] key simultaneously for about three seconds, until the front panel displays *zero base pressure* and the pressure level.

2. Use the Adjust knob to reconcile the pressure reading on the display with the known base pressure reading (displayed on another readout in the system).

3. Press the [STOP] key to exit.

How To Remove Zero

The remove zero function removes the zero correction factor stored in memory, and is used to determine the uncorrected signal from the pressure transducer. Each time a sensor is zeroed, the offset changes. In some applications it may be important to keep the zero offset within a specific range.

Press the [STOP] key and the [Zero] key simultaneously for about three seconds until the front panel display changes from a zero pressure reading to the uncorrected signal level.

How To Set a Process Limit Relay

There are two process limit (PLO) relays in the 651 controller. Each relay has two trip limits: a high trip limit, and a low trip limit. Refer to Table 10, page 34, for the I/O connector pinout to determine which pins are for relay 1, and which are for relay 2. Use the appropriate pins to configure the relays for normally-open or normally-closed operation.

While the pressure remains within PLO limits, the 651 pressure controller actuates the relay (a normally-open contact closes, and a normally-closed contact opens). The 651 pressure controller de-actuates the relay (a normally-open contact opens, and a normally-closed contact closes) when the pressure crosses:

- *above* the *high* trip point

or

- *below* the *low* trip point

How To View and Adjust a Process Limit Relay

1. Scroll to process limit 1.

PROCESS LIMIT 1
HIGH 50.0 mTorr

2. Select the desired pressure value for the high trip point of process limit 1.

3. Scroll to the next display.

PROCESS LIMIT 1
LOW 30.0 mTorr

4. Select the desired pressure value for the low trip point of process limit 1.

5. Scroll through the menu selections in the manner just described, to set the desired pressure values for process limit 2, high and low trip points.

How To Disable a Process Limit Relay

To disable a high limit trip point, set it to full scale.

To disable a low limit trip point, set it to negative full scale.

How To View and Adjust the Analog Set Point

The 651 controller is capable of accepting one analog set point through the I/O connector on the rear panel. The analog set point can be configured for 5 Volt or 10 Volt full scale input. The *analog set point* display reflects the voltage percent of the actual input. For example, if the 651 unit is configured for 5 Volt full scale input, and the actual input applied is 3 Volts, the analog set point display indicates that input by showing a value of 60%. Similarly, if the 651 unit is configured for 10 Volt full scale input, and the actual input applied is 5 Volts, the analog set point display indicates that input by showing a value of 50%. An example of the analog set point display is shown below.

```
ANALOG SETPOINT
VALUE:  50.0 %
```

There is no light on the front panel to indicate that the system is under analog set point control (in fact, all lights on the front panel go out).

How To Zero the Analog Set Point

1. From the default display, *pressure* and *position*, press [△] and the [STOP] key simultaneously for about three seconds until the following display appears.

```
CAUTION
CALIBRATION MODE
```

2. Press the [Set Point B] key. The analog set point display appears.

```
ANLG SP:-2.99%
LEARN+ZERO to CAL
```

3. Press the [LEARN] key and the [ZERO] key simultaneously for about three seconds until the analog set point goes to zero.

4. Press any key to return to the default display, *pressure* and *position*.

Note The maximum adjustment for zero is 15% of full scale.

How To Calibrate Full Scale Span for the Analog Set Point

The 651 units are calibrated at the factory for 10 Volt full scale input; if the actual input applied is 10 Volts, the analog set point display shows a value of 100%. To recalibrate the 651 unit to operate at a full scale input on your system, for example, 9.5 Volts, apply 9.5 Volts to the I/O connector on the rear panel and follow the steps below.

1. From the default display, *pressure* and *position*, press [△] and the [STOP] key simultaneously for about three seconds until the following display appears.

```
CAUTION
CALIBRATION MODE
```

2. Press the [Setpoint D] key. The following display appears.

```
ANLG SP:    99.90%
FULL SPAN:  20015
```

3. Use the Adjust knob to change the value of the analog set point to 100%. The 9.5 Volt input to the I/O connector on the rear panel is now the full scale value.

Note To ensure that the analog set point is adjusted correctly, turn the Adjust knob until the reading flickers between 99.99% and 100.00%. The display reads 100.00% for an overrange reading as well as a true 100% reading.

4. Press any key to return to the default display, *pressure* and *position*.

Note The maximum adjustment for full scale span is 15% of full scale.

How To Set Lead and Gain Parameters

When the 651 unit is configured for PID control, separate lead and gain parameters are maintained for each pressure set point. Set point A is associated with Lead A and Gain A. Set point B is associated with Lead B and Gain B, and so forth.

When an analog set point is used with PID control, the lead and gain parameters associated with any of the pressure set points (set points A through E) may be used. To specify which set point's lead and gain parameters to use, apply a TTL low level signal to the I/O connector pin assigned to the desired set point. Refer to Table 10, page 34, for a description of the pin assignments for the digital inputs. The TTL low level signal (0 to 0.8 Volts) is "level sensitive" meaning that once the signal is held low, the 651 unit may take up to 50 milliseconds to recognize the command. The line must be held low *continuously* for the 651 unit to use the selected parameters. Once the signal goes high, the instrument will default back to set point A parameters within 50 milliseconds. For example, to apply the lead and gain parameters associated with set point C to the analog set point, apply a 0 to 0.8 Volt signal to pin 14 (on the I/O connector) for as long as you wish to use those parameters.

1. Hold down both arrow keys, [▽] and [△] for approximately three seconds to enter the Setup menu.

2. Scroll to the Control mode screen appears and verify that PID is selected.

3. If Self-Tuning is selected, turn the Adjust knob clockwise to select PID control.

4. Adjust the set point lead and gain parameters.

   By careful adjustment of the lead and gain parameters, it is possible to achieve optimum control throughout a wide range of pressure regions. Examples of Lead and Gain for set point A are shown below.

```
LEAD A    1.25 SEC.
PRES    350 Torr
```

```
GAIN A    25.0%
PRES    350 Torr
```

5. Use the Adjust knob to enter the desired lead and gain parameters.

The 651 unit will use the lead and gain values associated with set point A by default.

If a set point is configured as a valve position, then *no* lead or gain parameters are associated with it.

How To Calibrate Span of the A/D Converter

The controller's A/D (analog-to-digital) converter converts the analog input to a digital value that the controller uses. The span of the A/D converter is calibrated at the factory before you receive your controller. You should perform this calibration if you receive a checksum error when you power up the controller, or if the transducer's readings are incorrect.

To calibrate the span of the A/D converter:

1. Apply a *known* voltage of between +6.6 Volts and +7.4 Volts to the pressure input pins on the transducer connector. Connect a differential voltage to pins 2 and 12 with pin 12 tied to pin 5.

   Refer to Table 11, page 36, for the transducer connector pinout. You must know the exact voltage applied, in order to complete step 4.

2. Press [△] and [STOP] key simultaneously for about three seconds. The following display appears.

CAUTION CALIBRATION MODE

3. Press the following keys, in the following order:

   [Set Point C] [Set Point A] and [Set Point E]. The following display appears.

CAL VOLTS: REF COUNTS:

4. Use the Adjust knob to enter the value from Step 1 as the Cal Volts.

5. Press the [STOP] key to exit the calibration procedure.

   The controller takes the Cal Volts value and assigns it to the converter reading of the pressure, as an analog input.

Calibrating the span of the A/D converter may take up to 5 seconds.

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Chapter Six: Remote Operation

Overview

Remote operation of the 651 Pressure Controller is accomplished via the rear panel either by RS-232 communication by means of a computer connected to the Serial Interface connector or through analog or digital logic levels at the I/O connector. When the Key Lock switch is set to Remote, all control commands and parameter modifications must be sent through the connectors. The front panel becomes locked; however, it is still possible to scroll through and view current set points (pressure and position). This chapter contains information about RS-232 and analog or digital logic control.

Refer to *RS-232 Communications*, page 42, discusses the initial settings for the communication parameters.

RS-232 Commands and Requests

Messages sent to the 651 controller are either *commands* that instruct the controller to change an operating parameter, or *requests* that prompt the controller to report status information.

Responses sent by the 651 controller reply to a request message issued by means of your computer's RS-232 communication software.

All messages must use a carriage return-line feed (CRLF) as the end-of-line delimiter. Use your host computer's communications software to assign the CRLF action to the [ENTER] key.

Message Syntax

The information presented in this section applies to all RS-232 messages. The RS-232 message syntax uses the following typographical conventions:

bold	Commands and requests that you must enter exactly as shown in the manual.
italics	Placeholder that represents text or numeric values that you must supply.
`response`	Format of messages sent from the 651 controller.
[ENTER]	Represents carriage return-line feed combination that you have configured as the end-of-line delimiter.

Commands Sent from the Computer to the 651 Controller

Table 26, page 128, lists the syntax for RS-232 commands. Commands are not case sensitive. If a command requires user-supplied parameters, it is not necessary to type a space between the command and the parameters. In the table, each command is separated from parameters with an optional space for clarity. For example, the **S1** command to assign set point A a *value* of 20 is shown in Table 26, page 128, as:

S1 *value* and the actual keys pressed would be:

S120 ENTER

If you choose to use an optional space for clarity, the actual keys pressed would be:

S1 20 ENTER

Note When sending *any* message (command or request) to the 651 controller, you must finish the message by pressing the ENTER key. This appends a carriage return-line feed to the end of the message. Use your communications software to configure the end-of-line delimiter as a carriage return-line feed.

Requests Sent from the Computer to the 651 Controller

Table 27, page 134, lists RS-232 request and response messages. Requests are not case sensitive. You do not supply additional parameters with requests. For example, the **R1** request to respond with the *value* of set point A is shown as:

R1 and the actual keys pressed would be:

R1 ENTER

Responses Sent from the 651 Controller to the Computer

Responses sent from the 651 controller to your computer are shown in the last column of Table 27, page 134. The format of responses sent by the 651 controller to the computer will appears in the table as:

`response` *`value`*

where `response` is a label that allows you to identify the response and *`value`* is the information requested.

Note Controller responses do not contain spaces. Any spaces shown in the response syntax are simply used to improve readability.

The 651 controller appends a carriage return-line feed to the end of every response.

For example, the controller's response to the **R1** request for the value of set point A is shown in the table as:

`S1` *`value`* where *value* is a % of F.S.

To report a set point of 3 Torr on a 10 Torr sensor, the controller sends:

`S130`

Priority of Command Execution

Each RS-232 command is executed in the order that it is received. There is no prioritization of RS-232 commands as is the case with digital logic commands. In fact, the appropriate RS-232 command will override a *high priority* digital logic command. For example, a valve being held closed with a digital logic command can be commanded to control to the level of set point A with the appropriate RS-232 command.

The RS-232 commands generally execute within 25 milliseconds or less with the exception of the following:

- **T** (set point type) and **F** (pressure unit) commands can take up to 100 milliseconds to execute
- **J** (valve calibration) and **L** (learn function) commands can take several seconds to execute

How To Change Valve Selection and Calibration

The 651 controller is initially configured as if it is controlling a Type 653 valve. You must reconfigure the 651 controller to work with a Type 253 valve. Follow the steps below to select another valve.

Caution **This procedure involves cycling the valve from the open to the close position. Be certain that the system can withstand valve cycling *before* proceeding. This test can be performed prior to installing the 651 controller and the valve in the system.**

1. Be sure that the valve is connected to the 651 unit.

2. Issue the following command to calibrate the controller and valve:

   J *value* ENTER

   where *value* = 1 for standard 253 valve
   2 for a fast 253 valve
   3 for a 653 valve

   The valve will move (from fully open to fully closed) and then stop at the completion of the calibration procedure.

Note Be sure to select the correct valve, otherwise the 651 pressure controller will not function properly.

3. Learn the new valve by following the procedures described in *How To Activate the Learn Function*, page 53.

How To Determine and Change the Control Mode

The 651 controller is initially configured for PID control. Follow the steps below to change the control mode setting.

1. To determine which control mode is currently selected, issue the request:

   R51 ENTER

   The 651 controller will return the following response:

   `V` *`value`*

   where *`value`* is:

   0 = Self-Tuning control
   1 = PID control

2. To change the control mode, issue one of the following two commands.

   For Self-Tuning control:

   V0 ENTER

   For PID control:

   V1 ENTER

3. If you choose Self-Tuning control, issue the following command to learn the system:

   L ENTER

   The 651 unit will "learn" the characteristics of your system.

Caution

During the learn process, the 651 controller moves the valve from the opened to the closed position. Be sure your system is set up to allow the valve to move from full open to full closed.

How To Configure the Sensor Parameters

The 651 controller is initially configured to use 100 Torr as the sensor full scale range, and 0 to 10 Volts for the sensor input signal. Follow the steps below to change these parameters.

Note Be sure that the sensor is connected to the 651 controller before changing the sensor parameters.

How To Change the Sensor Type

The 651 controller can work with either Absolute or Differential pressure sensors. Issue the following command to select the sensor type:

U *value*

where *value* is 0 for Absolute; 1 for Differential.

How To Change the Sensor Full Scale Voltage

The 651 controller is initially configured for a 10 Volt full scale sensor. To change the full scale voltage, issue the command:

G *value* ENTER

where *value* is a valid sensor full scale voltage. Valid full scale voltages are:

value		**Full Scale Voltage**
0	=	1 Volt
1	=	5 Volts
2	=	10 Volts*

** initial value*

How To Change the Sensor Range

The 651 controller is initially configured to work with a 100 Torr pressure sensor. If your sensor covers a different range, issue the command:

E *value* ENTER

where *value* is a valid sensor range. Refer to Table 15 for the complete list of valid sensor ranges.

Sensor Range Values					
Torr			**millibar**		
0	=	0.1	13	=	1.33
1	=	0.2	14	=	2.66
2	=	0.5	15	=	13.33
3	=	1	16	=	133.3
4	=	2	17	=	1333
5	=	5	18	=	6666
6	=	10	19	=	13332
7	=	50			
8	=	100*			
9	=	500			
10	=	1000			
11	=	5000			
12	=	10000			
* *initial value*					

Table 15: Sensor Range Values

Note

Pressure readings are reported as % of full scale (F.S.), where full scale is the sensor range value shown in the table. For example, if the actual pressure is 10 Torr for a 10 Torr F.S. unit, then the 651 controller reports a pressure reading *value* = 100 (for 100%).

If the pressure is 10 Torr for a 100 Torr F.S. unit, then the 651 controller reports a pressure reading *value* = 10 (for 10%).

How To Request the Pressure Reading

To request the system pressure, issue the request:

R5 ENTER

The 651 controller responds with the message:

`P value`

where *value* is % of Full Scale.

For example, if the pressure is 10 Torr for a 10 Torr F.S. unit, then *value* = 100.

If the pressure is 10 Torr for a 100 Torr F.S. unit, then *value* = 10.

Converting Pressure Readings to Absolute Pressure Values

To convert pressure readings to absolute pressure values:

1. Request the pressure reading by issuing the request:

   R5 ENTER

   The 651 controller responds with the message:

   `P value`

   where *value* is % of Full Scale.

2. Calculate the absolute pressure using the formula:

   Absolute pressure = (`P value/100`) X (Full Scale)

   For example, if the pressure reading for a 1000 Torr F.S. unit was reported as 65 (65%), the absolute pressure is:

   Absolute pressure = (65/100) X (1000) = 650 Torr

How To Zero a Sensor

Zeroing a sensor allows you to correct any zero offsets.

1. Turn the gas flow off.

2. Fully open the control valve.

3. Wait until the system is pumped down to base pressure.

   In order to achieve a proper zero, the pressure of the system must be *lower* than the resolution of the Baratron used to measure system pressure. If the pressure reading (at base pressure) is greater than 4% of full range, the sensor will not be zeroed.

4. Issue the following command to zero the sensor:

   Z1 [ENTER]

   The system responds by zeroing the sensor. The system pressure reading will be zero.

How To Use the Special Zero

The special zero function is used to zero base pressure in systems where the known base pressure is not *at*, but *near* zero (as measured by another transducer on the system).

- To command the special zero function, set your system at base pressure and send the command:

  Z2 *value* [ENTER]

  The *value* is expressed as % of full scale pressure.

$$value = \frac{\text{known base pressure reading}}{\text{transducer's full scale}}$$

How To Remove the Zero

The remove zero function removes the zero correction factors (**Z1** and **Z2** corrections) stored in memory, and is used to determine the uncorrected signal from the pressure transducer. Each time a sensor is zeroed, the offset changes. In some applications it may be important to keep the zero offset within a specific range.

- To remove the zero correction, send the command:

  Z3 [ENTER]

How To Activate the Learn Function

The learn function enables the 651 unit to identify important system characteristics for Self-Tuning control. Use the learn function whenever you install a new vacuum system or change any processing conditions (such as changed flow rate, new or refurbished pump, or piping changes). The learning process may take several minutes to complete.

Note The system pressure will vary during the learn cycle to as low and high as is possible for the current flow rate.

1. Initiate the proper gas flow into the system.

   Gas flow rate should be close to that used for the actual process (use the maximum flow rate if several flow rates are used in the process). ***Do not*** vary the gas flow rate during the learn function.

2. Issue the following command to initiate the learn function:

   L [ENTER]

   The system responds by initiating the learning process. This process may take several minutes to complete.

3. Issue a system status request message to determine the status of the learn process:

   R37 [ENTER]

   The 651 controller responds with the following message:

   M*XYZ*

   where *X* =0 for remote control
   Y indicates the system status
   0 when not performing the learn process
   1 when performing the learn process
   2 when learning the valve
   Z 0 for valve open
   1 for valve close
   2 valve stop
   3 set point A
   4 set point B
   5 set point C
   6 set point D
   7 set point E
   8 analog set point

How To Stop the Learn Function

It is recommended that the learn function go through to completion. However, if your process is slow to reach its highest pressures *and* your process will not be operating at those pressures, it is possible to stop the learn function early.

Caution **Do not stop the learn function until it is well above the highest pressure at which the process will be operating.**

- To stop the learn function, issue the command:

Q ENTER

The system responds by stopping the learn function and returning to its prior operation. For example, if the valve was closed before the learn function was initiated, the valve will now close.

How To Determine the Active Set Point

To determine the set point currently selected as active:

- Issue the following request to determine the active set point:

  R7 ENTER

  The 651 controller responds with the following message:

  M*XYZ*

  where *X* = indicates the active set point:
  0 for the analog set point
  1 for set point A
  2 for set point B
  3 for set point C
  4 for set point D
  5 for set point E

  Y = indicates the valve status:
  0 for controlling
  2 for valve open (direct direction)
  4 for valve close (direct direction)
  2 for valve close (reverse direction)
  4 for valve open (reverse direction)

  Z = indicates the pressure:
  0 when the pressure < 10% F.S.
  1 when the pressure ≥ 10% F.S.

How To Select the Active Set Point

The 651 instrument provides five user-definable set points (set point A through set point E) and one external analog set point, received through the I/O connector. The 651 controller uses the "active" set point to control the system. Only one set point can be designated as the active set point.

- Issue the following command to select the active set point:

D*x* ENTER

where *x* = 1 for set point A
2 for set point B
3 for set point C
4 for set point D
5 for set point E
6 for the analog set point

How To Select Pressure or Position Control

The 651 controller is initially configured to use *pressure* control for the internal set points, A through E, and the analog set point.

1. To select pressure or position control, issue the command:

   T*x value* ENTER

   where *x* = 1 for set point A type
   2 for set point B type
   3 for set point C type
   4 for set point D type
   5 for set point E type
   6 for the analog set point type

   value = 0 for position
   1 = pressure

Note This RS-232 command overrides the digital logic control for the analog set point. Refer to *Digital Logic Control*, page 90, for information about the digital logic control of the analog set point.

2. To check the type of control selected for a set point, issue the request:

   R*xx* ENTER

   where *xx* = 25 for the analog set point type
   26 for set point A type
   27 for set point B type
   28 for set point C type
   29 for set point D type
   30 for set point E type

   The 651 controller responds with the following message:

   `T`*`x value`*

   where *x* = 0 for the analog set point
   1 for set point A
   2 for set point B
   3 for set point C
   4 for set point D
   5 for set point E

   value = 0 for position
   1 = pressure

How To Change the Set Point Value

Follow these instructions to change the value of one of the internal set points, A through E. Refer to *How To Adjust the Analog Set Point Value*, page 76, for information on changing the analog set point value.

1. Issue the following command to set the value of the set point:

   S*x value* ENTER

   where *x* = 1 for set point A
   2 for set point B
   3 for set point C
   4 for set point D
   5 for set point E

   value = % of full scale pressure, if the unit is in pressure control
   % of open, if the unit is in position control (direct direction)
   % of close, if the unit is in position control (reverse direction)

   The system responds by immediately storing the set point value. The system pressure does not change however, unless the selected set point is the *active* set point.

2. To check the set point value for any set point, issue the request:

   R*x* ENTER

   where *x* = 1 for set point A value
   2 for set point B value
   3 for set point C value
   4 for set point D value
   10 for set point E value

   The 651 controller responds with the following message:

   `Sx value`

   where *x* = 1 for set point A value
   2 for set point B value
   3 for set point C value
   4 for set point D value
   5 for set point E value

   value = % of full scale pressure, if the unit is in pressure control
   % of open, if the unit is in position control (direct direction)
   % of close, if the unit is in position control (reverse direction)

How To Adjust the Analog Set Point Value

The 651 controller is capable of accepting one *analog set point* through the I/O connector on the rear panel. The analog set point value is expressed as a % of full scale, using the following formula:

analog set point = (analog set point voltage / full scale voltage)

For example, if the 651 unit is configured for 5 Volt full scale input, and the actual input applied is 3 Volts, the analog set point value will be 60%. Similarly, if the 651 unit is configured for 10 Volt full scale input, and the actual input applied is 5 Volts, the analog set point value will be 50%.

The system responds to an analog set point voltage by immediately storing the analog set point value. The system pressure does not change however, unless the analog set point is the active set point. Refer to *How To Determine the Active Set Point*, page 72, for more information.

How To Set the Analog Set Point Full Scale Range

The analog set point can be configured for 5 Volt or 10 Volt full scale input.

1. To change the analog set point full scale range, issue the command:

   A *value* [ENTER]

   where *value* is 0 for 5 Volt range; 1 for 10 Volt range.

2. To check the analog set point full scale range, issue the request:

   R24 [ENTER]

   The 651 controller will send the following response:

   `A value`

   where `value` is 0 for 5 Volt range; 1 for 10 Volt range.

How To Zero the Analog Set Point

Zeroing the analog set point allows you to correct any zero offsets.

The **Z4** command instructs the controller to take the current value of the external analog set point for its zero value.

To zero the analog set point:

1. Supply zero input voltage on I/O connector pins 33 and 34.

2. Issue the following command to learn the zero of the analog set point:

   Z4 ENTER

   The 651 controller learns the input voltage that corresponds to an analog set point zero value.

How To Learn Analog Set Point Full Scale

The controller is calibrated at the factory for 10 Volt full scale input; if the actual input applied is 10 Volts, the controller's analog set point reading is 100 (100%). To recalibrate the controller to operate at a full scale input of, for example, 9.5 Volts, you can learn the analog set point full scale via the **Y2** command. This command allows you to correct any full scale offsets.

The **Y2** command instructs the controller to take the current value of the external analog set point for its full scale value.

To learn the analog set point full scale:

1. Supply full scale input voltage on I/O connector pins 33 and 34.

2. Send the command:

   Y2 ENTER

   If the current value of the analog set point is beyond ±15% of full scale, the controller will not change the current full scale value.

How To Set the Full Scale Level of the Analog Set Point

1. Issue the following command to set the value of the analog set point:

   S6 *value* ENTER

   where *value* = 0 for 100% of the controlling transducer's range;
   1 for 10% of the controlling transducer's range.

2. To check the full scale level of the analog set point value, issue the request:

   R0 ENTER

   The 651 controller responds with the following message:

   `S0` *`value`*

   where *`value`* is % of the controlling transducer's range.

How To Calibrate Span of the A/D Converter

The controller's A/D (analog-to-digital) converter converts the analog input to a digital value that the controller uses. The span of the A/D converter is calibrated at the factory before you receive your controller. You should perform this calibration if you receive a checksum error when you power up the controller, or if the transducer's readings are incorrect.

To calibrate the span of the A/D converter:

1. Apply a voltage of between +6.6 Volts and +7.4 Volts to the pressure input pins on the transducer connector. Connect a differential voltage to pins 2 and 12 with pin 12 tied to pin 5.

   Refer to Table 11, page 36, for the transducer connector pinout. You must know the exact voltage applied, in order to complete step 2.

2. Send the command:

   Y1 *value* [ENTER]

   where *value* is the (applied voltage/F.S.) expressed as a percent. For example, if the applied voltage is 7.0 Volts with 10 Volts = F.S., *value* =+70

   For this example, *value* = 70 and the command is:

   Y1+70.00 [ENTER]

   The controller takes the value from the command and assigns it to the converter reading of the pressure as an analog input. In this example, the 7 Volt input = 70.00.

Calibrating the span of the A/D converter may take up to 5 seconds. To check that the calibration is finished, enter the request **R52** (checksum error request); the controller responds ''immediately.'' The controller will respond to the request immediately after it finishes the span calibration.

Note

If the response to the **R52** checksum command is ''1'', the controller is reporting that the checksum error still exists. In that case, perform the procedure to calibrate the span of the A/D converter again. If the error persists, it indicates a hardware failure of the EEPROM. Contact any MKS Service Center, listed on the inside back cover of this manual, for assistance.

How To Respond To a Checksum Error

A checksum error message indicates the controller has detected a calibration problem. The controller send a checksum error message in the following circumstances:

- at system power up
- in response to the **R52** checksum command (1 = error)

If the controller detects a checksum error, perform a full calibration to correct the problem.

To perform a full calibration:

1. Zero the analog set point.

   Perform the steps described in *How To Zero the Analog Set Point*, page 77.

2. Learn the analog set point full scale.

   Perform the steps described in *How To Learn Analog Set Point Full Scale*, page 77.

3. Calibrate the span of the A/D converter.

   Perform the steps described in *How To Calibrate Span of the A/D Converter*, page 79.

If the checksum error persists after you perform a full calibration, the error indicates a hardware failure of the EEPROM. Contact any MKS Service Center, listed on the inside back cover of this manual, for assistance.

How To Set the Lead and Gain Parameters

When the 651 unit is configured for PID control, separate lead and gain parameters are maintained for each pressure set point. Set point A is associated with Lead A and Gain A. Set point B is associated with Lead B and Gain B, and so forth.

When an analog set point is used with PID control, the lead and gain parameters associated with any of the pressure set points (set points A through E) may be used. To specify which set point's lead and gain parameters to use, apply a TTL low level signal to the I/O connector pin assigned to the desired set point. Refer to Table 10, page 34, for a description of the pin assignments for the digital inputs. The TTL low level signal (0 to 0.8 Volts) is "level sensitive" meaning that once the signal is held low, the 651 unit may take up to 50 milliseconds to recognize the command. The line must be held low *continuously* for the 651 unit to use the selected parameters. Once the signal goes high, the instrument will default back to set point A parameters within 50 milliseconds. The 651 unit will use the lead and gain values associated with set point A by default.

For example, to apply the lead and gain parameters associated with set point C to the analog set point, apply a 0 to 0.8 Volt signal to pin 14 (on the I/O connector) for as long as you wish to use those parameters.

If a set point is configured as a valve position, then *no* lead or gain parameters are associated with it.

1. To determine which control mode is currently selected, issue the request:

   R51 [ENTER]

   The 651 controller will return the following response:

   `V` *`value`*

   where *`value`* is a 0 for Self-Tuning control; a 1 for PID control.

2. If necessary, issue the following command to select PID control:

   V1 [ENTER]

3. Issue the following command to enter a new lead parameter:

   X*xvalue* [ENTER]

where *x* =	1 is the lead parameter for set point A
	2 is the lead parameter for set point B
	3 is the lead parameter for set point C
	4 is the lead parameter for set point D
	5 is the lead parameter for set point E
value =	lead value (in seconds)

4. Issue the following command to enter a new gain parameter:

M*x value* ENTER

where *x* =	1 is the gain parameter for set point A
	2 is the gain parameter for set point B
	3 is the gain parameter for set point C
	4 is the gain parameter for set point D
	5 is the gain parameter for set point E
value =	gain value (in percent)

5. To check the value of a lead or gain entry, issue the request:

R*xx* ENTER

where *xx* =	41 requests the lead parameter for set point A
	42 requests the lead parameter for set point B
	43 requests the lead parameter for set point C
	44 requests the lead parameter for set point D
	45 requests the lead parameter for set point E
	46 requests the gain parameter for set point A
	47 requests the gain parameter for set point B
	48 requests the gain parameter for set point C
	49 requests the gain parameter for set point D
	50 requests the gain parameter for set point E

If the request is for a *lead* parameter, the 651 controller sends the response:

`X`*`x value`*

where *x* =	1 is the lead parameter for set point A
	2 is the lead parameter for set point B
	3 is the lead parameter for set point C
	4 is the lead parameter for set point D
	5 is the lead parameter for set point E
value =	lead parameter (in seconds)

If the request is for a *gain* parameter, the 651 controller sends the response:

`M`*`x value`*

where *x* =	1 is the gain parameter for set point A
	2 is the gain parameter for set point B
	3 is the gain parameter for set point C
	4 is the gain parameter for set point D
	5 is the gain parameter for set point E
value =	gain parameter (in percent)

How To Set The Softstart Control Rate

Each set point, A through E, can be assigned a different softstart rate. In addition, you can assign a softstart rate for the valve open and valve close commands. If it is not necessary to utilize softstart control in your process, leave the softstart rate at 100% (of F.S.).

The softstart control rate is always expressed as a percent of the valve's full speed. The softstart rate can range from 0.1 to 100%.

How To Set the Softstart Rate

Issue the RS-232 command:

I*x value* ENTER

where *x* =	1 for set point A
	2 for set point B
	3 for set point C
	4 for set point D
	5 for set point E
	6 for the analog set point
	7 for valve open
	8 for valve close
value =	softstart rate, expressed as a percent of full speed (between 0.1 and 100%)

How To Use the Softstart Rate

The use of the softstart rate for the active set point is controlled by digital logic input (pin 7 on the I/O connector). This applies whether the set point is selected through the RS-232 command described above, or through the digital input logic. Refer to Table 10, page 34, for the digital input pinout.

The RS-232 command allows you to select the softstart rate, whereas the state of pin 7 determines whether the softstart rate is used.

To activate softstart control:

- Hold the softstart line low (pin 7 on the I/O connector)

Hold the TTL low signal for a minimum of 50 milliseconds. If the line is *not* held low, the valve will move at 100% full speed.

How To Check the Softstart Rate

Issue the RS-232 request:

R*xx* ENTER

where *xx* = 15 for set point A
16 for set point B
17 for set point C
18 for set point D
19 for set point E
20 for the analog set point
21 for valve open
22 for valve close

The 651 controller responds with the message:

`I`*`x value`*

where *x* = 1 for set point A
2 for set point B
3 for set point C
4 for set point D
5 for set point E
6 for the analog set point
7 for valve open
8 for valve close

value = softstart rate, expressed as a percent of full speed (between 0.1 and 100%)

How To Configure the Valve Parameters

In order for the 651 controller to work properly with your valve, you need to check several valve parameters. All of the parameters are set to an initial value, so it may be unnecessary for you to change any entries.

How To Check the Valve Selected

1. To check the type of valve selected, issue the request:

   R23 ENTER

   The 651 controller responds with the message:

   `J`*`type`*

   where *type* = 1 for a standard 253
   2 for a fast 253
   3 for a 653

How To Change and Calibrate the Valve

1. To change and calibrate the valve, issue the command:

   J *value* ENTER

   where *value* = 1 for a standard 253
   2 for a fast 253
   3 for a 653

Caution

During the calibration process, the 651 controller learns the valve by moving it from the opened to the closed position. Be sure your system is set up to allow the valve to move from full open to full closed.

How To Change the Valve Position Output

The valve position output can be configured for 5 Volts or 10 Volts full scale. The 651 controller is initially configured for 10 Volts. To change the valve position output, follow the steps below.

1. To change the valve position output range, issue the command:

   B *value* ENTER

   where *value* is 0 for the 5 Volt range; 1 for the 10 Volt range.

2. To check the current valve position output, issue the request:

   R31 ENTER

   The 651 controller responds with the message:

   `B` *`value`*

   where *`value`* is 0 for the 5 Volt range; 1 for the 10 Volt range.

How To Change the Valve Control Direction

A valve can be controlled to open and close in a *direct* or *reverse* direction. *Direct* valve control direction is defined as valve open at 100% of the valve position's full scale and valve close at 0%. *Reverse* valve control direction is defined as valve open at 0% of the valve position's full scale and valve close at 100%.

The 651 controller is initially configured to use direct action to control the valve.

1. To change the direction, issue the command:

   N *value* ENTER

   where *value* is a 0 for direct direction; 1 for reverse direction.

2. To check the current valve control selection, issue the request:

   R32 ENTER

   The 651 controller responds with the message:

   `N` *`value`*

   where *value* is a 0 for direct action; 1 for reverse action.

How To Control the Valve

You can command the 651 unit to drive the throttle valve to full open or full close, or hold the valve at its current position.

Note The RS-232 commands to open, close, or hold the valve, override the active set point control of the valve.

How To Open the Valve

To drive the valve to full open, issue the command:

O ENTER

The system responds by driving the throttle valve to full open.

How To Close the Valve

To drive the valve to full close, issue the command:

C ENTER

The system responds by driving the throttle valve to full close.

How To Halt the Valve

To halt the valve at its current position, issue the command:

H ENTER

The system responds by holding the throttle valve at its current position.

How To Set a Process Limit Relay

There are two process limit relays (also known as trip point relays) in the 651 controller. Each relay has two trip limits: a high trip limit, and a low trip limit. Refer to Table 10, page 34 for pinout of the I/O connector to determine which pins are for relay 1, and which are for relay 2. Use the appropriate pins to configure the relays for normally-open or normally-closed operation.

While the pressure remains within the specified limits, the relay is actuated (a normally-open contact closes, and a normally-closed contact opens). Whenever the pressure crosses *above* the *high* process limit, or *below* the *low* process limit, the corresponding relay becomes de-actuated (a normally-open contact opens, and a normally-closed contact closes).

How To View and Adjust a Process Limit Relay

1. To check a process limit threshold, issue the command:

   R*xx* [ENTER]

where *xx* =	10 for the low threshold for process limit 1
	11 for the high threshold for process limit 1
	13 for the low threshold for process limit 2
	14 for the high threshold for process limit 2

   The 651 controller responds with the message:

   `P`*`x value`*

where *x* =	1 for the low threshold for process limit 1
	2 for the high threshold for process limit 1
	3 for the low threshold for process limit 2
	4 for the low threshold for process limit 2
value =	pressure limit

2. To change a process limit threshold, issue the command:

   P*x value* [ENTER]

where *x* =	1 for the low threshold for process limit 1
	2 for the high threshold for process limit 1
	3 for the low threshold for process limit 2
	4 for the high threshold for process limit 2
value =	pressure limit

How To Disable a Process Limit Relay

To disable a high limit process limit, set the step 2 *value* to full scale.

To disable a low limit process limit, set the step 2 *value* to negative full scale.

How To Check the System Status

You can issue a "system status" request to determine the state of the 651 controller. The request is:

R37 ENTER

The 651 controller sends the response:

`M`*`XYZ`*

where *X* =	1 for remote control
Y =	describes the state of the learn function: 0 when not performing the learn function 1 when learning the system 2 when learning the valve
Z =	0 = open 1 = close 2 = stop 3 = set point A 4 = set point B 5 = set point C 6 = set point D 7 = set point E 8 = analog set point

How To Check the Firmware Version

To determine the firmware version, issue the request:

R38 ENTER

The 651 controller sends the response:

`H` *`version`*

Digital Logic Control

Digital and analog control of the 651 unit is accomplished via the I/O connector located on the rear panel. Refer to Table 10, page 34, for the pinout of the I/O connector.

Note Any RS-232 command takes priority over digital logic commands. For example, a valve being held closed with a digital logic command can be commanded to control to the level of set point A with the **D1** command.

Digital *inputs* and *outputs* are designed to interface with low power TTL and CMOS logic families. They also include additional components to protect against damage from ESD or transient voltages. A brief description of the digital circuitry of the I/O board is provided in the following section.

I/O Board Digital Circuitry

The I/O board contains 16 type 74HC *inputs*. To select an input function, pull the appropriate input pin low (0 to 0.8 Volts). The TTL low signal is "level sensitive" meaning that once the signal is held low, the 651 unit may take up to 50 milliseconds to recognize the command. The line must be held low *continuously* for the 651 unit to use the selected parameters. Once the signal goes high, the instrument will default back to the state associated with the high signal within 50 milliseconds. Each input consists of a single pole filter and pull-up resistor as shown in Figure 6.

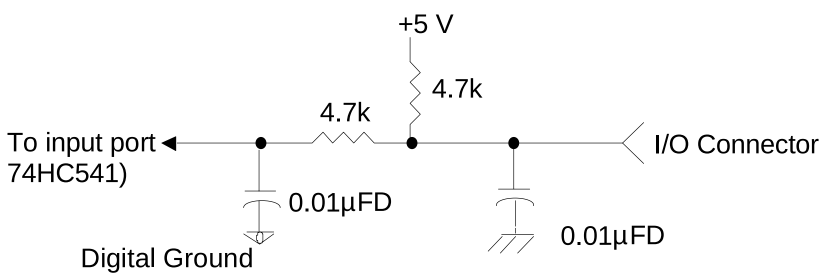

Figure 6: I/O Board Digital Input Circuitry

The I/O board contains 6 type 74HC digital *outputs*, each having the capacity to drive one standard TTL load. The approximate time constant of the outputs are 2.5 microseconds. Each output includes a 240 ohms series resistor to protect it against line surges and spikes. Additionally, there is a 0.01 µFD capacitor connected to the chassis.

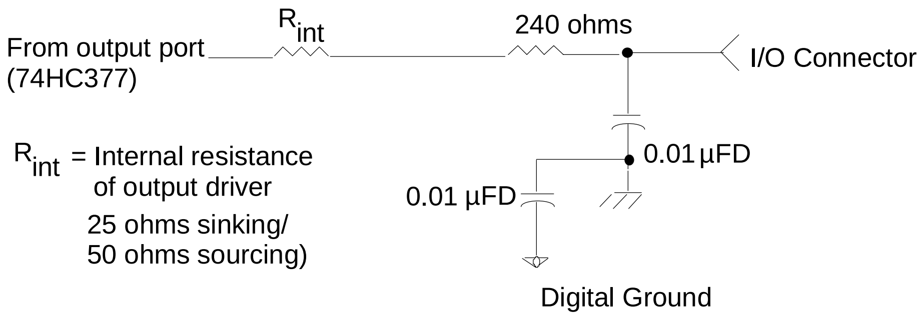

Figure 7: I/O Board Digital Output Circuitry

Digital Input Priorities

Digital inputs are scanned and selected in a prioritized manner, enabling a higher priority request to override a lower one. The order of priority is shown in Table 16.

Priority of Digital Inputs		
Order of Priority	**I/O Pin No.**	**Digital Input Function**
1	6	Analog set point (pressure or position)
2	10	Control range of analog set point
Note: Below this point, if any of the digital inputs are held low, lower priority signals are blocked; that is, they are not recognized until the higher priority signal is released.		
3	25	Remote zero
4	5	Learn system
5	8	Close valve
6	27	Open valve
7	26	Stop valve
8	11	Select analog set point
9	16	Select set point A
10	15	Select set point B
11	14	Select set point C
12	13	Select set point D
13	12	Select set point E

Table 16: Priority of Digital Inputs

The order of priority of digital inputs is based on the analog set point line (pin 11) being tied low to continuously select it, thus blocking set points A through E, except to use their gains. Refer to *How To Set the Lead and Gain Parameters*, page 81, for more information.

Note

Activating both the *open* and *close* commands simultaneously, causes the valve to *stop*.

Digital Functions

Most digital input functions are activated by pulling the input to a TTL low level (0 to 0.8 Volts) for a minimum of 50 milliseconds. If a higher priority function has not already been selected, the requested function will be activated. When the input is brought high (+2.4 to +5 Volts), any lower priority functions that have been selected will now be activated. If no lower priority functions have been selected, the function most recently requested remains in effect. Table 17 lists the specific function of each digital input. Table 18, page 95, lists the specific function of each digital output. The first column in each table lists the I/O port number assignment.

Digital Input Functions			
I/O Port No.	**I/O Pin No.**	**State**	**Digital Input Function**
1	27	Low High	Open the valve No function
2	8	Low High	Close the valve No function
3	26	Low High	Stop the valve No function
4	7	Low High	Softstart is *active* for selected command function Softstart is *inactive* for selected command function (used in conjunction with another valve control function)
5	25	Low High	Performs the *remote zero* function No function
6	6	Low High	Analog set point to *position* Analog set point to *pressure*
7	24	Low High	No function No function
8	5	Low High	Performs the *learn* system function No function

Table 17: Digital Input Functions
(Continued on next page)

Digital Input Functions *(Continued)*			
Digital Input No.	**I/O Pin No.**	**State**	**Digital Input Function**
9	16	Low High	Selects set point A No function
10	15	Low High	Selects set point B No function
11	14	Low High	Selects set point C No function
12	13	Low High	Selects set point D No function
13	12	Low High	Selects set point E No function
14	11	Low High	Selects analog set point No function
15	10	Low High	F.S. analog set point yields 1/10 the F.S. pressure of the controlling transducer or 10% position F.S. analog set point yields F.S. pressure of the controlling transducer or 100% position (Pressure/position function controlled by input 6)
16	9	Low High	No function No function

Table 17: Digital Input Functions

Digital Output Functions			
Digital Output No.	**I/O Pin No.**	**State**	**Digital Output Function**
1	29	Low	Pressure outside of PLO 1 band (relay is *not* energized)
		High	Pressure inside of PLO 1 band (relay *is* energized)
2	28	Low	Pressure outside of PLO 2 band (relay is *not* energized)
		High	Pressure inside of PLO 2 band (relay *is* energized)
3	23	Low	Valve is not closed
		High	Valve is closed
4	19	Low	Valve is not open
		High	Valve is open
5	18	Low	No function
		High	No function
6	17	Low	No function
		High	No function

Table 18: Digital Output Functions

Analog Set Point Inputs

The analog set point inputs, +set point (I/O pin 33) and -set point (I/O pin 34) on the I/O connector, are fully differential. The -set point must be connected to a ground to work correctly, and it is recommended that it be connected to ground at the source of the set point signal.

To achieve softstart control of analog (or digital logic) set points, the *softstart line (I/O pin 7) must be held low*. If the line is *not* held low, the valve will move at 100% full speed.

If an analog set point is established via RS-232 input, the softstart rate for the analog set point is selected through use of the **I6***value* RS-232 command.

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Chapter Seven: Battery-Backed Memory Module

Replacing the Battery-Backed Memory Module

The 651 pressure controller has a battery-backed memory module which stores configuration and *learned* system information while power is off. The battery-backed memory module (MKS part no. 037-9227) is specified to provide at least seven years of memory storage under all operating conditions. No maintenance should normally be required during this period.

Note

The module is also available from the following sources:

- Bench Marq (BQ 4011MA-100)
- SGS-Thompson (MK 48Z32B-10)
- Dallas Semiconductor (DS 1230AB-100)

Eventually, the memory module will need to be replaced. If the 651 unit continually requires relearning at each power cycle (power off then on again), it may be time to replace it. The memory module is located on the CPU board inside the electronics unit and may be replaced by MKS or other qualified personnel.

Opening the Unit

Warning

The 651 unit has lethal voltages inside. Servicing of the unit must be performed by qualified personnel only.

To avoid an electrical shock, disconnect the power line *before* opening the unit.

1. Turn the power off.
2. Disconnect the AC power cord.

Caution

To avoid damage to sensitive internal components, personnel should be grounded through a safety impedance while working inside the 651 unit, and the unit itself must be static-free.

3. Remove the two Phillips screws located at the top of the rear panel.
4. Disengage the cover from the rear chassis by lifting it up from the clips.
5. Remove the top cover by firmly pulling it up and back to clear the top of the connector plates.

Removing the CPU Board and Memory Module

1. Locate the CPU board.

   It is labeled on the rear panel as the Serial Interface connector (in slot 1).

2. Remove the screw to the left of the connector.

3. It may be necessary to remove the clamping spring that holds the card cage to the power supply. If so, use needle-nose pliers or a screwdriver to pull the clamping spring straight back and out.

4. Grasp each end of the board and rock it until it loosens from its position. Lift the board up and out of the unit.

5. Figure 8 provides the location of the battery-backed memory module on the CPU board.

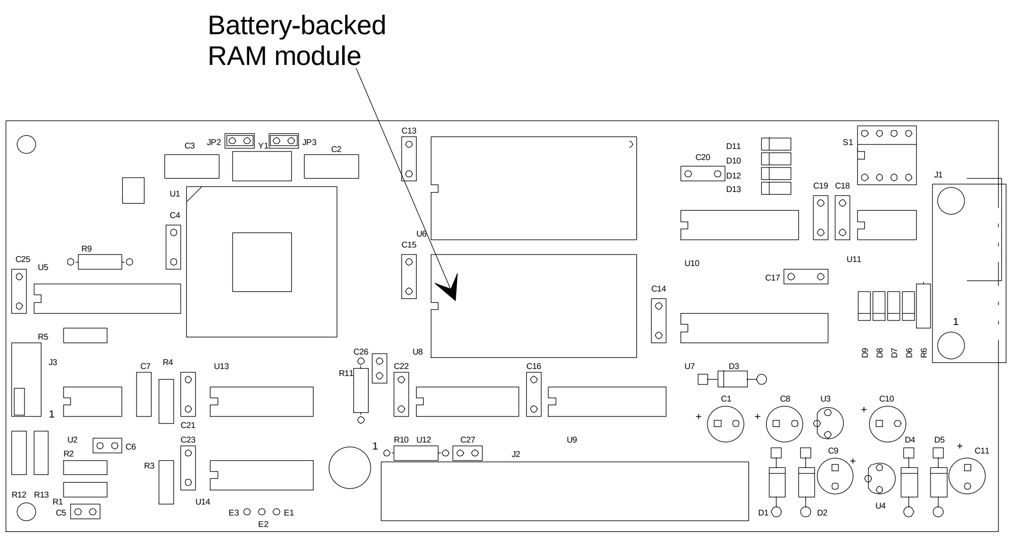

Figure 8: Location of the Battery-backed RAM Module

6. Use needle-nose pliers, a screwdriver, or an IC puller to remove the memory module from its socket.

Installing a New Memory Module and Replacing the CPU Board

1. Position the new memory module over the socket, being careful to line up the pins correctly (pin 1 is located directly to the left of the notch). Snap the module firmly into place.

2. Position the CPU board over its slot in the unit, ensuring that the board's edge is behind the next connector's edge. Push on the bottom tab to snap the board into the slot.

3. Use any instrument to gently seat the clamping spring firmly in place. A metal tab prevents the spring from sliding in completely. (The space left by the tab enables a small screwdriver to be inserted into the space for easy board removal the next time.)

Replacing the Cover

1. Using the clips on the cover as a guide, slide the cover (from rear to front) into place at the front panel.

2. Position the cover so that the cover slots engage the top of the connector plates. From the front (looking at the top of the unit toward the rear), push the cover toward the front while incrementally tightening the screws. (This ensures good electrical connection between the top cover and rear connector plates.)

3. Reconnect the AC power cord.

4. Turn the power on.

Note All user configuration settings may have to be reset and the control system may have to be relearned after replacement of the memory module.

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Chapter Eight: Valve Failsafe Battery Back-up Option

General Information

An optional Valve Failsafe Battery Back-up (lead-acid battery) provides full valve drive capability for approximately 30 seconds after an AC power failure. The 651 instrument can be set to drive the valve open, closed, or hold it in its current position upon a power loss. This battery is a rechargeable, 12 Volt, 2 amp-hour, sealed lead-acid battery (MKS part no. 003-1109451).

Note The lead-acid battery is also available from the following sources:

- Power Sonics (PS-1220)
- Panasonic (LCR 12 V2.2P)

This chapter provides instructions on how to check your controller to ensure that it recognizes when the battery back-up module is present, and how to configure the valve position upon a power loss when using either Local or Remote operation.

If a Valve Failsafe Battery Backup is installed, an **ATTENTION** label is affixed to the side of the 651 unit. The label states that the unit contains a lead-acid battery which is maintained in a properly charged state while the instrument is powered on. Basic maintenance information is also provided. Since the lead-acid battery is continually recharged while the 651 unit is powered and operating, the battery is typically maintenance free and needs attention only when it must be replaced. The upper limit of the ambient temperature range of a 651 unit, equipped with a Valve Failsafe Battery Back-up option is 35° C versus 40° C for a unit without the option.

Note If a Valve Failsafe battery backup is ordered for a 651A or 651B unit, the unit must be sent back to your local MKS Service Center to have the battery backup system installed. Before returning the instrument to MKS, obtain an ERA Number (Equipment Return Authorization Number) from an MKS Service Center.

Battery Voltage

The normal voltage level of the battery ranges from 11 V to 15.5 V. A voltage level *below* 11 V indicates a discharged battery. A voltage level *above* 15.5 V indicates an open fuse, a disconnected battery, or a defective charger.

Valve Positions

The controller can be configured so that the valve will be driven fully open, fully closed, or will be disabled upon an AC power failure.

Open: The controller opens the valve at power down. In the event that the valve is already open, the module provides power for approximately 1 second before turning off.

Closed: The controller closes the valve at power down. In the event that the valve is already closed, the module provides power for approximately 1 second before turning off.

Disable: The option is disabled and will not perform any function at power down. The controller turns off in a normal manner.

When the controller is configured to open or close the valve, it will perform the operation whenever power to the controller is turned off, regardless of whether the power is turned off via the power switch or by a power failure.

Note If for any reason the controller cannot open or close the valve within 30 seconds of a power failure, the battery back-up module automatically turns off. This prevents the battery from discharging when no valve is present or if the valve is defective in some way.

Startup

Threshold Voltage Check

When the 651 controller is turned on, it measures the voltage at the input port assigned to the battery back-up module. When the voltage level at the port exceeds a factory set minimum threshold value, the controller recognizes that the battery back-up is present, and the software menus which support the module are installed. Should the voltage level be below the threshold, the controller does not recognize the module and the software menus are not installed.

Once the 651 unit has been powered up and the battery back-up module has been recognized, the actual voltage of the battery is measured.

Battery Voltage Within Range

If the battery voltage is within the acceptable range of 11 V to 15.5 V, the instrument revision and the current software/firmware version appears on the front panel display for about five seconds, before advancing to the default *Pressure and Position* screen:

```
651C
V 1.8
```

Figure 9: Initial Display Screen

```
PRES  4.90 Torr
POS    35.0  %
```

Figure 10: Default Pressure and Position Screen

The controller is now ready for valve connection and setup (or normal operation once the system has been configured). The 651 unit does not display a status screen to indicate that the battery voltage is within range.

Battery Voltage Out-of-Range

If the battery voltage is out-of-range, the instrument revision and the current software/firmware version appears on the front panel display for about five seconds (refer to Figure 9, page 103), followed by the appropriate error message, rather than advancing to the default *Pressure and Position* display screen (refer to Figure 10, page 103).

If the battery voltage is below 11 V, the screen displays:

Battery is low
Press key to continue

Figure 11: Battery Voltage Low Message

If the battery voltage is above 15.5 V, the screen displays:

Battery is high
Press key to continue

Figure 12: Battery Voltage High Message

The system allows for continued operation when the battery voltage is out-of-range, since your process may not require that the battery voltage level be addressed immediately. To continue operation, press any key to advance to the default *Pressure and Position* display screen.

Note It is important to note that in addition to supporting the controller's valve position, the battery back-up feature powers the controller, and any pressure transducer or valve connected to it.

Operation

How To Check the Battery Voltage

To ensure that the 651 unit has recognized the battery back-up module, or to view the actual battery voltage and the current valve configuration without entering the software menus (regardless of whether you are using Local or Remote operation):

1. Ensure that the default *Pressure and Position* screen appears on the display:

```
PRES  4.90 Torr
POS    35.0  %
```

2. Press the [▽] key one time.

   If the battery back-up module has been recognized, the screen displays:

```
BATTERY     13.5V
BACK-UP:     OPEN
```

   This screen allows you to view the actual battery voltage and the current valve configuration. The valve configuration cannot be changed from this screen. Refer to *How To Set The Battery Back-up Valve Control*, page 106, for instructions on how to change the valve configuration; the battery voltage cannot be adjusted. Press any key to return to the default *Pressure and Position* screen.

   If the battery back-up module has *not* been recognized, the screen reverts to the initial display screen which lists the instrument revision and the current software/firmware version:

```
651C
V 1.8
```

   Press any key to return to the default *Pressure and Position* screen.

How To Set The Battery Back-up Valve Control

Local Operation

1. Ensure the Key Lock Switch is set to Local and that the default *Pressure and Position* display appears on the screen.

```
PRES  4.90 Torr
POS    35.0  %
```

2. Press the [△] and [▽] keys simultaneously for about 3 seconds to enter the Setup menu.

   The screen displays:

```
CONTROL
MODE:        PID
```

3. Press the [△] or [▽] down arrow key to scroll through the menu until the battery back-up option selection screen appears on the display.

   The screen displays:

```
BATTERY     13.5V
BACK-UP:    OPEN
```

   The screen displays the actual voltage level of the battery along with the position the valve is currently set to drive to upon a power loss.

   Select whether the valve will be driven fully open, fully closed, or will be disabled upon an AC power failure by turning the Adjust knob on the front panel to the desired setting. Choose from the options of open, closed, or disable (initial).

Note Press any key to exit the Setup menu and return to the default *Pressure and Position* display screen.

Remote RS-232 Operation

The command [**K** ***value***] defines the direction of valve control upon power failure, where:

value:	0	=	disable option
	1	=	open valve at power failure
	2	=	close valve at power failure

To check the type of valve battery back-up control, issue the request:

R 40

The controller responds with the message [`K` *`value`*], where:

`value`:	0	=	option disabled
	1	=	valve opens at power failure
	2	=	valve closes at power failure

An example response, if the valve is set to open upon a power failure, is:

`K` *`1`*

To change the valve control so that it closes upon a power failure, enter:

K ***2***

Expected Battery Life

When AC power is lost, the valve battery backup drives the valve to full open or full closed within 20 seconds. An AC power failure typically results in a 30% discharge of the battery. Under this condition, the battery life is at least 1000 cycles, and should be able to recharge within a few hours after power returns. Battery life under several conditions is listed in Table 19.

Expected Battery Life	
Expected Cycles	**% Discharge with each Battery Use**
1000	30
400	50
200	100
2-3 years if unused and charge is maintained	

Table 19: Expected Battery Life

When AC power returns, the battery recharges, provided that the 651 instrument is turned on. From a full discharge condition, the voltage typically increases from about 11 V to 15.5 V over a five hour period. The voltage is maintained at about 14.5 V for another five hours then gradually drops to 13.5 V. The 13.5 Volt charge is maintained in a trickle charge state (a top charged state) until there is an AC power failure. The recharge time for a completely discharged battery is a maximum of 12 hours.

Battery Storage

The lead-acid battery loses its capacity if it is stored with no power connected. In fact, the higher the ambient temperature, the faster the capacity is lost. Table 20 shows the time it takes for the battery to fall to fifty percent of its full capacity at various ambient temperatures.

Capacity Loss of Stored Battery	
Ambient Temperature (° C)	**No. Days to 50% Capacity**
20	500
30	250
40	150
50	75

Table 20: Capacity Loss of Stored Battery

Battery Replacement

Opening the Unit

Warning **The 651 unit has lethal voltages inside. Servicing of the unit must be performed by qualified personnel only.**

To avoid an electrical shock, disconnect the power line *before* opening the unit.

1. Turn the power off.
2. Disconnect the AC power cord.

Caution **To avoid damage to sensitive internal components, personnel should be grounded through a safety impedance while working inside the 651 unit, and the unit itself must be static-free.**

3. Remove the two Phillips screws located at the top of the rear panel.
4. Disengage the cover from the rear chassis by lifting it up from the clips.
5. Remove the top cover by firmly pulling it up and back to clear the top of the connector plates.
6. Locate the area of the unit where the chassis splits (to the rear of the front panel) and remove the two screws on both sides of the front panel as well as the two screws on both sides of the battery backup housing.
7. Slide the front panel out far enough to enable the ribbon cable to lay flat.
8. Slide the battery backup housing out about an inch.
9. Disconnect the battery power bus interface from the battery backup circuit board.
10. Unsnap the ribbon cable connector.
11. Pull both the front panel module and the battery backup housing away from the card cage/power assembly.
12. Remove the screw located on the left side of the housing.
13. Orient the housing on its side, and remove the two visible screws.

14. Pull the front panel module completely forward and remove the battery circuit board assembly.

Installing the New Battery

1. Disconnect the two insulated clips from the battery terminals.

Caution ***Do not* allow anything to short across the battery terminals; for example, a screwdriver.**

2. Push the battery straight up (from underneath) and out.
3. With the new battery positioned such that the terminals are at the rear and + is on the right-hand side, reconnect the two insulated clips.

   Be sure that + is connected to + and - is connected to - .
4. Feed the ribbon cable through the slot.

   Be sure to keep the cable away from the heatsink.
5. Replace the two screws that attach the circuit assembly to its chassis and the screw removed from the left side of the housing.
6. Position the front panel module and battery backup housing so that the ribbon cable connector can be plugged into the card cage.
7. Plug the bus connector into the circuit board located in the battery backup housing.
8. Slide the battery backup housing into position and snap it into place.
9. Replace the two screws on each side of the battery backup housing.
10. Push the front panel module slightly back and fold the ribbon cable.
11. Slide the front panel module into the battery backup housing and snap into place.
12. Replace the two screws on both sides of the front panel module.
13. Replace the top cover and its two screws.

The unit is now ready to be plugged in and powered up.

Chapter Nine: Maintenance

General Information

If the 651 instrument fails to operate properly upon receipt, check for shipping damages, and check the cables for continuity. Any damage should be reported to the carrier and MKS Instruments immediately. If it is necessary to return the unit to MKS, obtain an ERA number (Equipment Return Authorization Number) from a MKS Service Center before shipping. Please refer to the inside back cover of this manual for a list of MKS Calibration and Service Centers.

Periodically, check for wear on the cables and inspect the enclosure for visible signs of damage.

How To Replace Fuses

1. Select the proper fuses.

   All units should have two fuses installed to *fuse both sides* of the line.

2. Disconnect the power cord from the 651 instrument.

Warning **To avoid an electrical shock, be sure to disconnect the power cord *before* proceeding.**

3. Insert a small device, for example, a screwdriver, in the fuse holder clip on the right side of the fuse holder.

   Refer to Figure 13, page 112, for the location of the clip.

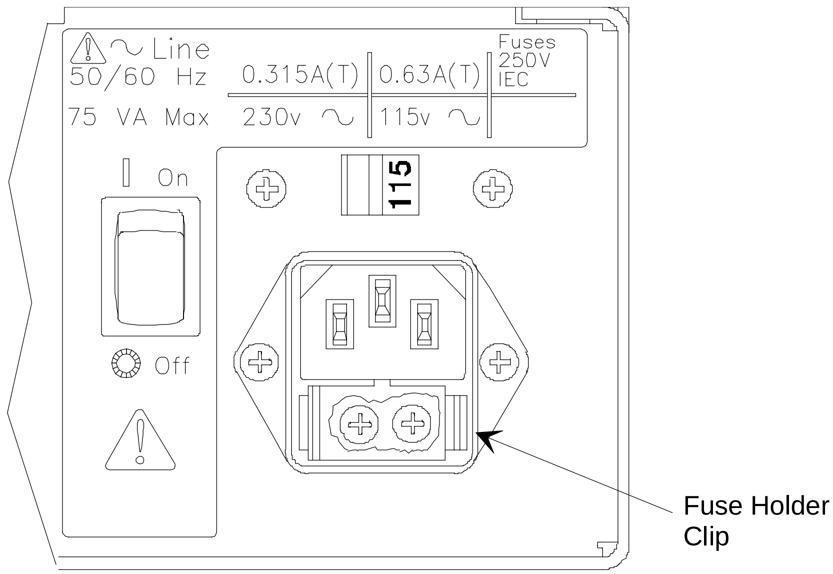


Figure 13: Fuse Holder

4. Gently press against the clip and push up with the screwdriver until the plastic fuse holder pops out.

   It may be necessary to repeat steps 2 and 3 on the left side to release the fuse holder.

5. Replace the old fuses with new ones and gently snap the fuse holder back into place.

Appendix A: Product Specifications

Ambient temperature	15° to 40° C (60° to 104° F) 15° to 35° C (60° to 95° F) with optional valve failsafe battery backup
Analog output signal Position Pressure	 0 to 5 Volts or 0 to 10 Volts, selectable 0 to 100% F.S. pressure, same range as sensor
CE Compliance Electromagnetic Compatibility[1] Low-Voltage Requirements Installation Category Pollution Degree Product Safety Requirements	 EMC Directive 89/336/EEC Low-Voltage Directive 73/23/EEC II, according to EN 61010-1 2, according to IEC 664 Product Safety Directive 92/59/EEC
Controller repeatability	±0.1% of F.S.
Connectors[2] Valve I/O Transducer RS-232 Serial Communications	 9-pin Type "D" female 37-pin Type "D" female 15-pin Type "D" female 9-pin Type "D" male
Display	2 line LCD with 4½ place readout
Display units	Torr, mTorr, mbar, µbar, Pascal, kPa, cmH_2O, inH_2O
External set point signal	0 to 5 Volts or 0 to 10 Volts, selectable
Fuses Low power unit: 90 to 132 VAC 180 to 264 VAC High power unit: 90 to 132 VAC 180 to 264 VAC	 0.63A (T), 250V, 5 x 20 mm 0.315A (T), 250V, 5 x 20 mm 1.25A (T), 250V, 5 x 20 mm 0.63A (T), 250V, 5 x 20 mm

[1]An overall metal braided shielded cable, properly grounded at both ends, is required during use.

[2]Interconnecting cables between the Type 651 and the valve, sensor, and serial communications are available at an additional charge. Please consult factory for ordering information. Necessary adapter cables are included when retrofitting MKS Type 152, 252, and 652 controllers.

Input power Low power unit High power unit	 90 to 132 or 180 to 264 VAC @50/60 Hz 75 VA (max) 90 to 132 or 180 to 264 VAC @48/62 Hz 150 VA (max)
Interface RS-232 Analog Digital	 Inputs (16): HCMOS pulled high with a 4.7k resistor to be TTL compatible. Driver must sink 1 mA and hold low for > 50 msec to select function. Outputs (6): HCMOS with 240 ohm series protection resistor. Will sink & source 1 TTL load. Time constant < 500 nanoseconds.
Output power Low power unit High power unit	 ±15 VDC @ 0.5 Amps (max)[3] ±15 VDC @ 1.5 Amps (max)
Overrange pressure	±10.5 Volts
Pressure input signal	-10 to 10 Volts
Process limit relays (2)	24 Volts AC/DC @ 1 Amp resistive (contact ratings)
Set points Internal External	 5, each one pressure or position selectable 1, pressure or position selectable
Size with optional valve failsafe battery backup	3½"H x 9½"W x 9"D (8.9 cm x 24.1 cm x 22.9 cm) 12"D (30.5 cm)
Weight Low power unit High power unit	 7 lbs. 3 oz. (3.26 kg) 6 lbs. (2.04 kg) *plus* 3 lbs. 8 oz. (1.25 kg) for optional valve failsafe battery backup

Due to continuing research and development activities, these specifications are subject to change without notice.

[3]Derated to 0.4 Amps with 90 to 99 or 180 to 198 VAC input.

Appendix B: Model Code Explanation

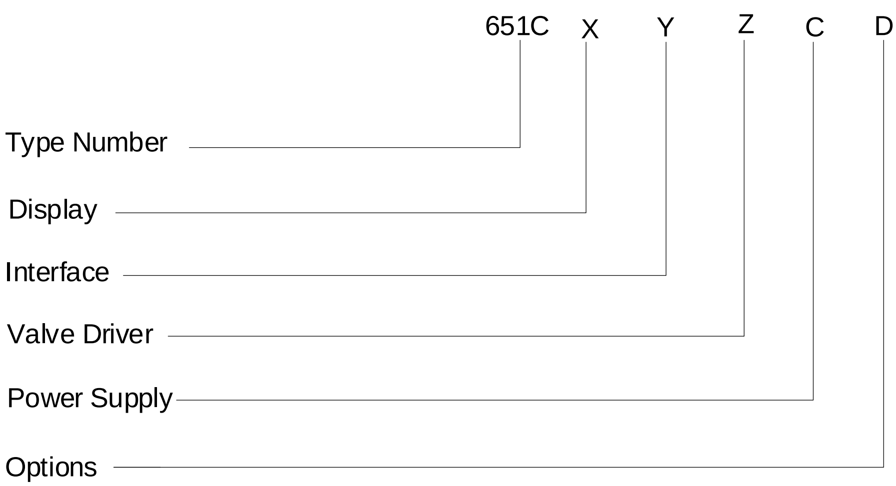
Model Code

The desired options for the 651 controller are identified in the model code when you order the unit.

The model code is identified as follows:

651C X Y Z C D

where:



Type Number (651C)

This designates the model number of the instrument.

Display (X)

The display on your 651 unit is designated by a single letter code.

	Ordering Code
No Display	N
Display	D

Interface (Y)

The type of interface is indicated by a single digit code.

	Ordering Code
RS-232	2

Valve Driver (Z)

The valve driver is designated by a single letter code.

	Ordering Code
Stepper Motor	S

Power Supply (C)

Two power supplies are available, designated by a single number code.

	Ordering Code
0.5 Amp	1
1.5 Amp	2

Options (D)

The battery back-up for valve control is designated by a single letter code.

	Ordering Code
None	N
Battery Back-Up	B

Appendix C: Product Compatibility

Product Compatibility

Valves

MKS *downstream* control valves compatible with the 651 unit include:

Types 253 and 653

Transducers

Table 21 lists the current available to a transducer from a 651 controller (and its specific valve configuration).

Transducer Current Available from Low and High Power Units			
Valve Configuration	**651 Supply Type**	**Line Voltage Range**	**Transducer Current Available**
253/653	Low power	90 to 99 VAC 50/60 Hz	400 mA
		180 to 198 VAC 50/60 Hz	400 mA
		100 to 132 VAC 50/60 Hz	500 mA
		200 to 264 VAC 50/60 Hz	500 mA
253/653	High power	90 to 132 VAC 48/62 Hz	1.5 A
		180 to 264 VAC 48/62 Hz	1.5 A

Table 21: Transducer Current Available from Low and High Power Units

MKS transducers compatible with the *low power* 651 unit include:

Types 122, 124, 127, 128[4], 220, 121, and 223.

MKS transducers compatible with the *high power* 651 unit include:

Types 120, 122, 124, 127, 128, 220, 121, 223, and 621.

---

[4]To ensure proper operation of the Type 128 transducer in the (90 to 99/180 to 198) power line voltage range, it is recommended that the *high power* 651 unit be used. Above 100/200 volts, the *low power* unit provides adequate power.

Adapter Cables

The 651 Pressure Controller can replace the 152, 252, and 652 controllers. It may, however, be necessary to fit the Type “D” connectors on the 651 unit with adapter cables. Refer to Table 22 for a listing of the appropriate cable numbers.

651 Adapter Cables		
From	**To**	**Cable Number**
252, 252+VPO 252+MSO	651 I/O 651 I/O	CB651-12-1 CB651-13-1
252+PLO 252+PLO+VPO	651 I/O	CB651-14-1
252+MSO+PLO 252+MOS+VPO 252+MSO+VPO+PLO	651 I/O	CB651-15-1
152 PC/VPO 152 PC/VPO+RS-232	651 I/O	CB651-16-1
152 RZ/VPO RZ/VPO+RS-232	651 I/O	CB651-17-1
152/252 Sensor Cables	651 Sensor	CB651-18-1
25-Pin Serial Cable[5]	651 Serial	CB651-19-1
652 I/O	651 I/O	CB651-20-1
152/252 Valve Cable	651 Valve	CB652-2-1

Table 22: 651 Adapter Cables

Note The RS-232 serial communication cables are listed in Table 9, page 33.

[5] Pins 2 and 3 not reversed. This cable is a 651 to 652 serial port converter cable. The 25-pin end simulates a 652 controller, and the opposite end connects to the 651 serial port.

Appendix D: Type 651 Displayless Unit

Type 651 Displayless Unit

The displayless unit is a standard 651 unit with the following differences:

- There is no front panel display
- An additional RS-232 serial port, located on the front panel, is intended to be used in conjunction with a laptop or notebook computer
- The baud rate is set at 9600 with no parity, 8 data bits, 1 stop bit, and [CR][LF] delimiter

To put the 651 displayless unit into operation via the RS-232 port on the front panel, set the Key Lock switch to the Local position. When the Key Lock switch is set to the Local position, TTL input and the rear serial communications port become locked out. Conversely, when the Key Lock switch is set to the Remote position, the front serial communications port becomes locked out, and the unit can be controlled either by TTL input or through the serial communications port on the rear panel.

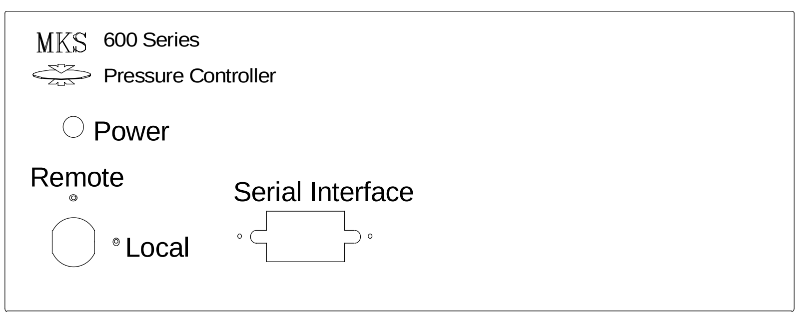


Figure 14: Front Panel of the 651 Displayless Unit

RS-232 Configuration

Since the displayless 651 controller cannot use the Setup menu to change the controller's RS-232 configuration, changes can be made by means of internal dipswitch settings.

Note

If a 651 controller has a front panel display, use the Setup menu to change the RS-232 configuration, described in *Setup Menu*, page 41.

The RS-232 configuration setting defined in the Setup menu override dipswitch settings.

Internal Switches

A dipswitch bank inside the 651 unit allows you to customize RS-232 communications parameters. The dipswitch bank is located on the I/O board.

Opening/Closing the Type 651 Controller

1. Turn the power off.

2. Remove the Phillips screws and washers on the top panel.

Caution

Be sure to be grounded while you are working on internal components of the 651 unit. This precaution will avoid damage to sensitive internal components of the unit.

3. Remove the top cover by firmly pulling it up and towards the back of the unit.

   The dipswitch bank is now accessible.

   After changing the dipswitch settings, replace the cover on the unit and replace the screws and washers you removed in step 2, above. After verifying that the unit is properly reassembled, power up the 651 controller. The new dipswitch settings will be recognized.

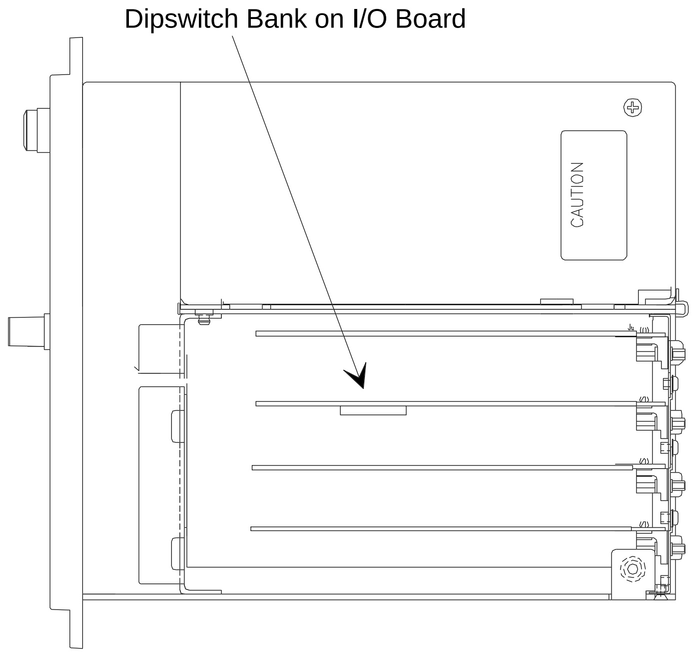


Figure 15: Dipswitch Bank Location (Top View)

The dipswitch bank is located on the I/O board, shown in Figure 15. You can also identify the I/O board by locating the I/O connector on the rear panel (refer to Figure 4, page 31).

Figure 16, shows an enlarged view of a dipswitch bank. The switches in the dipswitch bank are numbered from 1 to 8. The dipswitch bank has the word **OPEN** written on it. To set a dipswitch to open, push it toward the OPEN label. To set a dipswitch to closed, push it away from the OPEN label. For example, in Figure 16 all of the switches are closed.

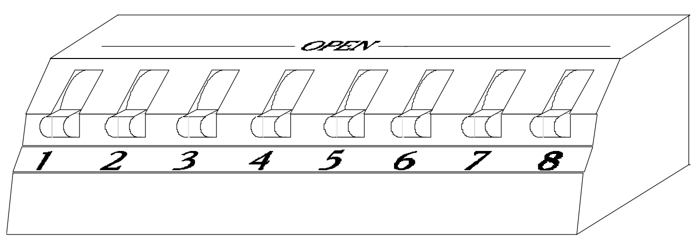


Figure 16: Example of Dipswitch Bank

Dipswitch Bank Settings

The dipswitch settings control the RS-232 communications parameters. When you receive your 651 controller, the unit is set up with the initial dipswitch settings listed in Table 23.

Default Dipswitch Settings		
Dipswitch	**Setting**	**Function**
Switch 1, 2, 3 Switch 4	Closed Open	9600 Baud Rate
Switch 5	Closed	Parity - None, 8 data bits
Switch 6	Closed	Reserved*
Switch 7	Closed	Reserved*
Switch 8	Closed	End-of-Line Delimiter CRLF
** The "Reserved" pin assignmnet refers to a pin with an internal connection which may be assigned a function in the future.*		

Table 23: Default Dipswitch Settings

Note

Parity and data bit setting are dependent. You may select either no parity with 8 data bits or even parity with 7 data bits.

There is no stop bit setting. RS-232 communications uses 1 stop bit under all circumstances. This setting *cannot* be changed.

If the initial settings, listed in Table 25, page 125, are not appropriate for your application, refer to Table 24, page 123, for switch settings you can use to change the baud rate, parity and data bits, and end-of-line delimiter.

Caution

Before opening the unit to change dipswitch settings, you must power off the unit as a safety precaution. Refer to *Opening/Closing the Type 651 Controller*, page 120. Any new dipswitch settings take effect when the unit is powered up.

I/O Board Dipswitch Bank and RS-232 Communications Settings									
Function	**Choices**	**Switches**							
RS-232 Baud Rate		**1**	**2**	**3**	**4**				
The five choices for baud rate are:	300	O	C	O	O				
	1200	O	O	C	O				
	2400	O	O	O	C				
	4800	O	C	C	O				
	9600	C	C	C	O				
RS-232 Parity and Data Bits						**5**			
The two choices for parity checking are:	Even 7 data bits					O			
	None 8 data bits					C			
Reserved Switches							6	**7**	
Reserved for future use.							C	C	
RS-232 End-of-Line Delimiter									**8**
The two choices for end-of-line delimiter are:	CR								O
	CRLF								C
Note: O = Open C = Closed									

Table 24: I/O Board Dipswitch Bank and RS-232 Communications Settings

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Appendix E: Initial Settings

Your 651 controller is shipped with the following initial configuration. This configuration is not a default configuration, however, since the 651 unit stores most of the configuration settings in non-volatile RAM. Settings stored in non-volatile RAM are not lost when the power is turned off. When the power is restored, the 651 unit “remembers” the latest configuration, not the initial configuration. Refer to Table 25 for a complete list of the initial configuration settings. The last column lists the page number for information on each entry, should you wish to change the setting.

Initial Settings			
Parameter	**Default**	**Options**	**Page**
Control Valve	653	253 Fast, 253 Standard	64
Control Mode	PID	Self Tuning	41
Internal Set points Gain and Lead Values	A Pressure B Pressure C Pressure D Pressure E Pressure A Gain = 100 Lead = 10 B Gain = 100 Lead = 10 C Gain = 100 Lead = 10 D Gain = 100 Lead = 10 E Gain = 100 Lead = 10	Position Position Position Position Position User selectable	74
Line Voltage (VAC)	115 VAC	230 VAC	25
Sensor Full Scale (Torr)	100	10000, 5000, 1000, 10, 2, 1, 0.1	66

Table 25: Initial Settings
(Continued on next page)

Initial Settings *(Continued)*			
Parameter	**Default**	**Options**	**Page**
Display Units	Torr	mTorr, mbar, μbar, Pa, kPa, cmH_2O, inH_2O	44
Analog Set point Input	0 to 5 V	0 to 10 V	45
Pressure Sensor Input	0 to 10 V	0 to 5 V, 0 to 1 V	44
Analog Output	Pressure: 0 to 10 V Position: 0 to 10 V	No option 0 to 5 V	45
Control Mode	Direct Acting	Reverse	86
RS-232 Baud Rate Parity/Data Bits Delimiter	 9600 None/8 CRLF	 4800, 2400, 1200, 300 Even/7 CR	42 120
Battery Backup Failsafe Mode	None	Close valve, Open valve, Disable	101

Table 25: Initial Settings

Appendix F: Command and Request Reference

Command Reference

A *command* sent to the 651 unit instructs it to perform a task or change a setting. Commands are grouped into two categories: *control commands* and *parameter commands*.

Control commands directly control the actions of the valve. Valve open, valve close, and valve halt, as well as selection of the controlling set point, are examples of control commands.

Parameter commands determine the settings used by the 651 controller. Set point levels, softstart rates, and sensor full scale are examples of parameter commands.

Note

To conserve space, the ENTER key is not included in the request messages listed the following tables. You must press the ENTER key to send the request message to the 651 controller.

Enter commands without spaces. Spaces are used in the manual to improve readability.

RS-232 command syntax is shown in Table 26, page 128.

RS-232 Command Summary	
Command	**Function**
S1 *value*	Set level of set point A; where *value* is the % of F.S. pressure for pressure set points; position for position set points % of open for direct direction control % of closed for reverse direction control
S2 *value*	Set level of set point B; where *value* is the % of F.S. pressure for pressure set points; position for position set points % of open for direct direction control % of closed for reverse direction control
S3 *value*	Set level of set point C; where *value* is the % of F.S. pressure for pressure set points; position for position set points % of open for direct direction control % of closed for reverse direction control
S4 *value*	Set level of set point D; where *value* is the % of F.S. pressure for pressure set points; position for position set points % of open for direct direction control % of closed for reverse direction control
S5 *value*	Set level of set point E; where *value* is the % of F.S. pressure for pressure set points; position for position set points % of open for direct direction control % of closed for reverse direction control
S6 *value*	Set F.S. level of analog set point 0 = 100% of controlling transducer's range 1 = 10% of controlling transducer's range
D1	Select set point A
D2	Select set point B

Table 26: RS-232 Command Summary
(Continued on next page)

RS-232 Command Summary *(Continued)*	
Command	**Function**
D3	Select set point C
D4	Select set point D
D5	Select set point E
D6	Select analog set point
E *value*	Sensor range *value* 0 = 0.1 10 = 1000 1 = 0.2 11 = 5000 2 = 0.5 12 = 10000 3 = 1 13 = 1.33 4 = 2 14 = 2.66 5 = 5 15 = 13.33 6 = 10 16 = 133.3 7 = 50 17 = 1333 8 = 100 18 = 6666 9 = 500 19 = 13332
F *value*	Pressure units *value* 0 = Torr 1 = mTorr 2 = mbar 3 = μbar 4 = kPa 5 = Pa 6 = cmH_2O 7 = inH_2O *Note:* The **F** command merely assigns a label to the pressure units. It does not convert pressure readings. Pressure readings are % of F. S.
G *value*	Sensor voltage range *value* 0 = 1 Volt 1 = 5 Volts 2 = 10 Volts
O	Open valve
C	Close valve
H	Hold valve

Table 26: RS-232 Command Summary
(Continued on next page)

RS-232 Command Summary *(Continued)*	
Command	**Function**
I1 *value*	Set softstart rate of set point A, *value* is % of full speed
I2 *value*	Set softstart rate of set point B, *value* is % of full speed
I3 *value*	Set softstart rate of set point C, *value* is % of full speed
I4 *value*	Set softstart rate of set point D, *value* is % of full speed
I5 *value*	Set softstart rate of set point E, *value* is % of full speed
I6 *value*	Set softstart rate of analog set point, *value* is % of full speed
I7 *value*	Set softstart rate of open valve, *value* is % of full speed
I8 *value*	Set softstart rate of close valve, *value* is % of full speed
P1 *value*	Set low threshold for process limit 1 *value* is % of F.S.
P2 *value*	Set high threshold for process limit 1 *value* is % of F.S.
P3 *value*	Set low threshold for process limit 2 *value* is % of F.S.
P4 *value*	Set high threshold for process limit 2 *value* is % of F.S.
Z1	Zero the sensor
Z2 *value*	Special zero *value* is % F.S. of the base pressure reading
Z3	Remove the zero correction factors
Z4	Learn the zero of the analog set point. Assigns current value of external analog set point to zero value. If the current value of the analog set point is beyond ±15% of full scale, the controller ignores the command and does not change the current zero value.

Table 26: RS-232 Command Summary
(Continued on next page)

RS-232 Command Summary *(Continued)*	
Command	**Function**
Y1 *value*	Calibrate span of A/D converter; calibrate position output and zeroed pressure output. The controller will assign *value* to the converter reading of the pressure channel.
Y2	Learn the full scale of the analog set point. Assigns current value of external analog set point to the full scale value. If the current value of the analog set point exceeds ±15% of full scale, the controller ignores the command and does not change the current full scale value.
L	Learn the system (Self-Tuning control)
Q	Stop the learn function (while in process)
J *value*	Calibrate the valve, where *value* is: 1 = Std 253 2 = Fast 253 3 = 653
A *value*	Analog set point range where *value* is: 0 = 5 Volts 1 = 10 Volts
T1 *value*	Set point A type where *value* is: 0 = position 1 = pressure
T2 *value*	Set point B type where *value* is: 0 = position 1 = pressure
T3 *value*	Set point C type where *value* is: 0 = position 1 = pressure
T4 *value*	Set point D type where *value* is: 0 = position 1 = pressure

Table 26: RS-232 Command Summary
(Continued on next page)

RS-232 Command Summary *(Continued)*	
Command	**Function**
T5 *value*	Set point E type where *value* is: 0 = position 1 = pressure
T6 *value*	Set point analog type where *value* is: 0 = position 1 = pressure
B *value*	Valve position output range where *value* is: 0 = 5 Volts 1 = 10 Volts
N *value*	Direct/reverse control where *value* is: 0 = direct 1 = reverse
U *value*	Sensor type where *value* is: 0 = Absolute 1 = Differential
X1 *value*	Set lead of set point A, where *value* = seconds
X2 *value*	Set lead of set point B, where *value* = seconds
X3 *value*	Set lead of set point C, where *value* = seconds
X4 *value*	Set lead of set point D, where *value* = seconds
X5 *value*	Set lead of set point E, where *value* = seconds
M1 *value*	Set gain of set point A, where *value* = % gain
M2 *value*	Set gain of set point B, where *value* = % gain
M3 *value*	Set gain of set point C, where *value* = % gain
M4 *value*	Set gain of set point D, where *value* = % gain
M5 *value*	Set gain of set point E, where *value* = % gain
V0	Select Self-Tuning control
V1	Select PID control

Table 26: RS-232 Command Summary
(Continued on next page)

RS-232 Command Summary *(Continued)*	
Command	**Function**
K0	Disable battery backup
K1	Select valve to open upon power fail
K2	Select valve to close upon power fail

Table 26: RS-232 Command Summary

Request and Response Reference

A *request* to the 651 controller causes it to send back information. Refer to Table 27 for a complete list of request messages.

Note To conserve space, the ENTER key is not included in the request messages listed the following tables. You must press the ENTER key to send the request message to the 651 controller.

Response message do not contain spaces. Spaces are used in the response messages to improve readability.

RS-232 Requests and Response Summary		
Request Message	**Information Requested**	**Response Message**
R0	Analog set point value	`S0` *`value`* where *`value`* is % of F.S.
R1	Set point A value	`S1` *`value`*. where *`value`* is % of F.S.
R2	Set point B value	`S2` *`value`* where *`value`* is % of F.S.
R3	Set point C value	`S3` *`value`*. where *`value`* is % of F.S.
R4	Set point D value	`S4 value` where *`value`* is % of F.S.
R5	System pressure value	`P` *`value`* where *`value`* is % of F.S.

Table 27: RS-232 Request and Response Summary
(Continued on next page)

Note Unless specified otherwise, the *value* in a response is a percent value. For example, a response of `S1+30.00` means the set point value is 30% of F.S. For a 10 Torr F. S. unit, the set point would be 3 Torr.

RS-232 Request and Response Summary *(Continued)*		
Request Message	**Information Requested**	**Response Message**
R7	Alternate system status (for compatibility)	`MXYZ` For the *value* of *X:* 0 = analog set point 1 = set point A 2 = set point B 3 = set point C 4 = set point D 5 = set point E For the *value* of Y*:* 0 = controlling 2 = valve open 4 = valve close For the *value* of *Z:* 0 = pressure $\leq$ 10% F.S. 1 = pressure > 10% F.S.
R10	Set point E value	`S5` *value* where *value* is % of F.S.
R11	Low threshold process limit #1	`P1` *value* where *value* is % of F.S.
R12	High threshold process limit #1	`P2` *value* where *value* is % of F.S.
R13	Low threshold process limit #2	`P3` *value* where *value* is % of F.S.
R14	High threshold process limit #2	`P4` *value* where *value* is % of F.S.
R15	Softstart rate for set point A	`I1` *value* where *value* is % of full speed
R16	Softstart rate for set point B	`I2` *value* where *value* is % of full speed
R17	Softstart rate for set point C	`I3` *value* where *value* is % of full speed

Table 27: RS-232 Request and Response Summary
(Continued on next page)

RS-232 Request and Response Summary *(Continued)*		
Request Message	**Information Requested**	**Response Message**
R18	Softstart rate for set point D	`I4` *`value`* where *`value`* is % of full speed
R19	Softstart rate for set point E	`I5` *`value`* where *`value`* is % of full speed
R20	Softstart rate for analog set point	`I6` *`value`* where *`value`* is % of full speed
R21	Softstart rate for valve open	`I7` *`value`* where *`value`* is % of full speed
R22	Softstart rate for valve close	`I8` *`value`* where *`value`* is % of full speed
R23	Valve type	`J` *`type`*, where *`type`* equals: 1 = Std 253 2 = Fast 253 3 = 653
R24	Analog set point range	`A` *`range`*, where *`range`* equals: 0 = 5 Volts 1 = 10 Volts
R25	Analog set point type(either pressure or position)	`T0` *`type`*, where *`type`* equals: 0 = position 1 = pressure
R26	Set point A type (either pressure or position)	`T1` *`type`*, where *`type`* equals: 0 = position 1 = pressure
R27	Set point B type (either pressure or position)	`T2` *`type`*, where *`type`* equals: 0 = position 1 = pressure
R28	Set point C type (either pressure or position)	`T3` *`type`*, where *`type`* equals: 0 = position 1 = pressure

Table 27: RS-232 Request and Response Summary
(Continued on next page)

RS-232 Request and Response Summary *(Continued)*		
Request Message	**Information Requested**	**Response Message**
R29	Set point D type (either pressure or position)	`T4` *`type`*, where *`type`* equals: 0 = position 1 = pressure
R30	Set point E type (either pressure or position)	`T5` *`type`*, where *`type`* equals: 0 = position 1 = pressure
R31	Position indicator range output	`B` *`value`*, where *`value`* equals: 0 = 5 Volts 1 = 10 Volts
R32	Direct/reverse control	`N` *`value`*, where *`value`* equals: 0 = direct 1 = reverse
R33	Sensor range	`E` *`value`*, where *`value`* equals: 00 = 0.1 10 = 1000 01 = 0.2 11 = 5000 02 = 0.5 12 = 10000 03 = 1 13 = 1.33 04 = 2 14 = 2.66 05 = 5 15 = 13.33 06 = 10 16 = 133.3 07 = 50 17 = 1333 08 = 100 18 = 6666 09 = 500 19 = 13332
R34	Pressure units	`F` *`value`*, where *`value`* equals: 00 = Torr 01 = mTorr 02 = mbar 03 = µbar 04 = kPa 05 = Pa 06 = cmH_2O 07 = inH_2O

Table 27: RS-232 Request and Response Summary
(Continued on next page)

RS-232 Request and Response Summary *(Continued)*		
Request Message	**Information Requested**	**Response Message**
R35	Sensor voltage range	`G` *`value,`* where *`value`* equals: 0 = 1 Volt 1 = 5 Volts 2 = 10 Volts
R36	Sensor type	`U` *`value`*, where *`value`* equals: 0 = Absolute 1 = Differential
R37	System status	`M`*`XYZ`* For the *value* of *X:* 0 = Local 1 = Remote For the *value* of *Y:* 0 = not learning 1 = learning system 2 = learning valve For the *value* of *Z:* 0 = open 1 = close 2 = stop 3 = set point A 4 = set point B 5 = set point C 6 = set point D 7 = set point E 8 = Analog set point
R38	Software version	`H` *`version number`*
R39	Status of battery used in optional valve failsafe backup	`BT` = Battery is bad `BT1` = Battery is good `BT2` = Option is not installed

Table 27: RS-232 Request and Response Summary
(Continued on next page)

RS-232 Request and Response Summary *(Continued)*		
Request Message	**Information Requested**	**Response Message**
R40	Valve response to power fail (when using the optional valve failsafe backup)	`K0` = Option is disabled (or not installed) `K1` = Valve opens at power fail `K2` = Valve closes at power fail
R41	Lead A value	`X1` *`value`* where *`value`* is seconds
R42	Lead B value	`X2` *`value`* where *`value`* is seconds
R43	Lead C value	`X3` *`value`* where *`value`* is seconds
R44	Lead D value	`X4` *`value`* where *`value`* is seconds
R45	Lead E value	`X5` *`value`* where *`value`* is seconds
R46	Gain A value	`M1` *`value`* where *`value`* is % gain
R47	Gain B value	`M2` *`value`* where *`value`* is % gain
R48	Gain C value	`M3` *`value`* where *`value`* is % gain
R49	Gain D value	`M4` *`value`* where *`value`* is % gain
R50	Gain E value	`M5` *`value`* where *`value`* is % gain
R51	Type of control	`V` *`value`* 0 = Self-Tuning 1 = PID
R52	Checksum error	`CS` *`value`* 0 = OK 1 = Error condition *If a checksum error condition is reported perform a full calibration, as described on page 80.*

Table 27: RS-232 Request and Response Summary

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121192-P1
Rev A, 6/97
Supplement 1
EO 10510

MKS Type 651C
Pressure Controller

Supplement 1

This supplement contains important information about the valve failsafe battery back-up option for the 651 controller. Specifically, it provides instructions on how to check your controller to ensure that it recognizes when the battery back-up module is present, and how to configure the valve position upon a power loss when using either Local or Remote operation.

Please read the information carefully and make the following additions to your 651C, Revision E instruction manual (MKS p/n 115605-P1).

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Please Note:
MKS Instruments provides these documents as the latest version for the revision indicated. The material is subject to change without notice, and should be verified if used in a critical application.

This manual is for firmware/software version 1.8x.

Introduction

The optional valve failsafe battery back-up provides full valve drive capability for approximately 30 seconds after an AC power failure.

This supplement provides instructions on how to check your controller to ensure that it recognizes when the battery back-up module is present, and how to configure the valve position upon a power loss when using either Local or Remote operation.

Note For complete, detailed information on the battery back-up option, refer to *Chapter Eight: Valve Failsafe Battery Back-up Option*, in Revision E of the 651C instruction manual.

Battery Voltage

The normal voltage level of the battery ranges from 11 V to 15.5 V. A voltage level *below* 11 V indicates a discharged battery. A voltage level *above* 15.5 V indicates an open fuse, a disconnected battery, or a defective charger.

Valve Positions

The controller can be configured so that the valve will be driven fully open, fully closed, or will be disabled upon an AC power failure.

Open: The controller opens the valve at power down. In the event that the valve is already open, the module provides power for approximately 1 second before turning off.

Closed: The controller closes the valve at power down. In the event that the valve is already closed, the module provides power for approximately 1 second before turning off.

Disable: The option is disabled and will not perform any function at power down. The controller turns off in a normal manner.

When the controller is configured to open or close the valve, it will perform the operation whenever power to the controller is turned off, regardless of whether the power is turned off via the power switch or by a power failure.

Note If for any reason the controller cannot open or close the valve within 30 seconds of a power failure, the battery back-up module automatically turns off. This prevents the battery from discharging when no valve is present or if the valve is defective in some way.

Startup

Threshold Voltage Check

When the 651 controller is turned on, it measures the voltage at the input port assigned to the battery back-up module. When the voltage level at the port exceeds a factory set minimum threshold value, the controller recognizes that the battery back-up is present, and the software menus which support the module are installed. Should the voltage level be below the threshold, the controller does not recognize the module and the software menus are not installed.

Once the 651 unit has been powered up and the battery back-up module has been recognized, the actual voltage of the battery is measured.

Battery Voltage Within Range

If the battery voltage is within the acceptable range of 11 V to 15.5 V, the instrument revision and the current software/firmware version appears on the front panel display for about five seconds, before advancing to the default *Pressure and Position* screen:

```
651C
V 1.8
```

Figure 1: Initial Display Screen

```
PRES  4.90 Torr
POS    35.0  %
```

Figure 2: Default Pressure and Position Screen

The controller is now ready for valve connection and setup (or normal operation once the system has been configured). The 651 unit does not display a status screen to indicate that the battery voltage is within range.

Battery Voltage Out-of-Range

If the battery voltage is out-of-range, the instrument revision and the current software/firmware version appears on the front panel display for about five seconds (refer to Figure 1, page 4), followed by the appropriate error message, rather than advancing to the default *Pressure and Position* display screen (refer to Figure 2, page 4).

If the battery voltage is below 11 V, the screen displays:

Battery is low
Press key to continue

Figure 3: Battery Voltage Low Message

If the battery voltage is above 15.5 V, the screen displays:

Battery is high
Press key to continue

Figure 4: Battery Voltage High Message

The system allows for continued operation when the battery voltage is out-of-range, since your process may not require that the battery voltage level be addressed immediately. To continue operation, press any key to advance to the default *Pressure and Position* display screen.

Note It is important to note that in addition to supporting the controller's valve position, the battery back-up feature powers the controller, and any pressure transducer or valve connected to it.

Operation

How To Check the Battery Voltage

To ensure that the 651 unit has recognized the battery back-up module, or to view the actual battery voltage and the current valve configuration without entering the software menus (regardless of whether you are using Local or Remote operation):

1. Ensure that the default *Pressure and Position* screen appears on the display:

```
PRES  4.90 Torr
POS    35.0  %
```

2. Press the [▽] key one time.

   If the battery back-up module has been recognized, the screen displays:

```
BATTERY     13.5V
BACK-UP:     OPEN
```

   This screen allows you to view the actual battery voltage and the current valve configuration. The valve configuration cannot be changed from this screen. Refer to *How To Set The Battery Back-up Valve Control*, page 7, for instructions on how to change the valve configuration; the battery voltage cannot be adjusted. Press any key to return to the default *Pressure and Position* screen.

   If the battery back-up module has *not* been recognized, the screen reverts to the initial display screen which lists the instrument revision and the current software/firmware version:

```
651C
V 1.8
```

   Press any key to return to the default *Pressure and Position* screen.

How To Set The Battery Back-up Valve Control

Local Operation

1. Ensure the Key Lock Switch is set to Local and that the default *Pressure and Position* display appears on the screen.

```
PRES  4.90 Torr
POS    35.0  %
```

2. Press the [△] and [▽] keys simultaneously for about 3 seconds to enter the Setup menu.

   The screen displays:

```
CONTROL
MODE:        PID
```

2. Press the [△] or [▽] down arrow key to scroll through the menu until the battery back-up option selection screen appears on the display.

   The screen displays:

```
BATTERY     13.5V
BACK-UP:     OPEN
```

   The screen displays the actual voltage level of the battery along with the position the valve is currently set to drive to upon a power loss.

   Select whether the valve will be driven fully open, fully closed, or will be disabled upon an AC power failure by turning the Adjust knob on the front panel to the desired setting. Choose from the options of open, closed, or disable (initial).

Note Press any key to exit the Setup menu and return to the default *Pressure and Position* display screen.

Remote RS-232 Operation

The command [**K *value***] defines the direction of valve control upon power failure, where:

value:	0	=	disable option
	1	=	open valve at power failure
	2	=	close valve at power failure

To check the type of valve battery back-up control, issue the request:

R 40

The controller responds with the message [`K` *`value`*], where:

`value`:	0	=	option disabled
	1	=	valve opens at power failure
	2	=	valve closes at power failure

An example response, if the valve is set to open upon a power failure, is:

`K` *`1`*

To change the valve control so that it closes upon a power failure, enter:

K *2*

122094-P1
Rev A, 3/98
Firmware Kit Instructions

MKS Type 651C and 655A Pressure Controllers

Firmware Revision Kit FRK-651C-V1.9 FRK-655A-V1.9

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Please Note:
MKS Instruments provides these documents as the latest version for the revision indicated. The material is subject to change without notice, and should be verified if used in a critical application.

Firmware version: 1.9x

General Information

Unpacking Checklist

This Firmware Revision Kit comes with the following items:

- FIRMWARE EPROM (U6) - Rev. 1.9x
  For units *with* a display: MKS part no. 114547-P1
  For units *without* a display: MKS part no. 114547-P2
- Instructions on how to upgrade to EPROM version 1.9x
  (this document, MKS part no. 122094-P1)

Downward Compatibility

The 651C and 655A version 1.9x firmware is completely compatible with the 651C and 655A version 1.8x firmware.

Returning the Type 651/655 Unit for Firmware Revision

Standard maintenance services are available at all of our regional MKS Calibration and Service Centers listed on the inside back cover of your instruction manual. Should you prefer to have MKS upgrade your Type 651/655 instrument, contact any authorized MKS Service Center.

Before shipping the instrument to MKS, please obtain an ERA Number (Equipment Return Authorization Number) from the MKS Service Center. The ERA Number expedites handling and assures proper servicing of your instrument. Please refer to the inside of the back cover of your instruction manual for a list of MKS Calibration and Service Centers.

Warning **All returns to MKS Instruments must be free of harmful, corrosive, radioactive, or toxic materials.**

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Safety Information

The following general safety precautions must be observed during all phases of upgrading this instrument. MKS Instruments, Inc. assumes no liability for the customer's failure to comply with these requirements.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Do not install substitute parts or perform any unauthorized modification to the instrument.

SERVICE BY QUALIFIED PERSONNEL ONLY

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel only.

KEEP AWAY FROM LIVE CIRCUITS

Lethal voltages are present in the instrument when the power cord is connected. Do not replace components with power cable connected. To avoid injuries, always disconnect power cord and discharge circuits before touching them.

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EPROM Replacement Instructions

How To Open the Unit

Warning

DISCONNECT THE POWER CORD

The 651/655 unit has lethal voltages present when the power cord is connected. To avoid the danger of electrical shock, disconnect the power cord before opening the unit.

1. Turn the power off.
2. Disconnect the AC power cord.

Caution

To avoid damage to sensitive internal components, personnel should be grounded through a safety impedance while working inside the 651/655 unit, and the unit itself must be static-free.

3. Remove the two Phillips screws located at the top of the rear panel.
4. Disengage the cover from the rear chassis by lifting it up from the clips.
5. Remove the top cover by firmly pulling it up and back to clear the top of the connector plates.

How To Remove the CPU Board

1. Locate the CPU board.

   It is labeled on the rear panel as the Serial Interface connector (1) and is adjacent to the power supply.

2. Remove the screw to the left of the CPU connector.

   It may be necessary to remove the clamping spring that holds the card cage to the power supply. If so, use needle-nose pliers or a screwdriver to pull the clamping spring straight back and out.

3. Grasp each end of the board and rock it until it loosens. Lift the board up and out of the unit.

How To Replace the EPROM

1. Locate the EPROM.

   The EPROM is located in the middle of the CPU board, when viewed from the top.

2. Firmly grasp the EPROM and disengage it from the socket.

3. Position the new EPROM so that the notch matches the notch marked on the CPU board and on the socket, and firmly seat the EPROM in the socket.

How To Replace the CPU Board

1. Position the CPU board over its slot in the unit, ensuring that the board's edge is behind the next connector's edge. Push on the bottom tab to snap the board into the slot.

2. Use any grounded instrument to gently seat the clamping spring firmly in place.

   A metal tab prevents the spring from sliding in completely. To remove the board the next time, insert a small screwdriver into the space left by the tab.

How To Replace the Cover

1. Slide the cover (from rear to front) into place at the front panel.

2. Position the cover so that the cover slots engage the top of the connector plates.

   From the front (looking at the top of the unit toward the rear), pull the cover toward the front while alternately tightening the screws. This ensures a good electrical connection between the top cover and the rear connector plates.

3. Reconnect the AC power cord and turn the power on.

Note You must reset all configuration settings and repeat the learn process after replacement of the EPROM.

1034138-001
Revision A, 5/09

MKS Baratron®
Type 722B
Absolute Pressure Transducer

Table of Contents

List of Figures and Tables

Figures

Tables

Pressure Transducer Safety Information

Symbols Used in This Instruction Manual

Definitions of WARNING, CAUTION, and NOTE messages used throughout the manual.

Warning

The WARNING sign denotes a hazard to personnel. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.

Caution

The CAUTION sign denotes a hazard to equipment. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of all or part of the product.

Note

The NOTE sign denotes important information. It calls attention to a procedure, practice, condition, or the like, which is essential to highlight.

Symbols Found on the Unit

The following table describes symbols that may be found on the unit.

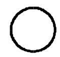
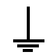
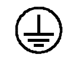
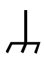
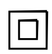
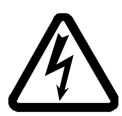
Definition of Symbols Found on the Unit			
 On (Supply) IEC 417, No.5007	 Off (Supply) IEC 417, No.5008	 Earth (ground) IEC 417, No.5017	 Protective earth (ground) IEC 417, No.5019
 Frame or chassis IEC 417, No.5020	 Equipotentiality IEC 417, No.5021	 Direct current IEC 417, No.5031	 Alternating current IEC 417, No.5032
 Both direct and alternating current IEC 417, No.5033-a	 Class ll equipment IEC 417, No.5172-a	 Three phase alternating current IEC 617-2 No.020206	
 Caution, refer to accompanying documents ISO 3864, No.B.3.1	 Caution, risk of electric shock ISO 3864, No.B.3.6	 Caution, hot surface IEC 417, No.5041	

Table 1: Definition of Symbols Found on the Unit

Safety Procedures and Precautions

Observe the following general safety precautions during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of intended use of the instrument and may impair the protection provided by the equipment. MKS Instruments, Inc. assumes no liability for the customer's failure to comply with these requirements.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an MKS Calibration and Service Center for service and repair to ensure that all safety features are maintained.

SERVICE BY QUALIFIED PERSONNEL ONLY

Operating personnel must not attempt component replacement and internal adjustments. Any service must be made by qualified service personnel only.

USE CAUTION WHEN OPERATING WITH HAZARDOUS MATERIALS

If hazardous materials are used, users must take responsibility to observe the proper safety precautions, completely purge the instrument when necessary, and ensure that the material used is compatible with the materials in this product, including any sealing materials.

PURGE THE INSTRUMENT

After installing the unit, or before removing it from a system, purge the unit completely with a clean, dry gas to eliminate all traces of the previously used flow material.

USE PROPER PROCEDURES WHEN PURGING

This instrument must be purged under a ventilation hood, and gloves must be worn for protection.

DO NOT OPERATE IN AN EXPLOSIVE ENVIRONMENT

To avoid explosion, do not operate this product in an explosive environment unless it has been specifically certified for such operation.

USE PROPER FITTINGS AND TIGHTENING PROCEDURES

All instrument fittings must be consistent with instrument specifications, and compatible with the intended use of the instrument. Assemble and tighten fittings according to manufacturer's directions.

CHECK FOR LEAK-TIGHT FITTINGS

Carefully check all vacuum component connections to ensure leak-tight installation.

OPERATE AT SAFE INLET PRESSURES

Never operate at pressures higher than the rated maximum pressure (refer to the product specifications for the maximum allowable pressure).

INSTALL A SUITABLE BURST DISC

When operating from a pressurized gas source, install a suitable burst disc in the vacuum system to prevent system explosion should the system pressure rise.

KEEP THE UNIT FREE OF CONTAMINANTS

Do not allow contaminants to enter the unit before or during use. Contamination such as dust, dirt, lint, glass chips, and metal chips may permanently damage the unit or contaminate the process.

ALLOW PROPER WARM UP TIME FOR TEMPERATURE-CONTROLLED UNITS

Temperature-controlled units will only meet specifications when sufficient time is allowed for the unit to meet, and stabilize at, the designed operating temperature. Do not zero or calibrate the unit until the warm up is complete.

Sicherheitshinweise für den Druckmeßumformer

In dieser Betriebsanleitung vorkommende Symbole

Bedeutung der mit WARNUNG!, VORSICHT! und HINWEIS gekennzeichneten Absätze in dieser Betriebsanleitung.

Warnung!

Das Symbol WARNUNG! weist auf eine Gefahr für das Bedienpersonal hin. Es macht auf einen Arbeitsablauf, eine Arbeitsweise, einen Zustand oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. ungenügende Berücksichtigung zu Verletzungen führen kann.

Vorsicht!

Das Symbol VORSICHT! weist auf eine Gefahr für das Gerät hin. Es macht auf einen Bedienungsablauf, eine Arbeitsweise oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. ungenügende Berücksichtigung zu einer Beschädigung oder Zerstörung des Gerätes oder von Teilen des Gerätes führen kann.

Hinweis

Das Symbol HINWEIS macht auf wichtige Informationen bezüglich eines Arbeitsablaufs, einer Arbeitsweise, eines Zustands oder einer sonstige Gegebenheit aufmerksam.

Erklärung der am Gerät angebrachten Symbole

Nachstehender Tabelle sind die Bedeutungen der Symbole zu entnehmen, die am Gerät angebracht sein können.

Bedeutung der am Gerät angebrachten Symbole			
Ein (Energie) IEC 417, No.5007	Aus (Energie) IEC 417, No.5008	Erdanschluß IEC 417, No.5017	Schutzleiteranschluß IEC 417, No.5019
Masseanschluß IEC 417, No.5020	Aquipotential- anschluß IEC 417, No.5021	Gleichstrom IEC 417, No.5031	Wechselstrom IEC 417, No.5032
Gleich- oder Wechselstrom IEC 417, No.5033-a	Durchgängige doppelte oder verstärkte Isolierung IEC 417, No.5172-a	3 Dreileiter- Wechselstrom (Drehstrom) IEC 617-2, No.020206	
Warnung vor einer Gefahrenstelle (Achtung, Dokumen- tation beachten) ISO 3864, No.B.3.1	Warnung vor gefährlicher elektrischer Spannung ISO 3864, No.B.3.6	Höhere Temperatur an leicht zugänglichen Teilen IEC 417, No.5041	

Tabelle 2: Bedeutung der am Gerät angebrachten Symbole

Sicherheitsvorschriften und Vorsichtsmaßnahmen

Folgende allgemeine Sicherheitsvorschriften sind während allen Betriebsphasen dieses Gerätes zu befolgen. Eine Mißachtung der Sicherheitsvorschriften und sonstiger Warnhinweise in dieser Betriebsanleitung verletzt die für dieses Gerät und seine Bedienung geltenden Sicherheitsstandards, und kann die Schutzvorrichtungen an diesem Gerät wirkungslos machen. MKS Instruments, Inc. haftet nicht für Mißachtung dieser Sicherheitsvorschriften seitens des Kunden.

Niemals Teile austauschen oder Änderungen am Gerät vornehmen!

Ersetzen Sie keine Teile mit baugleichen oder ähnlichen Teilen, und nehmen Sie keine eigenmächtigen Änderungen am Gerät vor. Schicken Sie das Gerät zwecks Wartung und Reparatur an den MKS-Kalibrierungs- und -Kundendienst ein. Nur so wird sichergestellt, daß alle Schutzvorrichtungen voll funktionsfähig bleiben.

Wartung nur durch qualifizierte Fachleute!

Das Auswechseln von Komponenten und das Vornehmen von internen Einstellungen darf nur von qualifizierten Fachleuten durchgeführt werden, niemals vom Bedienpersonal.

Vorsicht beim Arbeiten mit gefährlichen Stoffen!

Wenn gefährliche Stoffe verwendet werden, muß der Bediener die entsprechenden Sicherheitsvorschriften genauestens einhalten, das Gerät, falls erforderlich, vollständig spülen, sowie sicherstellen, daß der Gefahrstoff die am Gerät verwendeten Materialien, insbesondere Dichtungen, nicht angreift.

Spülen des Gerätes mit Gas!

Nach dem Installieren oder vor dem Ausbau aus einem System muß das Gerät unter Einsatz eines reinen Trockengases vollständig gespült werden, um alle Rückstände des Vorgängermediums zu entfernen.

Anweisungen zum Spülen des Gerätes

Das Gerät darf nur unter einer Ablufthaube gespült werden. Schutzhandschuhe sind zu tragen.

Gerät nicht zusammen mit explosiven Stoffen, Gasen oder Dämpfen benutzen!

Um der Gefahr einer Explosion vorzubeugen, darf dieses Gerät niemals zusammen mit (oder in der Nähe von) explosiven Stoffen aller Art eingesetzt werden, sofern es nicht ausdrücklich für diesen Zweck zugelassen ist.

Anweisungen zum Installieren der Armaturen!

Alle Anschlußstücke und Armaturenteile müssen mit der Gerätespezifikation übereinstimmen, und mit dem geplanten Einsatz des Gerätes kompatibel sein. Der Einbau, insbesondere das Anziehen und Abdichten, muß gemäß den Anweisungen des Herstellers vorgenommen werden.

Verbindungen auf Undichtigkeiten prüfen!

Überprüfen Sie sorgfältig alle Verbindungen der Vakuumkomponenten auf undichte Stellen.

Gerät nur unter zulässigen Anschlußdrücken betreiben!

Betreiben Sie das Gerät niemals unter Drücken, die den maximal zulässigen Druck (siehe Produktspezifikationen) übersteigen.

Geeignete Berstscheibe installieren!

Wenn mit einer unter Druck stehenden Gasquelle gearbeitet wird, sollte eine geeignete Berstscheibe in das Vakuumsystem installiert werden, um eine Explosionsgefahr aufgrund von steigendem Systemdruck zu vermeiden.

Verunreinigungen im Gerät vermeiden!

Stellen Sie sicher, daß Verunreinigungen jeglicher Art weder vor dem Einsatz noch während des Betriebs in das Instrumenteninnere gelangen können. Staub- und Schmutzpartikel, Glassplitter oder Metallspäne können das Gerät dauerhaft beschädigen oder Prozeß und Meßwerte verfälschen.

Bei Geräten mit Temperaturkontrolle korrekte Anwärmzeit einhalten!

Temperaturkontrollierte Geräte arbeiten nur dann gemäß ihrer Spezifikation, wenn genügend Zeit zum Erreichen und Stabilisieren der Betriebstemperatur eingeräumt wird. Kalibrierungen und Nulleinstellungen sollten daher nur nach Abschluß des Anwärmvorgangs durchgeführt werden.

Informations relatives à la sécurité pour le transducteur de pression

Symboles utilisés dans ce manuel d'utilisation

Définitions des indications AVERTISSEMENT, ATTENTION, et REMARQUE utilisées dans ce manuel.

Avertissement

L'indication AVERTISSEMENT signale un danger pour le personnel. Elle attire l'attention sur une procédure, une pratique, une condition, ou toute autre situation présentant un risque d'accident pour le personnel, en cas d'exécution incorrecte ou de non respect des consignes.

Attention

L'indication ATTENTION signale un danger pour l'appareil. Elle attire l'attention sur une procédure d'exploitation, une pratique, ou toute autre situation, présentant un risque d'endommagement ou de destruction d'une partie ou de la totalité de l'appareil, en cas d'exécution incorrecte ou de non respect des consignes.

Remarque

L'indication REMARQUE signale une information importante. Elle attire l'attention sur une procédure, une pratique, une condition, ou toute autre situation, présentant un intérêt particulier.

Symboles apparaissant sur l'unité

Le tableau suivant décrit les symboles pouvant apparaître sur l'unité.

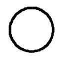
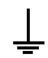
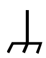
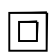
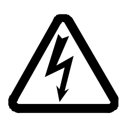
Définition des symboles apparaissant sur l'unité			
Marche (sous tension) IEC 417, No.5007	 Arrêt (hors tension) IEC 417, No.5008	 Terre (masse) IEC 417, No.5017	 Terre de protection (masse) IEC 417, No.5019
 Masse IEC 417, No.5020	 Equipotentialité IEC 417, No.5021	 Courant continu IEC 417, No.5031	 Courant alternatif IEC 417, No.5032
 Courant continu et alternatif IEC 417, No.5033-a	 Matériel de classe II IEC 417, No.5172-a	 Courant alternatif triphasé IEC 617-2, No.020206	
 Attention : se reporter à la documentation ISO 3864, No.B.3.1	 Attention : risque de choc électrique ISO 3864, No.B.3.6	 Attention : surface brûlante IEC 417, No.5041	

Tableau 3: Définition des symboles apparaissant sur l'unité

Mesures de sécurité et précautions

Prendre les précautions générales de sécurité suivantes pendant toutes les phases d'exploitation de cet appareil. Le non respect des ces précautions ou des avertissements contenus dans ce manuel constitue une violation des normes de sécurité relatives à l'utilisation de l'appareil et peut diminuer la protection fournie par l'appareil. MKS Instruments, Inc. n'assume aucune responsabilité concernant le non respect des consignes par les clients.

PAS DE SUBSTITUTION DE PIÈCES OU DE MODIFICATION DE L'APPAREIL

Ne pas installer des pièces de substitution ou effectuer des modifications non autorisées sur l'appareil. Renvoyer l'appareil à un centre de service et de calibrage MKS pour tout dépannage ou réparation afin de garantir le l'intégrité des dispositifs de sécurité.

DÉPANNAGE UNIQUEMENT PAR DU PERSONNEL QUALIFIÉ

Le personnel d'exploitation ne doit pas essayer de remplacer des composants ou de faire des réglages internes. Tout dépannage doit être uniquement effectué par du personnel qualifié.

PRÉCAUTION EN CAS D'UTILISATION AVEC DES PRODUITS DANGEREUX

Si des produits dangereux sont utilisés, l'utilisateur est responsable de la prise des mesures de précaution appropriées, de la purge complète de l'appareil quand cela est nécessaire, et de la garantie que les produits utilisés sont compatibles avec les composants de cet appareil, y compris les matériaux d'étanchéité.

PURGE DE L'APPAREIL

Après l'installation de l'unité, ou avant son enlèvement d'un système, purger l'unité complètement avec un gaz propre et sec afin d'éliminer toute trace du produit de flux utilisé précédemment.

UTILISATION DES PROCÉDURES APPROPRIÉES POUR LA PURGE

Cet appareil doit être purgé sous une hotte de ventilation, et il faut porter des gants de protection.

PAS D'EXPLOITATION DANS UN ENVIRONNEMENT EXPLOSIF

Pour éviter toute explosion, ne pas utiliser cet appareil dans un environnement explosif, sauf en cas d'homologation spécifique pour une telle exploitation.

UTILISATION D'ÉQUIPEMENTS APPROPRIÉS ET PROCÉDURES DE SERRAGE

Tous les équipements de l'appareil doivent être cohérents avec ses spécifications, et compatibles avec l'utilisation prévue de l'appareil. Assembler et serrer les équipements conformément aux directives du fabricant.

VÉRIFICATION DE L'ÉTANCHÉITÉ DES CONNEXIONS

Vérifier attentivement toutes les connexions des composants pour le vide afin de garantir l'étanchéité de l'installation.

EXPLOITATION AVEC DES PRESSIONS D'ENTRÉE NON DANGEREUSES

Ne jamais utiliser des pressions supérieures à la pression nominale maximum (se reporter aux spécifications de l'unité pour la pression maximum admissible).

INSTALLATION D'UN DISQUE D'ÉCHAPPEMENT ADAPTÉ

En cas d'exploitation avec une source de gaz pressurisé, installer un disque d'échappement adapté dans le système à vide, afin d'éviter une explosion du système en cas d'augmentation de la pression.

MAINTIEN DE L'UNITÉ À L'ABRI DES CONTAMINATIONS

Ne pas laisser des produits contaminants pénétrer dans l'unité avant ou pendant l'utilisation. Des produits contaminants tels que des poussières et des fragments de tissu, de glace et de métal peuvent endommager l'unité d'une manière permanente ou contaminer le processus.

RESPECT DU TEMPS D'ÉCHAUFFEMENT APPROPRIÉ POUR LES UNITÉS Á TEMPÉRATURE CONTRÔLÉE

Les unités à température contrôlée atteignent leurs spécifications uniquement quand on leur laisse un temps suffisant pour atteindre d'une manière stable la température d'exploitation. Ne pas remettre à zéro ou calibrer l'unité tant que l'échauffement n'est pas terminé.

Medidas de seguridad del transductor de presión

Símbolos usados en este manual de instrucciones

Definiciones de los mensajes de advertencia, precaución y de las notas usados en el manual.

Advertencia

El símbolo de advertencia indica la posibilidad de que se produzcan daños personales. Pone de relieve un procedimiento, práctica, estado, etc. que en caso de no realizarse u observarse correctamente puede causar daños personales.

Precaución

El símbolo de precaución indica la posibilidad de producir daños al equipo. Pone de relieve un procedimiento operativo, práctica, estado, etc. que en caso de no realizarse u observarse correctamente puede causar daños o la destrucción total o parcial del equipo.

Nota

El símbolo de notas indica información de importancia. Este símbolo pone de relieve un procedimiento, práctica o condición cuyo conocimiento es esencial destacar.

Símbolos hallados en la unidad

La tabla siguiente contiene los símbolos que puede hallar en la unidad.

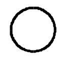
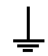
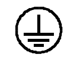
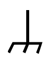
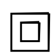
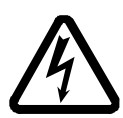
Definición de los símbolos hallados en la unidad			
 Encendido (alimentación eléctrica) IEC 417, N° 5007	 Apagado (alimentación eléctrica) IEC 417, N° 5008	 Puesta a tierra IEC 417, N° 5017	 Protección a tierra IEC 417, N° 5019
 Caja o chasis IEC 417, N° 5020	 Equipotencialidad IEC 417, N° 5021	 Corriente continua IEC 417, N° 5031	 Corriente alterna IEC 417, N° 5032
 Corriente continua y alterna IEC 417, N° 5033-a	 Equipo de clase II IEC 417, N° 5172-a	 Corriente alterna trifásica IEC 617-2, N° 020206	
 Precaución. Consulte los documentos adjuntos ISO 3864, N° B.3.1	 Precaución. Riesgo de descarga eléctrica ISO 3864, N° B.3.6	 Precaución. Superficie caliente IEC 417, N° 5041	

Tabla 4: Definición de los símbolos hallados en la unidad

Procedimientos y precauciones de seguridad

Las precauciones generales de seguridad descritas a continuación deben observarse durante todas las etapas de funcionamiento del instrumento. La falta de cumplimiento de dichas precauciones o de las advertencias específicas a las que se hace referencia en el manual, constituye una violación de las normas de seguridad establecidas para el uso previsto del instrumento y podría anular la protección proporcionada por el equipo. Si el cliente no cumple dichas precauciones y advertencias, MKS Instruments, Inc. no asume responsabilidad legal alguna.

NO UTILICE PIEZAS NO ORIGINALES O MODIFIQUE EL INSTRUMENTO

No instale piezas que no sean originales ni modifique el instrumento sin autorización. Para asegurar el correcto funcionamiento de todos los dispositivos de seguridad, envíe el instrumento al Centro de servicio y calibración de MKS toda vez que sea necesario repararlo o efectuar tareas de mantenimiento.

LAS REPARACIONES DEBEN SER EFECTUADAS ÚNICAMENTE POR TÉCNICOS AUTORIZADOS

Los operarios no deben intentar reemplazar los componentes o realizar tareas de ajuste en el interior del instrumento. Las tareas de mantenimiento o reparación deben ser realizadas únicamente por personal autorizado.

TENGA CUIDADO CUANDO TRABAJE CON MATERIALES TÓXICOS

Cuando se utilicen materiales tóxicos, es responsabilidad de los operarios tomar las medidas de seguridad correspondientes, purgar totalmente el instrumento cuando sea necesario y comprobar que el material utilizado sea compatible con los materiales del instrumento e inclusive, con todos los materiales de sellado.

PURGUE EL INSTRUMENTO

Una vez instalada la unidad o antes de retirarla del sistema, purgue completamente la unidad con gas limpio y seco para eliminar todo resto de la sustancia líquida empleada anteriormente.

USE PROCEDIMIENTOS ADECUADOS PARA REALIZAR LA PURGA

El instrumento debe purgarse debajo de una campana de ventilación y deben utilizarse guantes protectores.

NO HAGA FUNCIONAR EL INSTRUMENTO EN AMBIENTES CON RIESGO DE EXPLOSIÓN

Para evitar que se produzcan explosiones, no haga funcionar este instrumento en un ambiente con riesgo de explosiones, excepto cuando el mismo haya sido certificado específicamente para tal uso.

USE ACCESORIOS ADECUADOS Y REALICE CORRECTAMENTE LOS PROCEDIMIENTOS DE AJUSTE

Todos los accesorios del instrumento deben cumplir las especificaciones del mismo y ser compatibles con el uso que se debe dar al instrumento. Arme y ajuste los accesorios de acuerdo con las instrucciones del fabricante.

COMPRUEBE QUE LAS CONEXIONES SEAN A PRUEBA DE FUGAS

Inspeccione cuidadosamente las conexiones de los componentes de vacío para comprobar que hayan sido instalados a prueba de fugas.

HAGA FUNCIONAR EL INSTRUMENTO CON PRESIONES DE ENTRADA SEGURAS

No haga funcionar nunca el instrumento con presiones superiores a la máxima presión nominal (en las especificaciones del instrumento hallará la presión máxima permitida).

INSTALE UNA CÁPSULA DE SEGURIDAD ADECUADA

Cuando el instrumento funcione con una fuente de gas presurizado, instale una cápsula de seguridad adecuada en el sistema de vacío para evitar que se produzcan explosiones cuando suba la presión del sistema.

MANTENGA LA UNIDAD LIBRE DE CONTAMINANTES

No permita el ingreso de contaminantes en la unidad antes o durante su uso. Los productos contaminantes tales como polvo, suciedad, pelusa, lascas de vidrio o virutas de metal pueden dañar irreparablemente la unidad o contaminar el proceso.

CALIENTE ADECUADAMENTE LAS UNIDADES CONTROLADAS POR MEDIO DE TEMPERATURA

Las unidades controladas por medio de temperatura funcionarán de acuerdo con las especificaciones sólo cuando se las caliente durante el tiempo suficiente para permitir que lleguen y se estabilicen a la temperatura de operación indicada. No calibre la unidad y no la ponga en cero hasta que finalice el procedimiento de calentamiento.

Chapter One: General Information

Introduction

The Baratron® Type 722B Absolute Pressure Transducer offers the proven technology of the Baratron transducer in a smaller RoHS (Restriction of Hazardous Substances)- compliant package. The unit provides an accuracy of 0.5% of Reading and carries a CE Mark to indicate full compliance with the EMC Directive 2004/108/EEC.

The 722B transducer is available with a selection of options.

- *Range:* 1 Torr through 25,000 Torr (0.2 psia through 500 psia)
- *Fittings:* ½ " tube, 4-VCR® , 8-VCR®, 8-VCO®, Mini-CF, and NW-16-KF
- *Connectors:* 5-pin terminal block, 9-pin Type "D", and 15-pin Type "D" on a six inch length of cable

Refer to *Appendix A: Product Specifications,* page 65, for a complete list of product specifications. The model code of your transducer specifies the options chosen. Refer to *Appendix B: Model Code Explanation,* page 67, for more information on the model code.

How This Manual is Organized

This manual is designed to provide instructions on how to set up, install, and operate a Type 722B unit.

Before installing your Type 722B unit in a system and/or operating it, carefully read and familiarize yourself with all precautionary notes in the *Safety Messages and Procedures* section at the front of this manual. In addition, observe and obey all WARNING and CAUTION notes provided throughout the manual.

Pressure Transducer Safety Information

Symbols Used in This Instruction Manual

Definitions of WARNING, CAUTION, and NOTE messages used throughout the manual.

Warning

The WARNING sign denotes a hazard to personnel. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.

Caution

The CAUTION sign denotes a hazard to equipment. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of all or part of the product.

Note

The NOTE sign denotes important information. It calls attention to a procedure, practice, condition, or the like, which is essential to highlight.

Symbols Found on the Unit

The following table describes symbols that may be found on the unit.

Definition of Symbols Found on the Unit			
On (Supply) IEC 417, No.5007	Off (Supply) IEC 417, No.5008	Earth (ground) IEC 417, No.5017	Protective earth (ground) IEC 417, No.5019
Frame or chassis IEC 417, No.5020	Equipotentiality IEC 417, No.5021	Direct current IEC 417, No.5031	Alternating current IEC 417, No.5032
Both direct and alternating current IEC 417, No.5033-a	Class ll equipment IEC 417, No.5172-a	3~ Three phase alternating current IEC 617-2 No.020206	
Caution, refer to accompanying documents ISO 3864, No.B.3.1	Caution, risk of electric shock ISO 3864, No.B.3.6	Caution, hot surface IEC 417, No.5041	

Table 1: Definition of Symbols Found on the Unit

Safety Procedures and Precautions

Observe the following general safety precautions during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of intended use of the instrument and may impair the protection provided by the equipment. MKS Instruments, Inc. assumes no liability for the customer's failure to comply with these requirements.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an MKS Calibration and Service Center for service and repair to ensure that all safety features are maintained.

SERVICE BY QUALIFIED PERSONNEL ONLY

Operating personnel must not attempt component replacement and internal adjustments. Any service must be made by qualified service personnel only.

USE CAUTION WHEN OPERATING WITH HAZARDOUS MATERIALS

If hazardous materials are used, users must take responsibility to observe the proper safety precautions, completely purge the instrument when necessary, and ensure that the material used is compatible with the materials in this product, including any sealing materials.

PURGE THE INSTRUMENT

After installing the unit, or before removing it from a system, purge the unit completely with a clean, dry gas to eliminate all traces of the previously used flow material.

USE PROPER PROCEDURES WHEN PURGING

This instrument must be purged under a ventilation hood, and gloves must be worn for protection.

DO NOT OPERATE IN AN EXPLOSIVE ENVIRONMENT

To avoid explosion, do not operate this product in an explosive environment unless it has been specifically certified for such operation.

USE PROPER FITTINGS AND TIGHTENING PROCEDURES

All instrument fittings must be consistent with instrument specifications, and compatible with the intended use of the instrument. Assemble and tighten fittings according to manufacturer's directions.

CHECK FOR LEAK-TIGHT FITTINGS

Carefully check all vacuum component connections to ensure leak-tight installation.

OPERATE AT SAFE INLET PRESSURES

Never operate at pressures higher than the rated maximum pressure (refer to the product specifications for the maximum allowable pressure).

INSTALL A SUITABLE BURST DISC

When operating from a pressurized gas source, install a suitable burst disc in the vacuum system to prevent system explosion should the system pressure rise.

KEEP THE UNIT FREE OF CONTAMINANTS

Do not allow contaminants to enter the unit before or during use. Contamination such as dust, dirt, lint, glass chips, and metal chips may permanently damage the unit or contaminate the process.

ALLOW PROPER WARM UP TIME FOR TEMPERATURE-CONTROLLED UNITS

Temperature-controlled units will only meet specifications when sufficient time is allowed for the unit to meet, and stabilize at, the designed operating temperature. Do not zero or calibrate the unit until the warm up is complete.

Sicherheitshinweise für den Druckmeßumformer

In dieser Betriebsanleitung vorkommende Symbole

Bedeutung der mit WARNUNG!, VORSICHT! und HINWEIS gekennzeichneten Absätze in dieser Betriebsanleitung.

Warnung!

Das Symbol WARNUNG! weist auf eine Gefahr für das Bedienpersonal hin. Es macht auf einen Arbeitsablauf, eine Arbeitsweise, einen Zustand oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. ungenügende Berücksichtigung zu Verletzungen führen kann.

Vorsicht!

Das Symbol VORSICHT! weist auf eine Gefahr für das Gerät hin. Es macht auf einen Bedienungsablauf, eine Arbeitsweise oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. ungenügende Berücksichtigung zu einer Beschädigung oder Zerstörung des Gerätes oder von Teilen des Gerätes führen kann.

Hinweis

Das Symbol HINWEIS macht auf wichtige Informationen bezüglich eines Arbeitsablaufs, einer Arbeitsweise, eines Zustands oder einer sonstige Gegebenheit aufmerksam.

Erklärung der am Gerät angebrachten Symbole

Nachstehender Tabelle sind die Bedeutungen der Symbole zu entnehmen, die am Gerät angebracht sein können.

Bedeutung der am Gerät angebrachten Symbole			
Ein (Energie) IEC 417, No.5007	Aus (Energie) IEC 417, No.5008	Erdanschluß IEC 417, No.5017	Schutzleiteranschluß IEC 417, No.5019
Masseanschluß IEC 417, No.5020	Aquipotential- anschluß IEC 417, No.5021	Gleichstrom IEC 417, No.5031	Wechselstrom IEC 417, No.5032
Gleich- oder Wechselstrom IEC 417, No.5033-a	Durchgängige doppelte oder verstärkte Isolierung IEC 417, No.5172-a	3~ Dreileiter- Wechselstrom (Drehstrom) IEC 617-2, No.020206	
Warnung vor einer Gefahrenstelle (Achtung, Dokumen- tation beachten) ISO 3864, No.B.3.1	Warnung vor gefährlicher elektrischer Spannung ISO 3864, No.B.3.6	Höhere Temperatur an leicht zugänglichen Teilen IEC 417, No.5041	

Tabelle 2: Bedeutung der am Gerät angebrachten Symbole

Sicherheitsvorschriften und Vorsichtsmaßnahmen

Folgende allgemeine Sicherheitsvorschriften sind während allen Betriebsphasen dieses Gerätes zu befolgen. Eine Mißachtung der Sicherheitsvorschriften und sonstiger Warnhinweise in dieser Betriebsanleitung verletzt die für dieses Gerät und seine Bedienung geltenden Sicherheitsstandards, und kann die Schutzvorrichtungen an diesem Gerät wirkungslos machen. MKS Instruments, Inc. haftet nicht für Mißachtung dieser Sicherheitsvorschriften seitens des Kunden.

Niemals Teile austauschen oder Änderungen am Gerät vornehmen!

Ersetzen Sie keine Teile mit baugleichen oder ähnlichen Teilen, und nehmen Sie keine eigenmächtigen Änderungen am Gerät vor. Schicken Sie das Gerät zwecks Wartung und Reparatur an den MKS-Kalibrierungs- und -Kundendienst ein. Nur so wird sichergestellt, daß alle Schutzvorrichtungen voll funktionsfähig bleiben.

Wartung nur durch qualifizierte Fachleute!

Das Auswechseln von Komponenten und das Vornehmen von internen Einstellungen darf nur von qualifizierten Fachleuten durchgeführt werden, niemals vom Bedienpersonal.

Vorsicht beim Arbeiten mit gefährlichen Stoffen!

Wenn gefährliche Stoffe verwendet werden, muß der Bediener die entsprechenden Sicherheitsvorschriften genauestens einhalten, das Gerät, falls erforderlich, vollständig spülen, sowie sicherstellen, daß der Gefahrstoff die am Gerät verwendeten Materialien, insbesondere Dichtungen, nicht angreift.

Spülen des Gerätes mit Gas!

Nach dem Installieren oder vor dem Ausbau aus einem System muß das Gerät unter Einsatz eines reinen Trockengases vollständig gespült werden, um alle Rückstände des Vorgängermediums zu entfernen.

Anweisungen zum Spülen des Gerätes

Das Gerät darf nur unter einer Ablufthaube gespült werden. Schutzhandschuhe sind zu tragen.

Gerät nicht zusammen mit explosiven Stoffen, Gasen oder Dämpfen benutzen!

Um der Gefahr einer Explosion vorzubeugen, darf dieses Gerät niemals zusammen mit (oder in der Nähe von) explosiven Stoffen aller Art eingesetzt werden, sofern es nicht ausdrücklich für diesen Zweck zugelassen ist.

Anweisungen zum Installieren der Armaturen!

Alle Anschlußstücke und Armaturenteile müssen mit der Gerätespezifikation übereinstimmen, und mit dem geplanten Einsatz des Gerätes kompatibel sein. Der Einbau, insbesondere das Anziehen und Abdichten, muß gemäß den Anweisungen des Herstellers vorgenommen werden.

Verbindungen auf Undichtigkeiten prüfen!

Überprüfen Sie sorgfältig alle Verbindungen der Vakuumkomponenten auf undichte Stellen.

Gerät nur unter zulässigen Anschlußdrücken betreiben!

Betreiben Sie das Gerät niemals unter Drücken, die den maximal zulässigen Druck (siehe Produktspezifikationen) übersteigen.

Geeignete Berstscheibe installieren!

Wenn mit einer unter Druck stehenden Gasquelle gearbeitet wird, sollte eine geeignete Berstscheibe in das Vakuumsystem installiert werden, um eine Explosionsgefahr aufgrund von steigendem Systemdruck zu vermeiden.

Verunreinigungen im Gerät vermeiden!

Stellen Sie sicher, daß Verunreinigungen jeglicher Art weder vor dem Einsatz noch während des Betriebs in das Instrumenteninnere gelangen können. Staub- und Schmutzpartikel, Glassplitter oder Metallspäne können das Gerät dauerhaft beschädigen oder Prozeß und Meßwerte verfälschen.

Bei Geräten mit Temperaturkontrolle korrekte Anwärmzeit einhalten!

Temperaturkontrollierte Geräte arbeiten nur dann gemäß ihrer Spezifikation, wenn genügend Zeit zum Erreichen und Stabilisieren der Betriebstemperatur eingeräumt wird. Kalibrierungen und Nulleinstellungen sollten daher nur nach Abschluß des Anwärmvorgangs durchgeführt werden.

Informations relatives à la sécurité pour le transducteur de pression

Symboles utilisés dans ce manuel d'utilisation

Définitions des indications AVERTISSEMENT, ATTENTION, et REMARQUE utilisées dans ce manuel.

Avertissement

L'indication AVERTISSEMENT signale un danger pour le personnel. Elle attire l'attention sur une procédure, une pratique, une condition, ou toute autre situation présentant un risque d'accident pour le personnel, en cas d'exécution incorrecte ou de non respect des consignes.

Attention

L'indication ATTENTION signale un danger pour l'appareil. Elle attire l'attention sur une procédure d'exploitation, une pratique, ou toute autre situation, présentant un risque d'endommagement ou de destruction d'une partie ou de la totalité de l'appareil, en cas d'exécution incorrecte ou de non respect des consignes.

Remarque

L'indication REMARQUE signale une information importante. Elle attire l'attention sur une procédure, une pratique, une condition, ou toute autre situation, présentant un intérêt particulier.

Symboles apparaissant sur l'unité

Le tableau suivant décrit les symboles pouvant apparaître sur l'unité.

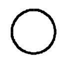
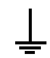
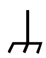
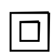
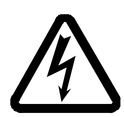
Définition des symboles apparaissant sur l'unité			
 Marche (sous tension) IEC 417, No.5007	 Arrêt (hors tension) IEC 417, No.5008	 Terre (masse) IEC 417, No.5017	 Terre de protection (masse) IEC 417, No.5019
 Masse IEC 417, No.5020	 Equipotentialité IEC 417, No.5021	 Courant continu IEC 417, No.5031	 Courant alternatif IEC 417, No.5032
 Courant continu et alternatif IEC 417, No.5033-a	 Matériel de classe II IEC 417, No.5172-a	 Courant alternatif triphasé IEC 617-2, No.020206	
 Attention : se reporter à la documentation ISO 3864, No.B.3.1	 Attention : risque de choc électrique ISO 3864, No.B.3.6	 Attention : surface brûlante IEC 417, No.5041	

Tableau 3: Définition des symboles apparaissant sur l'unité

Mesures de sécurité et précautions

Prendre les précautions générales de sécurité suivantes pendant toutes les phases d'exploitation de cet appareil. Le non respect des ces précautions ou des avertissements contenus dans ce manuel constitue une violation des normes de sécurité relatives à l'utilisation de l'appareil et peut diminuer la protection fournie par l'appareil. MKS Instruments, Inc. n'assume aucune responsabilité concernant le non respect des consignes par les clients.

PAS DE SUBSTITUTION DE PIÈCES OU DE MODIFICATION DE L'APPAREIL

Ne pas installer des pièces de substitution ou effectuer des modifications non autorisées sur l'appareil. Renvoyer l'appareil à un centre de service et de calibrage MKS pour tout dépannage ou réparation afin de garantir le l'intégrité des dispositifs de sécurité.

DÉPANNAGE UNIQUEMENT PAR DU PERSONNEL QUALIFIÉ

Le personnel d'exploitation ne doit pas essayer de remplacer des composants ou de faire des réglages internes. Tout dépannage doit être uniquement effectué par du personnel qualifié.

PRÉCAUTION EN CAS D'UTILISATION AVEC DES PRODUITS DANGEREUX

Si des produits dangereux sont utilisés, l'utilisateur est responsable de la prise des mesures de précaution appropriées, de la purge complète de l'appareil quand cela est nécessaire, et de la garantie que les produits utilisés sont compatibles avec les composants de cet appareil, y compris les matériaux d'étanchéité.

PURGE DE L'APPAREIL

Après l'installation de l'unité, ou avant son enlèvement d'un système, purger l'unité complètement avec un gaz propre et sec afin d'éliminer toute trace du produit de flux utilisé précédemment.

UTILISATION DES PROCÉDURES APPROPRIÉES POUR LA PURGE

Cet appareil doit être purgé sous une hotte de ventilation, et il faut porter des gants de protection.

PAS D'EXPLOITATION DANS UN ENVIRONNEMENT EXPLOSIF

Pour éviter toute explosion, ne pas utiliser cet appareil dans un environnement explosif, sauf en cas d'homologation spécifique pour une telle exploitation.

UTILISATION D'ÉQUIPEMENTS APPROPRIÉS ET PROCÉDURES DE SERRAGE

Tous les équipements de l'appareil doivent être cohérents avec ses spécifications, et compatibles avec l'utilisation prévue de l'appareil. Assembler et serrer les équipements conformément aux directives du fabricant.

VÉRIFICATION DE L'ÉTANCHÉITÉ DES CONNEXIONS

Vérifier attentivement toutes les connexions des composants pour le vide afin de garantir l'étanchéité de l'installation.

EXPLOITATION AVEC DES PRESSIONS D'ENTRÉE NON DANGEREUSES

Ne jamais utiliser des pressions supérieures à la pression nominale maximum (se reporter aux spécifications de l'unité pour la pression maximum admissible).

INSTALLATION D'UN DISQUE D'ÉCHAPPEMENT ADAPTÉ

En cas d'exploitation avec une source de gaz pressurisé, installer un disque d'échappement adapté dans le système à vide, afin d'éviter une explosion du système en cas d'augmentation de la pression.

MAINTIEN DE L'UNITÉ À L'ABRI DES CONTAMINATIONS

Ne pas laisser des produits contaminants pénétrer dans l'unité avant ou pendant l'utilisation. Des produits contaminants tels que des poussières et des fragments de tissu, de glace et de métal peuvent endommager l'unité d'une manière permanente ou contaminer le processus.

RESPECT DU TEMPS D'ÉCHAUFFEMENT APPROPRIÉ POUR LES UNITÉS Á TEMPÉRATURE CONTRÔLÉE

Les unités à température contrôlée atteignent leurs spécifications uniquement quand on leur laisse un temps suffisant pour atteindre d'une manière stable la température d'exploitation. Ne pas remettre à zéro ou calibrer l'unité tant que l'échauffement n'est pas terminé.

Medidas de seguridad del transductor de presión

Símbolos usados en este manual de instrucciones

Definiciones de los mensajes de advertencia, precaución y de las notas usados en el manual.

Advertencia 

El símbolo de advertencia indica la posibilidad de que se produzcan daños personales. Pone de relieve un procedimiento, práctica, estado, etc. que en caso de no realizarse u observarse correctamente puede causar daños personales.

Precaución 

El símbolo de precaución indica la posibilidad de producir daños al equipo. Pone de relieve un procedimiento operativo, práctica, estado, etc. que en caso de no realizarse u observarse correctamente puede causar daños o la destrucción total o parcial del equipo.

Nota 

El símbolo de notas indica información de importancia. Este símbolo pone de relieve un procedimiento, práctica o condición cuyo conocimiento es esencial destacar.

Símbolos hallados en la unidad

La tabla siguiente contiene los símbolos que puede hallar en la unidad.

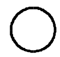
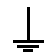
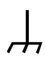
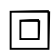
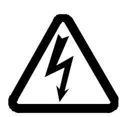
Definición de los símbolos hallados en la unidad			
 Encendido (alimentación eléctrica) IEC 417, N° 5007	 Apagado (alimentación eléctrica) IEC 417, N° 5008	 Puesta a tierra IEC 417, N° 5017	 Protección a tierra IEC 417, N° 5019
 Caja o chasis IEC 417, N° 5020	 Equipotencialidad IEC 417, N° 5021	 Corriente continua IEC 417, N° 5031	 Corriente alterna IEC 417, N° 5032
 Corriente continua y alterna IEC 417, N° 5033-a	 Equipo de clase II IEC 417, N° 5172-a	 Corriente alterna trifásica IEC 617-2, N° 020206	
 Precaución. Consulte los documentos adjuntos ISO 3864, N° B.3.1	 Precaución. Riesgo de descarga eléctrica ISO 3864, N° B.3.6	 Precaución. Superficie caliente IEC 417, N° 5041	

Tabla 4: Definición de los símbolos hallados en la unidad

Procedimientos y precauciones de seguridad

Las precauciones generales de seguridad descritas a continuación deben observarse durante todas las etapas de funcionamiento del instrumento. La falta de cumplimiento de dichas precauciones o de las advertencias específicas a las que se hace referencia en el manual, constituye una violación de las normas de seguridad establecidas para el uso previsto del instrumento y podría anular la protección proporcionada por el equipo. Si el cliente no cumple dichas precauciones y advertencias, MKS Instruments, Inc. no asume responsabilidad legal alguna.

NO UTILICE PIEZAS NO ORIGINALES O MODIFIQUE EL INSTRUMENTO

No instale piezas que no sean originales ni modifique el instrumento sin autorización. Para asegurar el correcto funcionamiento de todos los dispositivos de seguridad, envíe el instrumento al Centro de servicio y calibración de MKS toda vez que sea necesario repararlo o efectuar tareas de mantenimiento.

LAS REPARACIONES DEBEN SER EFECTUADAS ÚNICAMENTE POR TÉCNICOS AUTORIZADOS

Los operarios no deben intentar reemplazar los componentes o realizar tareas de ajuste en el interior del instrumento. Las tareas de mantenimiento o reparación deben ser realizadas únicamente por personal autorizado.

TENGA CUIDADO CUANDO TRABAJE CON MATERIALES TÓXICOS

Cuando se utilicen materiales tóxicos, es responsabilidad de los operarios tomar las medidas de seguridad correspondientes, purgar totalmente el instrumento cuando sea necesario y comprobar que el material utilizado sea compatible con los materiales del instrumento e inclusive, con todos los materiales de sellado.

PURGUE EL INSTRUMENTO

Una vez instalada la unidad o antes de retirarla del sistema, purgue completamente la unidad con gas limpio y seco para eliminar todo resto de la sustancia líquida empleada anteriormente.

USE PROCEDIMIENTOS ADECUADOS PARA REALIZAR LA PURGA

El instrumento debe purgarse debajo de una campana de ventilación y deben utilizarse guantes protectores.

NO HAGA FUNCIONAR EL INSTRUMENTO EN AMBIENTES CON RIESGO DE EXPLOSIÓN

Para evitar que se produzcan explosiones, no haga funcionar este instrumento en un ambiente con riesgo de explosiones, excepto cuando el mismo haya sido certificado específicamente para tal uso.

USE ACCESORIOS ADECUADOS Y REALICE CORRECTAMENTE LOS PROCEDIMIENTOS DE AJUSTE

Todos los accesorios del instrumento deben cumplir las especificaciones del mismo y ser compatibles con el uso que se debe dar al instrumento. Arme y ajuste los accesorios de acuerdo con las instrucciones del fabricante.

COMPRUEBE QUE LAS CONEXIONES SEAN A PRUEBA DE FUGAS

Inspeccione cuidadosamente las conexiones de los componentes de vacío para comprobar que hayan sido instalados a prueba de fugas.

HAGA FUNCIONAR EL INSTRUMENTO CON PRESIONES DE ENTRADA SEGURAS

No haga funcionar nunca el instrumento con presiones superiores a la máxima presión nominal (en las especificaciones del instrumento hallará la presión máxima permitida).

INSTALE UNA CÁPSULA DE SEGURIDAD ADECUADA

Cuando el instrumento funcione con una fuente de gas presurizado, instale una cápsula de seguridad adecuada en el sistema de vacío para evitar que se produzcan explosiones cuando suba la presión del sistema.

MANTENGA LA UNIDAD LIBRE DE CONTAMINANTES

No permita el ingreso de contaminantes en la unidad antes o durante su uso. Los productos contaminantes tales como polvo, suciedad, pelusa, lascas de vidrio o virutas de metal pueden dañar irreparablemente la unidad o contaminar el proceso.

CALIENTE ADECUADAMENTE LAS UNIDADES CONTROLADAS POR MEDIO DE TEMPERATURA

Las unidades controladas por medio de temperatura funcionarán de acuerdo con las especificaciones sólo cuando se las caliente durante el tiempo suficiente para permitir que lleguen y se estabilicen a la temperatura de operación indicada. No calibre la unidad y no la ponga en cero hasta que finalice el procedimiento de calentamiento.

Chapter One: General Information, (this chapter) introduces the product and describes the organization of the manual.

Chapter Two: Installation, explains the environmental requirements and describes how to mount the instrument in your system.

Chapter Three: Overview, gives a brief description of the instrument and its functionality.

Chapter Four: Operation, describes how to use the instrument and explains all the functions and features.

Chapter Five: Maintenance and Troubleshooting, lists a few general practices to follow to ensure that the unit will perform optimally. It also includes a table of hints for reference in the event the unit malfunctions.

Appendix A: Product Specifications, lists the specifications of the instrument.

Appendix B: Model Code Explanation, describes the model code.

Customer Support

Standard maintenance and repair services are available at all of our regional MKS Calibration and Service Centers listed on the back cover. In addition, MKS accepts the instruments of other manufacturers for recalibration using the Primary and Transfer Standard calibration equipment located at all of our regional service centers. Should any difficulties arise in the use of your Type 722B instrument, or to obtain information about companion products MKS offers, contact any authorized MKS Calibration and Service Center. If it is necessary to return the instrument to MKS, please obtain an RMA (Return Material Authorization) Number from the MKS Calibration and Service Center before shipping. The RMA Number expedites handling and ensures proper servicing of your instrument.

Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Warning **All returns to MKS Instruments must be free of harmful, corrosive, radioactive, or toxic materials.**

Chapter Two: Installation

How To Unpack the Type 722B Unit

MKS has carefully packed the Type 722B unit so that it will reach you in perfect operating order. Upon receiving the unit, however, you should check for defects, cracks, broken connectors, etc., to be certain that damage has not occurred during shipment.

Note Do *not* discard any packing materials until you have completed your inspection and are sure the unit arrived safely.

If you find any damage, notify your carrier and MKS immediately. If it is necessary to return the unit to MKS, obtain an RMA (Return Material Authorization) Number from the MKS Service Center before shipping. Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Caution **Only qualified individuals should perform the installation and any user adjustments. They must comply with all the necessary ESD and handling precautions while installing and adjusting the instrument. Proper handling is essential when working with all highly sensitive precision electronic instruments.**

Unpacking Checklist

Standard Equipment:

- Type 722B Unit
- Type 722B Instruction Manual (this book)

Optional Equipment:

- Electrical Connector Accessories Kit - 722B-K1 (includes a mating connector for the electrical connector)
- Most pressure, flow, flow ratio, and throttling valve controllers
- MKS Type 146, Type 660, Type PDR-C-1C, or Type PDR-C-2C power supply/readout unit, or PDR 2000 dual channel power supply/readout unit
- Cables to connect the 722B transducer to the above equipment

Product Location and Requirements

Operating Environmental Requirements

- Ambient Operating Temperature: 0° C to 50° C (32° F to 122° F),
  15° C to 40° C(59° F to 104° F) 1 and 2 torr only.
- Ventilation requirements include sufficient air circulation

Dimensions

Note All dimensions are listed in inches with millimeters referenced in parentheses.

The dimensions of the 722B transducer vary depending upon the full scale range:

Full scale ranges up to and including 1000 Torr: are referred to as "low pressure" transducers

Full scale ranges above 1000 Torr: are referred to as "high pressure" transducers

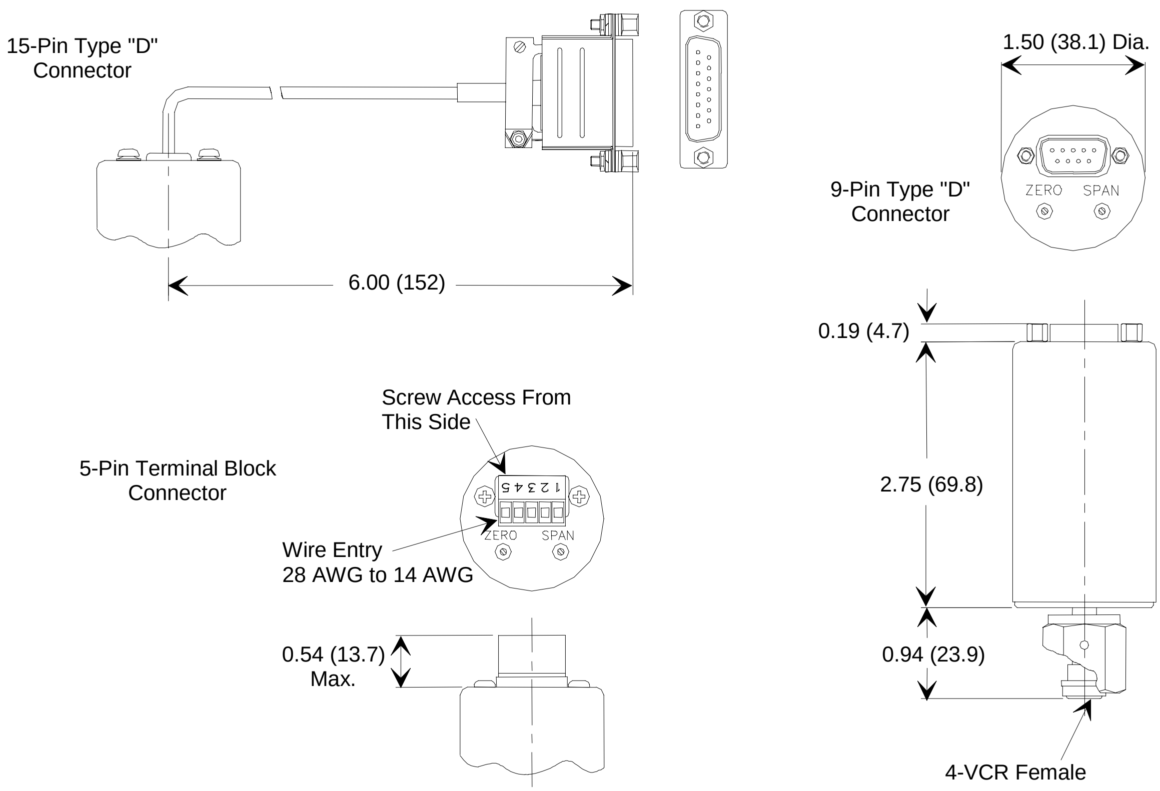


Figure 1: Dimensions of the Low Pressure (up to 1000 Torr) Type 722B Transducer

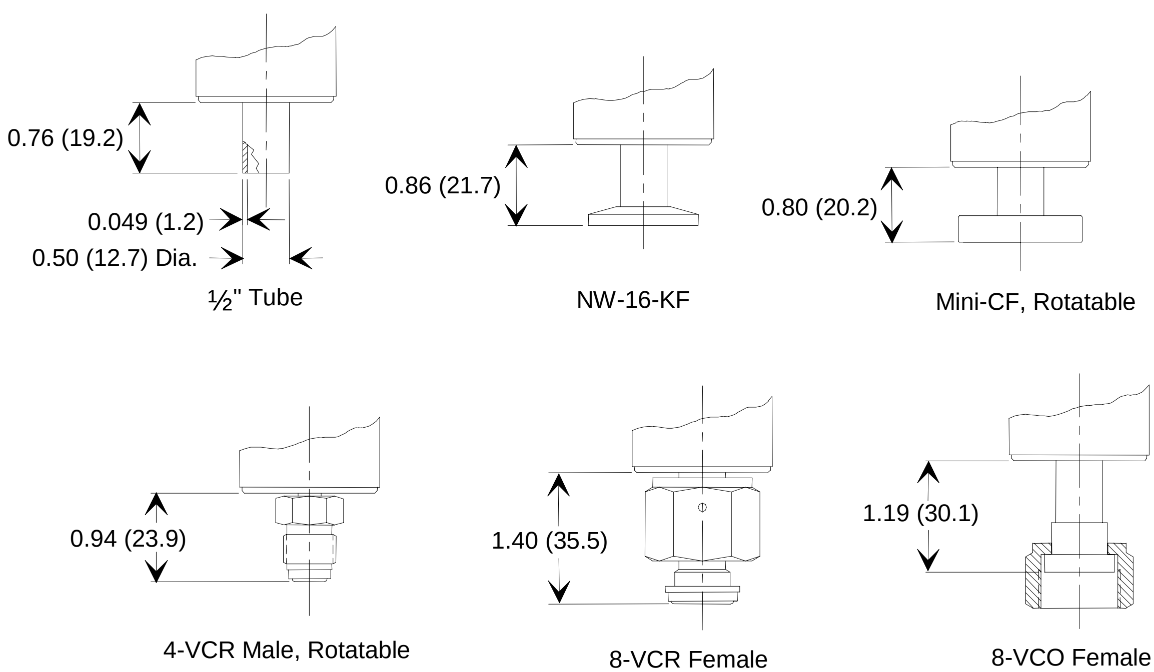


Figure 2: Fitting Dimensions for the Low Pressure Type 722B Transducer

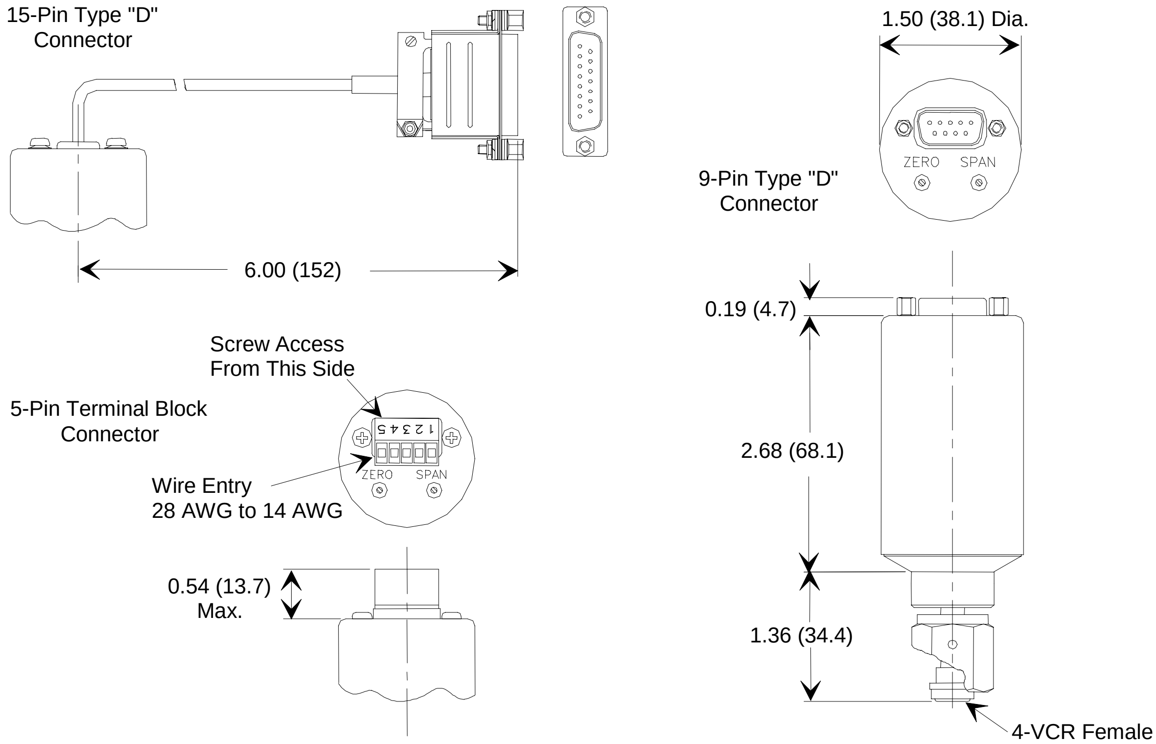


Figure 3: Dimensions of the High Pressure (>1000 to 25,000 Torr) Type 722B Transducer

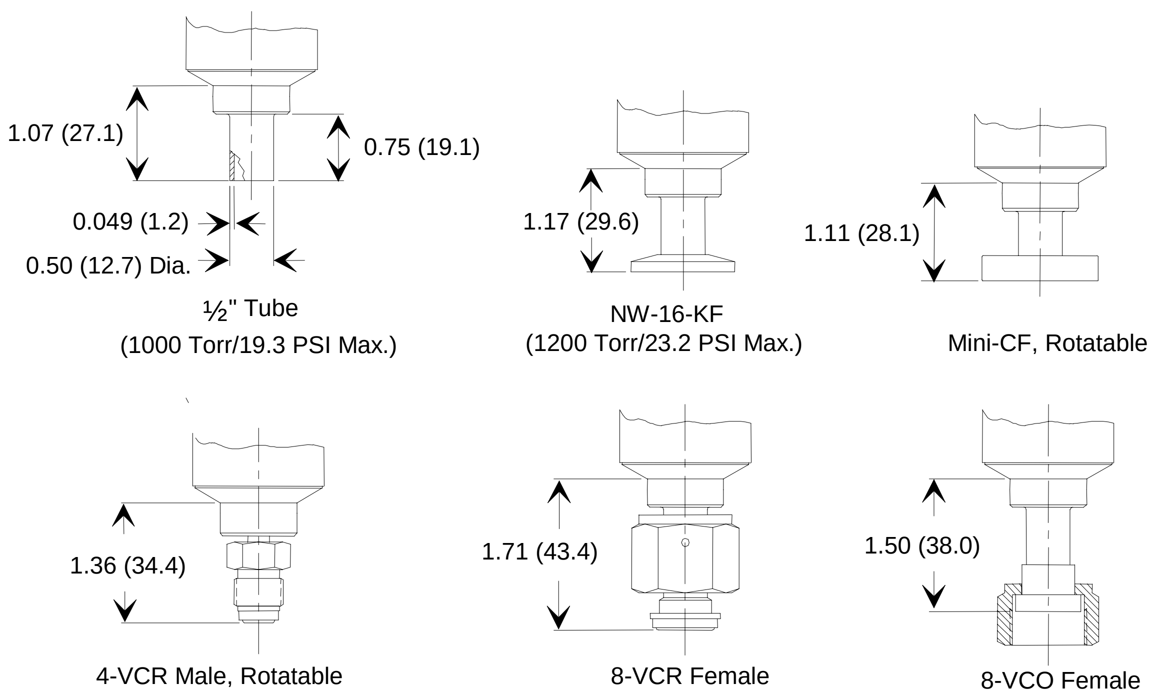


Figure 4: Fitting Dimensions of the High Pressure Type 722B Transducer

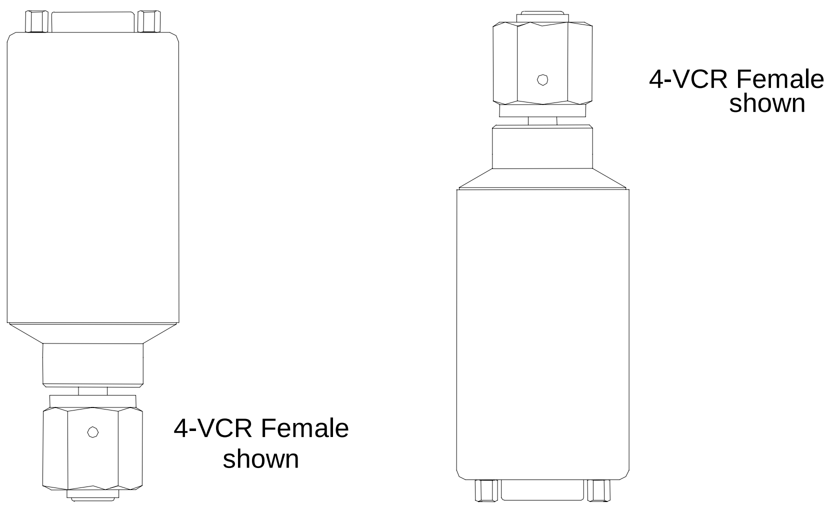
Setup

Mounting

The 722B transducer can be mounted with the cylindrical end in either a vertical (upright) or horizontal position. The mounting requirements allow any foreign matter entering the pressure port to fall *away from* the sensing diaphragm.

Mounting the Unit in a Vertical Position

If the unit is mounted in a vertical position, the cylindrical end of the unit must point upwards, as shown in Figure **Error! Bookmark not defined.**. Do not install the unit with the cylindrical end of the unit pointing downward because particulate impurities may accumulate on the sensing diaphragm and alter the pressure reading.



Acceptable Vertical Mounting ***Unacceptable*** Vertical Mounting

Figure 5: Vertical Mounting Positions

Mounting the Unit in a Horizontal Position

In a horizontal position, the cylindrical end of the unit can point in any direction.

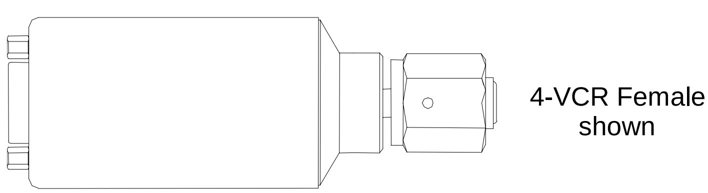


Figure 6: Acceptable Horizontal Mounting Position

Fittings

The 722B transducer is available with a variety of different fittings, listed below:

- ½" Tube
- 4-VCR® type Female
- 8-VCR® type Female
- 8-VCO® type Female
- NW-16-KF
- Mini-CF

Caution

1. **MKS *does not warranty* the 722B transducer when single or double metal ferrule compression-type vacuum fittings are used because damage will occur to the transducer when improper tightening procedures are followed.**
2. **Before proceeding to *Setup*, page 47, carefully check all plumbing connections to the instrument to ensure a leak-tight installation.**

Making Mechanical Connections

To make mechanical connections in line to a system, use the recommended installation practices, as specified by the fitting manufacturer or by an appropriate standard.

Warning

Improper installation can cause personal injury or damage equipment. Follow proper installation procedures at all times.

How To Tighten Fitting Attachments

For VCR Fittings: Tighten ⅛ turn past the finger tight position for 316 SS or nickel gaskets (¼ turn for copper or aluminum).

Connectors

The 722B transducer is available with a 9-pin Type "D", a 5-pin terminal block connector, or a 15-pin Type "D" on a 6 inch cable

Note A "No Connection" pin assignment means that the pin has no internal connection.

Pinout of the 9-Pin Type "D" Connector	
Pin	**Assignment**
1	Pressure Output
2	No Connection
3	No Connection
4	+ Power Input
5	No Connection
6	No Connection
7	No Connection
8	Pressure Return
9	Power Return

Table 5: Pinout of the 9-Pin Type "D" Connector

Pinout of the 5-Pin Terminal Block Connector	
Pin	**Assignment**
1	Power Return
2	Pressure Return
3	Pressure Output
4	No Connection
5	+ Power Input

Table 6: Pinout of the 5-Pin Terminal Block Connector

Pinout of the 15-Pin Type "D" Connector	
Pin	**Assignment**
1	No Connection
2	Pressure Output
3	No Connection
4	No Connection
5	Power Return
6	No Connection
7	+ Power Input
8	No Connection
9	No Connection
10	No Connection
11	No Connection
12	Pressure Return
13	No Connection
14	No Connection
15	Chassis

Table 7: Pinout of the 15-Pin Type "D" Connector

How to Wire a PDR-C and PDR-D Series Readout to a Type 722B Transducer with a 9-pin Type "D" Connector.

Caution

DO NOT use the -15 VDC output of the PDR-C and PDR-D readout to power the 722B transducer. When the -15 VDC signal of the PDR-C and PDR-D is connected to the power return of the transducer, a short between the -15 VDC of the transducer and the A GND of the PDR-C and PDR-D occurs. The PDR –C and PDR-D readout will blank out. Either unit may be damaged.

The correct cable to use to connect the 9 pin Type "D" connector to the PDR-C and PDR- D readout is a CB700-2 cable. This cable has the mating Type "D" connector on the transducer end and flying leads on the PDR-C and PDR-D end. Table 4 lists the pin assignments for the various colored wires on the flying leads end of the cable.

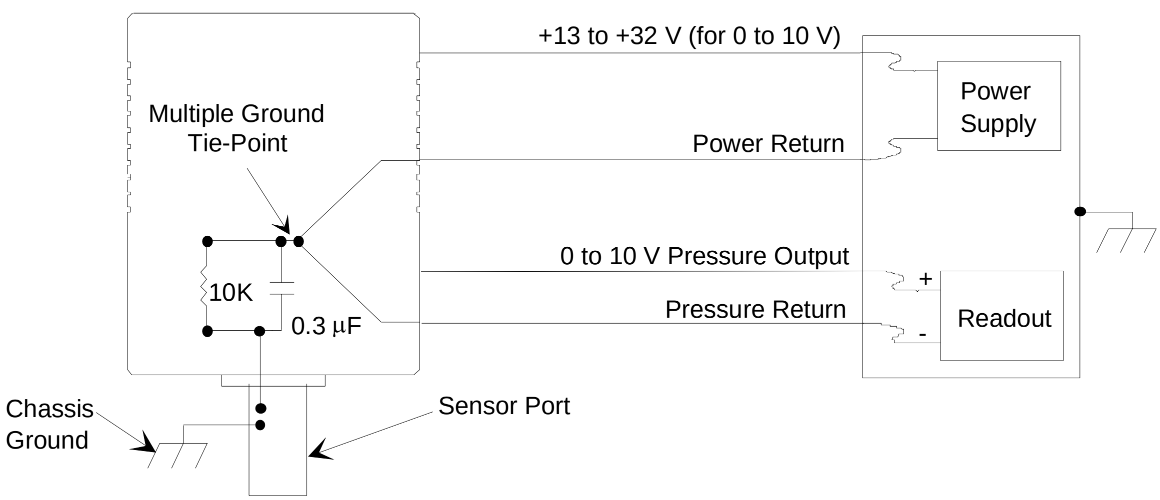
Connections Between a Transducer with a Type "D" Connector and a PDR-C/-D Readout			
Pin Number	**Transducer Signal**	**Flying Lead Color Code**	**PDR Signal**
1	Pressure Output	Red	Pressure Input
4	+ Power Input	Green	+ 15 VDC
8	Pressure Return	Black	Signal Ground (A GND)
9	Power Return	White	Power Ground (D GND)

Table 8: Connections Between a Transducer with a Type "D" Connector and a PDR-C /- D Readout

Electrical Information

The 722B transducer requires an external power source capable of supplying the voltages listed in *Appendix A: Product Specifications,* page 65. Noise and ripple should be less than 20 mV (peak-to-peak) over a 10 kHz bandwidth. You may use any readout device capable of reading from -0.6 V to 11 V. Refer to Figure 1 for the power, signal and chassis grounding scheme for a voltage unit.

Note The ground of any external power supply and readout should be the same as the transducer ground (chassis ground) to minimize any possible ground loops and power supply noise which can affect the performance and stability of the system.



Note 1: For best results, use a readout with fully differential inputs.

Note 2: The absolute value of the potential difference between the chassis ground and signal common/power ground should not exceed 14 Volts.

Figure 1: Electrical Scheme for a Voltage Unit

NW16-KF Fitting Information

The NW16-KF fittings are only available for units with full scale pressure of a maximum of 5000 Torr (100 psia) or less.

Warning **Units with NW16-KF fittings and a full scale range greater than 1200 Torr (23 psi) require an HPS overpressure ring. Operating the unit without a protective overpressure ring may result in injury.**

The HPS part number for the overpressure ring is 100316301.

Interface Cables

Interface cables to all MKS companion products can be purchased from MKS. Refer to Table 5 for a listing of the cable numbers.

As of July 20, 2009, all products shipped to the European Community must comply with the EMC Directive 2004/108/EEC, which covers radio frequency emissions and immunity tests. MKS products that meet these requirements are identified by application of the CE Mark.

Note Metal braided, shielded cables are required to meet CE Mark specifications.

Interface Cables			
Transducer Connector	**MKS Power Supply/Readout**	**Cable Description**	**Cable Number**
9-pin Type "D"	Type 146, 660	9-pin Type "D" to 15-pin Type "D"	CB700-S-1-X
	PDR-C-1C, PDR-C-2C, PDR-D-1	9-pin Type "D" to flying leads	CB700-S-2-X
9-Pin Type "D"	PDR 2000 Dual Channel	Single 9-Pin Type "D" to Dual 9-Pin Type "D"	CB2000-2-m1 (10ft) -M2 (20ft)-M3 (30ft)
where X indicates the length of the cable, in feet			

Table 9: Interface Cables

Generic Shielded Cable Description

MKS offers a full line of cables for all MKS equipment. Should you choose to manufacture your own cables, follow the guidelines listed below:

1. The cable must have a *braided* shield, covering all wires. Neither aluminum foil nor spiral shielding will be as effective; using either may nullify regulatory compliance.
2. The connectors must have a metal case, which has direct contact to the cable's shield on the whole circumference of the cable. The inductance of a flying lead or wire from the shield to the connector will seriously degrade the shield's effectiveness. The shield should be grounded to the connector before its internal wires exit.
3. With very few exceptions, the connector(s) must make good contact to the device's case (ground). "Good contact" is about 0.01 ohms; and the ground should surround all wires. Contact to ground at just one point may not suffice.
4. For shielded cables with flying leads at one or both ends; it is important at each such end, to ground the shield *before* the wires exit. Make this ground with absolute minimum length. Refer to Figures 2 and 3, page 55. (A ¼ inch piece of #22 wire may be undesirably long since it has approximately 5 nH of inductance, equivalent to 31 ohms at 1000 MHz). After picking up the braid's ground, keep wires and braid flat against the case. With very few exceptions, grounded metal covers are not required over terminal strips. If one is required, it will be stated in the Declaration of Conformity or in the instruction manual.
5. In selecting the appropriate type and wire size for cables, consider:
   A. The voltage ratings;
   B. The cumulative I^2R heating of all the conductors (keep them safely cool);
   C. The IR drop of the conductors, so that adequate power or signal voltage gets to the device;
   D. The capacitance and inductance of cables which are handling fast signals, (such as data lines or stepper motor drive cables); and
   E. That some cables may need internal shielding from specific wires to others; please see the instruction manual for details regarding this matter.

Attaching the Terminal Block Connector Cable

The cable to the terminal block connector must be firmly attached to the top of the transducer, in order to comply with CE Mark requirements. Figure 2 shows the preferred method to connect the cable; using a metal cable clamp to affix the cable to the transducer. Figure 3 shows an alternate method; wrapping the braided shield under the screw. Both examples show the cable securely clamped to the transducer.

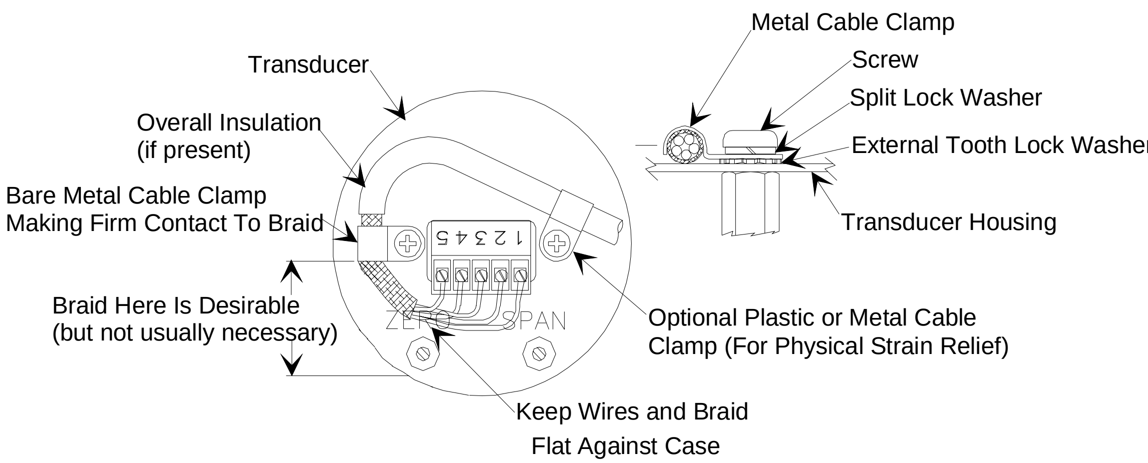


Figure 2: How To Connect the Cable to a Terminal Block (Example 1)

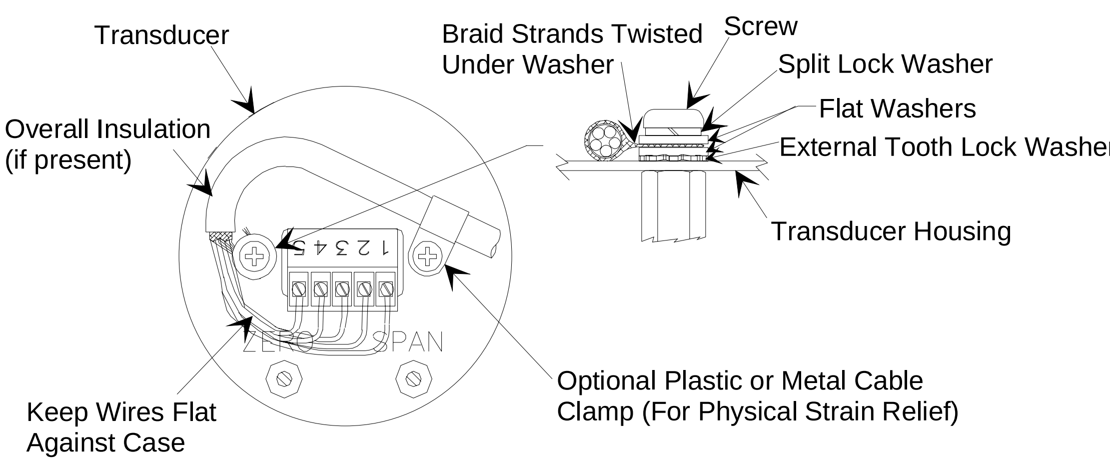


Figure 3: How To Connect the Cable to a Terminal Block (Example 2)

How To Check the Transducer Zero

Check the transducer zero prior to the initial operation and then periodically as required. The zero can be set (or reset) by adjusting the zero potentiometer located on the top cover of the transducer or, on the front panel of an MKS Power Supply/Readout, if you are using one. Refer to Figure **Error! Bookmark not defined.**, page 45, for the location of the zero potentiometer on a low pressure 722B transducer; Figure **Error! Bookmark not defined.**, page 46, for a high pressure 722B transducer.

How To Zero the 722B Transducer

To zero the 722B transducer, you must pump the unit, with the power on, down to a pressure less than the transducer's resolution (0.01% of Full Scale).

Note

The zero adjustment ***must*** be made at a pressure less than the transducer's resolution (0.01% of F.S.).

In addition, you should position the transducer in the *same orientation* as it will be positioned when installed in your system.

Zeroing a transducer at a pressure above its stated minimum resolution creates a *zero offset* relative to true absolute pressure. All subsequent readings are then linear and accurate *relative to the offset value*.

Note

If your system cannot achieve a sufficiently low pressure to set the transducer zero, you may use a vacuum leak detector with sufficient vacuum pumping (to achieve proper zeroing pressures). In this case, mount the transducer on the leak detector *in the same plane of orientation as it will be during actual use*.

To properly zero an absolute transducer, follow this procedure:

1. Install the transducer in a system and connect a power supply/readout.

2. Pump the system down to a pressure below the resolution of the transducer.

Refer to Table 6, page 57, for recommended pressure levels.

3. Using a small screwdriver, adjust the ZERO pot until the readout displays zero (0000).

   Refer to the figure listed below for the location of the ZERO pot.

   Low Pressure 722B Transducer: Figure **Error! Bookmark not defined.**, page 45,

   High Pressure 722B Transducer: Figure **Error! Bookmark not defined.**, page 46.

Highest Pressure for Proper Zero Adjustment	
Full Scale Range	**Pressure**
1 Torr	<5 x 10^{-5} Torr
2 Torr	<2 x 10^{-5} Torr
10 Torr	< 5 x 10^{-4} Torr
100 Torr	< 5 x 10^{-3} Torr
500 Torr	< 5 x 10^{-3} Torr
1000 Torr	< 5 x 10^{-2} Torr
30 psia	< 1 x 10^{-3} psia
100 psia	< 5 x 10^{-3} psia
500 psia	< 2 x 10^{-2} psia

Table 10: Highest Pressure for Proper Zero Adjustment

Span Adjustment

The span setting may require adjustment periodically. Only adjust the SPAN pot in conjunction with a calibration transfer standard. ***Do not*** adjust the span setting if a calibration transfer standard is not available. Instead, send the unit back to an MKS Service Center for calibration.

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Chapter Three: Overview

General Information

A complete pressure transducer system requires three components to convert pressure to a linear DC voltage output: a sensor, signal conditioner, and power supply. An analog or digital meter is required to display the DC output in pressure units.

The 722B transducer contains two of the above components: the sensor and signal conditioner. An MKS or MKS-compatible power supply is required to complete the pressure to DC voltage output conversion, and an MKS or MKS-compatible display unit is required for direct pressure readout. The display unit could be a personal computer, an MKS pressure controller, or an MKS PDR Series power supply/readout unit.

Sensor

The variable capacitance sensor consists of a pressure inlet tube (port) connected to a small chamber in the transducer body. One wall of this chamber is a metal diaphragm. The front side of the diaphragm is exposed to the gas whose pressure is to be measured. The back, or *reference* side of the diaphragm faces a rigidly mounted ceramic disc containing two electrodes. The diaphragm is positioned opposite the inlet port.

The reference side is permanently evacuated below the resolution of the instrument and its vacuum is maintained with a chemical getter system.

The diaphragm deflects with changing pressure (force per unit area) independently of the gas type or composition of the measured gas. This deflection causes an imbalance of the sensor electrode capacitances since the distance to the diaphragm is now different for each electrode. Using a precision constant frequency oscillator for excitation, the imbalance of capacitances is converted to a DC voltage. The resultant signal is then linearized, zeroed, and amplified via the signal conditioner electronics, to produce a precise output signal scaled to the range of the transducer.

Signal Conditioning Electronics

The signal conditioner contains state-of-the-art balanced bridge circuitry, self-compensated for thermal stability with ambient temperature changes. The circuit board construction uses surface mount technology. The output is either a DC voltage or mA current, which is linear with pressure. The transducer is then calibrated against a transfer standard to provide the selected output over the range of the transducer. The electronics are compliant with most RoHS (Restriction of Hazardous Substances) Directives.

Label

The 722B transducer has one product identification label, shown in Figure 4.

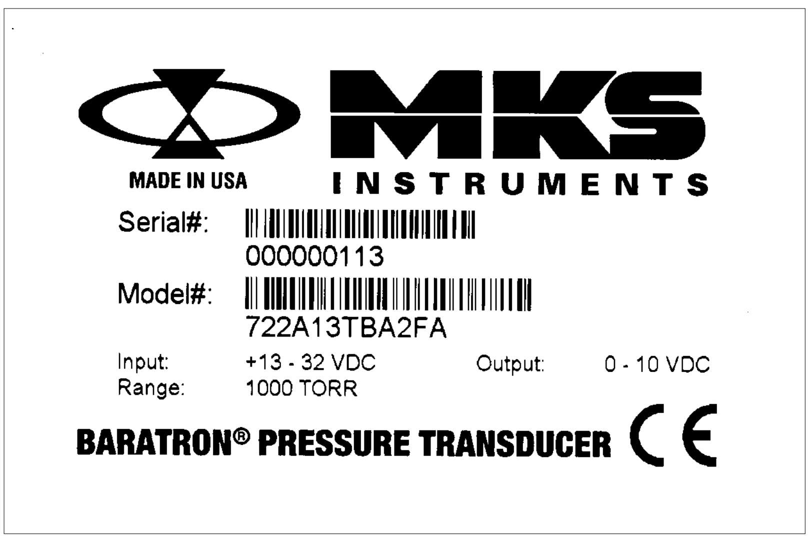

Figure 4: Product Label

Chapter Four: Operation

General

After installation and during periodic maintenance, check the transducer zero to verify proper output. If the output is incorrect, set the output by adjusting the zero potentiometer. Refer to *How To Check the Transducer Zero,* page 56, for zeroing instructions.

Lowest Suggested Pressure Available for Reading

The pressures listed in the middle column of Table 7 reflect reliable and practical pressures for different range transducers. Lower readings may be obtained in environments, which have stable temperature and air flow.

Lowest Suggested Pressure to Use for Control

The pressures listed in the last column of Table 7 are for reference, and represent the pressure reading of the transducer at 50 mV signal output. A DC signal of at least 50 mV is the recommended minimum signal level to use when integrating any transducer into complex processing systems.

Suggested Pressures for Reading and Control		
Full Scale Range	**Lowest Suggested Pressure for Reading**	**Lowest Suggested Pressure for Control**
1 Torr	5×10^{-4}	$5 \text{ X } 10^{-3}$
2 Torr	1×10^{-3}	1×10^{-2}
10 Torr	5×10^{-3} Torr	5×10^{-2} Torr
100 Torr	5×10^{-2} Torr	5×10^{-1} Torr
500 Torr	5×10^{-2} Torr	5×10^{-1} Torr
1000 Torr	0.5 Torr	5 Torr
30 psia	3×10^{-2} psia	3×10^{-1} psia
100 psia	0.1 psia	1 psia
500 psia	0.5 psia	5 psia

Table 11: Suggested Pressures for Reading and Control

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Chapter Five: Maintenance and Troubleshooting

General

In general, no maintenance is required other than proper installation and operation, and an occasional zero adjustment. If a transducer fails to operate properly upon receipt, check for shipping damage, and check the power/signal cable for correct continuity. Any damage should be reported to the carrier and MKS Instruments immediately. If there is no obvious damage and the continuity is correct, obtain an ERA Number (Equipment Return Authorization Number) before returning the unit to MKS Instruments for service.

Caution

Only qualified individuals should perform the installation and any user adjustments. They must comply with all the necessary ESD and handling precautions while installing and adjusting the instrument. Proper handling is essential when working with all highly sensitive precision electronic instruments.

In production operations, verify the transducer zero (and adjust if necessary) each time the equipment is shut down for routine maintenance.

Periodically check for wear on the cables and inspect the enclosure for visible signs of damage.

Note

The zero adjustment is the ***only*** adjustment that should usually be made in the field. Only adjust the span setting if you have access to proper calibration standards. Return the transducer to MKS Instruments for other adjustments, calibration, or servicing.

Zero Adjustment

All pressure transducers require initial and periodic zero adjustments. Make these adjustments at a pressure *lower than* the transducer's minimum resolution to achieve the full dynamic range specified for the transducer. Refer to *How To Zero the 722B Transducer*, page 56, for instructions on adjusting the zero setting.

Troubleshooting

Troubleshooting Chart		
Symptom	**Possible Cause**	**Solution**
Overrange positive or negative signal	A shorted transducer or a damaged interconnect cable (transducer to electronics module).	Measure supply voltages at the connector. Inspect cable and transducer. Replace if necessary.
Measurement slowly goes positive over time	Overpressure and/or a build-up of contamination in the P_x cavity.	Return to MKS for servicing or transducer replacement.
Unstable zero output	The ambient temperature may be too high. *or* The ambient temperature is varying over a wide range.	Refer to *Operating Environmental Requirements*, page 44, and be sure the ambient temperature is within product requirements.

Table 12: Troubleshooting Chart

Appendix A: Product Specifications

Performance Specifications

Accuracy	0.5% of Reading
CE Mark Compliance[1]	EMC Directive 2004/108/EEC
RoHS (Restriction of Hazardous Substances) Compliance	Fully compliant to Directive 2002-95-EC
Temperature Coefficients	
Zero	0.008% of F.S./ °C 10 Torr through 25,000 Torr
	0.020% of F.S./ °C 1 and 2 Torr
Span	0.04% of Rdg./ °C
	0.05% of Rdg./ °C 1 and 2 Torr

Physical Specifications

Ambient Operating Temperature Range	0° to 50° C (32° to 122° F),15° to 40° C(59° to 104°F) 1&2 Torr only
Burst Pressure	10 times full scale or 100 psi, whichever is greater
Fittings	½ inch Tube; 4-VCR female, 8-VCR female, 8-VCO female, NW16-KF, Mini-CF.
Full Scale Pressure Ranges	1 Torr through 25,000 Torr (0.02 psia through 500 psia)
Material Exposed to Gas	Inconel®
Overpressure Limit	45 psia or 2 times full scale, whichever is greater
Weight	< 10 oz. (< 283 g)

NW16-KF Fitting Information

The NW16-KF fittings are only available for units with full scale pressure up to a maximum of 5000 Torr (100 psia).

[1] Requires a metal, braided, shielded cable properly grounded at both ends.

Warning **Units with NW16-KF fittings and a full scale range greater than 1200 Torr (23 psi) require an HPS overpressure ring. Operating the unit without a protective overpressure ring may result in injury.**

The HPS part number for the overpressure ring is HPS 100316301.

Electrical Specifications

Input Required	
0 to 5 Volt output	10.8 VDC to +32 VDC (regulated if below 13 VDC) @ 10 mA max.
0 to 10 Volt output	+13 VDC to +32 VDC @ 10 mA max.
Output	
0 to 5 VDC	into >10 K ohm load
0 to 10 VDC	into >10 K ohm load

Due to continuing research and development activities, these product specifications are subject to change without notice.

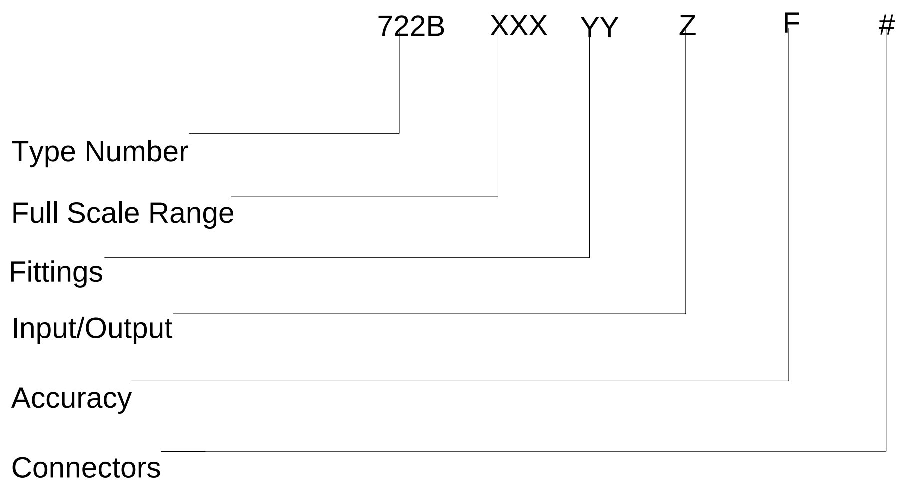
Appendix B: Model Code Explanation

Model Code

The options of your transducer are identified in the model code when you order the unit. The model code is identified as follows:

722BXXXYYZF#

where:



Type Number (722B)

This designates the model number of the instrument.

Full Scale Range (XXX)

The full scale range is indicated by a two digit / one letter code.

Full Scale Range	Ordering Code
1	01T
2	02T
10	11T
20	21T
100	12T
500	52T
1,000*	13T
5,000*	53T
10,000*	14T
25,000*	RCT

*must include a fitting.

Fittings (YY)

Six types of fittings are available, designated by a two letter code.

	Ordering Code
4-VCR Type Female	CD
½0 tube weld stub	BA
8-VCR Type Female	CE
8-VCO Type Female	DA
Mini-CF, rotatable	HA
NW-16-KF	GA

Power (Z)

The input/output power is designated by a single number code.

	Ordering Code
+13 to +32 VDC/0 to 10 VDC	2
+10.8 to 32 VDC/0 to 5 VDC	3

NW-16-KF Fitting Information

The NW-16-KF fittings are only available for units with full scale pressure of a maximum of 5000 Torr (100 psia).

Warning

Units with NW-16-KF fittings and a full scale range greater than 1200 Torr (23 psi) require an HPS overpressure ring. Operating the unit without a protective overpressure ring may result in injury.

The HPS part number for the overpressure ring is HPS 10031.

Accuracy (F)

The accuracy (0.5% of Reading) is specified by a letter F in this field.

Connector (#)

Three types of connectors are available, indicated by a single code.

	Ordering Code
9-pin Type “D”	A
15-pin Type “D” with a 6 inch cable	K
5-pin terminal strip	J

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Index

1034144-001
Rev. A, 5/09

MKS Baratron®
Type 627D
Absolute Pressure Transducer

Printed in the United States of America

Table of Contents

List of Figures and Tables

Figures

Tables

Pressure Transducer Safety Information

Symbols Used in This Instruction Manual

Definitions of WARNING, CAUTION, and NOTE messages used throughout the manual.

Warning

The WARNING sign denotes a hazard to personnel. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.

Caution

The CAUTION sign denotes a hazard to equipment. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of all or part of the product.

Note

The NOTE sign denotes important information. It calls attention to a procedure, practice, condition, or the like, which is essential to highlight.

Symbols Found on the Unit

The following table describes symbols that may be found on the unit.

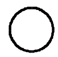
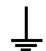
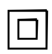
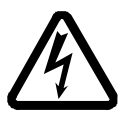
Definition of Symbols Found on the Unit			
 On (Supply) IEC 417, No.5007	 Off (Supply) IEC 417, No.5008	 Earth (ground) IEC 417, No.5017	 Protective earth (ground) IEC 417, No.5019
 Frame or chassis IEC 417, No.5020	 Equipotentiality IEC 417, No.5021	 Direct current IEC 417, No.5031	 Alternating current IEC 417, No.5032
 Both direct and alternating current IEC 417, No.5033-a	 Class ll equipment IEC 417, No.5172-a	 Three phase alternating current IEC 617-2 No.020206	
 Caution, refer to accompanying documents ISO 3864, No.B.3.1	 Caution, risk of electric shock ISO 3864, No.B.3.6	 Caution, hot surface IEC 417, No.5041	

Table 1: Definition of Symbols Found on the Unit

Safety Procedures and Precautions

Observe the following general safety precautions during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of intended use of the instrument and may impair the protection provided by the equipment. MKS Instruments, Inc. assumes no liability for the customer's failure to comply with these requirements.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an MKS Calibration and Service Center for service and repair to ensure that all safety features are maintained.

SERVICE BY QUALIFIED PERSONNEL ONLY

Operating personnel must not attempt component replacement and internal adjustments. Any service must be made by qualified service personnel only.

USE CAUTION WHEN OPERATING WITH HAZARDOUS MATERIALS

If hazardous materials are used, users must take responsibility to observe the proper safety precautions, completely purge the instrument when necessary, and ensure that the material used is compatible with the materials in this product, including any sealing materials.

PURGE THE INSTRUMENT

After installing the unit, or before removing it from a system, purge the unit completely with a clean, dry gas to eliminate all traces of the previously used flow material.

USE PROPER PROCEDURES WHEN PURGING

This instrument must be purged under a ventilation hood, and gloves must be worn for protection.

DO NOT OPERATE IN AN EXPLOSIVE ENVIRONMENT

To avoid explosion, do not operate this product in an explosive environment unless it has been specifically certified for such operation.

USE PROPER FITTINGS AND TIGHTENING PROCEDURES

All instrument fittings must be consistent with instrument specifications, and compatible with the intended use of the instrument. Assemble and tighten fittings according to manufacturer's directions.

CHECK FOR LEAK-TIGHT FITTINGS

Carefully check all vacuum component connections to ensure leak-tight installation.

OPERATE AT SAFE INLET PRESSURES

Never operate at pressures higher than the rated maximum pressure (refer to the product specifications for the maximum allowable pressure).

INSTALL A SUITABLE BURST DISC

When operating from a pressurized gas source, install a suitable burst disc in the vacuum system to prevent system explosion should the system pressure rise.

KEEP THE UNIT FREE OF CONTAMINANTS

Do not allow contaminants to enter the unit before or during use. Contamination such as dust, dirt, lint, glass chips, and metal chips may permanently damage the unit or contaminate the process.

ALLOW PROPER WARM UP TIME FOR TEMPERATURE-CONTROLLED UNITS

Temperature-controlled units will only meet specifications when sufficient time is allowed for the unit to meet, and stabilize at, the designed operating temperature. Do not zero or calibrate the unit until the warm up is complete.

Sicherheitshinweise für den Druckmeßumformer

In dieser Betriebsanleitung vorkommende Symbole

Bedeutung der mit WARNUNG!, VORSICHT! und HINWEIS gekennzeichneten Absätze in dieser Betriebsanleitung.

Warnung!

Das Symbol WARNUNG! weist auf eine Gefahr für das Bedienpersonal hin. Es macht auf einen Arbeitsablauf, eine Arbeitsweise, einen Zustand oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. ungenügende Berücksichtigung zu Verletzungen führen kann.

Vorsicht!

Das Symbol VORSICHT! weist auf eine Gefahr für das Gerät hin. Es macht auf einen Bedienungsablauf, eine Arbeitsweise oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. ungenügende Berücksichtigung zu einer Beschädigung oder Zerstörung des Gerätes oder von Teilen des Gerätes führen kann.

Hinweis

Das Symbol HINWEIS macht auf wichtige Informationen bezüglich eines Arbeitsablaufs, einer Arbeitsweise, eines Zustands oder einer sonstige Gegebenheit aufmerksam.

Erklärung der am Gerät angebrachten Symbole

Nachstehender Tabelle sind die Bedeutungen der Symbole zu entnehmen, die am Gerät angebracht sein können.

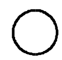
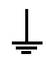
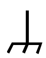
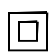
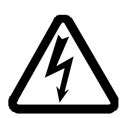
Bedeutung der am Gerät angebrachten Symbole			
 Ein (Energie) IEC 417, No.5007	 Aus (Energie) IEC 417, No.5008	 Erdanschluß IEC 417, No.5017	 Schutzleiteranschluß IEC 417, No.5019
 Masseanschluß IEC 417, No.5020	 Aquipotential- anschluß IEC 417, No.5021	 Gleichstrom IEC 417, No.5031	 Wechselstrom IEC 417, No.5032
 Gleich- oder Wechselstrom IEC 417, No.5033-a	 Durchgängige doppelte oder verstärkte Isolierung IEC 417, No.5172-a	 Dreileiter- Wechselstrom (Drehstrom) IEC 617-2, No.020206	
 Warnung vor einer Gefahrenstelle (Achtung, Dokumen- tation beachten) ISO 3864, No.B.3.1	 Warnung vor gefährlicher elektrischer Spannung ISO 3864, No.B.3.6	 Höhere Temperatur an leicht zugänglichen Teilen IEC 417, No.5041	

Tabelle 2: Bedeutung der am Gerät angebrachten Symbole

Sicherheitsvorschriften und Vorsichtsmaßnahmen

Folgende allgemeine Sicherheitsvorschriften sind während allen Betriebsphasen dieses Gerätes zu befolgen. Eine Mißachtung der Sicherheitsvorschriften und sonstiger Warnhinweise in dieser Betriebsanleitung verletzt die für dieses Gerät und seine Bedienung geltenden Sicherheitsstandards, und kann die Schutzvorrichtungen an diesem Gerät wirkungslos machen. MKS Instruments, Inc. haftet nicht für Mißachtung dieser Sicherheitsvorschriften seitens des Kunden.

Niemals Teile austauschen oder Änderungen am Gerät vornehmen!

Ersetzen Sie keine Teile mit baugleichen oder ähnlichen Teilen, und nehmen Sie keine eigenmächtigen Änderungen am Gerät vor. Schicken Sie das Gerät zwecks Wartung und Reparatur an den MKS-Kalibrierungs- und -Kundendienst ein. Nur so wird sichergestellt, daß alle Schutzvorrichtungen voll funktionsfähig bleiben.

Wartung nur durch qualifizierte Fachleute!

Das Auswechseln von Komponenten und das Vornehmen von internen Einstellungen darf nur von qualifizierten Fachleuten durchgeführt werden, niemals vom Bedienpersonal.

Vorsicht beim Arbeiten mit gefährlichen Stoffen!

Wenn gefährliche Stoffe verwendet werden, muß der Bediener die entsprechenden Sicherheitsvorschriften genauestens einhalten, das Gerät, falls erforderlich, vollständig spülen, sowie sicherstellen, daß der Gefahrstoff die am Gerät verwendeten Materialien, insbesondere Dichtungen, nicht angreift.

Spülen des Gerätes mit Gas!

Nach dem Installieren oder vor dem Ausbau aus einem System muß das Gerät unter Einsatz eines reinen Trockengases vollständig gespült werden, um alle Rückstände des Vorgängermediums zu entfernen.

Anweisungen zum Spülen des Gerätes

Das Gerät darf nur unter einer Ablufthaube gespült werden. Schutzhandschuhe sind zu tragen.

Gerät nicht zusammen mit explosiven Stoffen, Gasen oder Dämpfen benutzen!

Um der Gefahr einer Explosion vorzubeugen, darf dieses Gerät niemals zusammen mit (oder in der Nähe von) explosiven Stoffen aller Art eingesetzt werden, sofern es nicht ausdrücklich für diesen Zweck zugelassen ist.

Anweisungen zum Installieren der Armaturen!

Alle Anschlußstücke und Armaturenteile müssen mit der Gerätespezifikation übereinstimmen, und mit dem geplanten Einsatz des Gerätes kompatibel sein. Der Einbau, insbesondere das Anziehen und Abdichten, muß gemäß den Anweisungen des Herstellers vorgenommen werden.

Verbindungen auf Undichtigkeiten prüfen!

Überprüfen Sie sorgfältig alle Verbindungen der Vakuumkomponenten auf undichte Stellen.

Gerät nur unter zulässigen Anschlußdrücken betreiben!

Betreiben Sie das Gerät niemals unter Drücken, die den maximal zulässigen Druck (siehe Produktspezifikationen) übersteigen.

Geeignete Berstscheibe installieren!

Wenn mit einer unter Druck stehenden Gasquelle gearbeitet wird, sollte eine geeignete Berstscheibe in das Vakuumsystem installiert werden, um eine Explosionsgefahr aufgrund von steigendem Systemdruck zu vermeiden.

Verunreinigungen im Gerät vermeiden!

Stellen Sie sicher, daß Verunreinigungen jeglicher Art weder vor dem Einsatz noch während des Betriebs in das Instrumenteninnere gelangen können. Staub- und Schmutzpartikel, Glassplitter oder Metallspäne können das Gerät dauerhaft beschädigen oder Prozeß und Meßwerte verfälschen.

Bei Geräten mit Temperaturkontrolle korrekte Anwärmzeit einhalten!

Temperaturkontrollierte Geräte arbeiten nur dann gemäß ihrer Spezifikation, wenn genügend Zeit zum Erreichen und Stabilisieren der Betriebstemperatur eingeräumt wird. Kalibrierungen und Nulleinstellungen sollten daher nur nach Abschluß des Anwärmvorgangs durchgeführt werden.

Informations relatives à la sécurité pour le transducteur de pression

Symboles utilisés dans ce manuel d'utilisation

Définitions des indications AVERTISSEMENT, ATTENTION, et REMARQUE utilisées dans ce manuel.

Avertissement

L'indication AVERTISSEMENT signale un danger pour le personnel. Elle attire l'attention sur une procédure, une pratique, une condition, ou toute autre situation présentant un risque d'accident pour le personnel, en cas d'exécution incorrecte ou de non respect des consignes.

Attention

L'indication ATTENTION signale un danger pour l'appareil. Elle attire l'attention sur une procédure d'exploitation, une pratique, ou toute autre situation, présentant un risque d'endommagement ou de destruction d'une partie ou de la totalité de l'appareil, en cas d'exécution incorrecte ou de non respect des consignes.

Remarque

L'indication REMARQUE signale une information importante. Elle attire l'attention sur une procédure, une pratique, une condition, ou toute autre situation, présentant un intérêt particulier.

Symboles apparaissant sur l'unité

Le tableau suivant décrit les symboles pouvant apparaître sur l'unité.

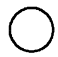
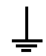
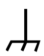
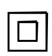
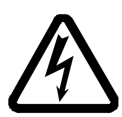
Définition des symboles apparaissant sur l'unité			
Marche (sous tension) IEC 417, No.5007	 Arrêt (hors tension) IEC 417, No.5008	 Terre (masse) IEC 417, No.5017	 Terre de protection (masse) IEC 417, No.5019
 Masse IEC 417, No.5020	 Equipotentialité IEC 417, No.5021	 Courant continu IEC 417, No.5031	 Courant alternatif IEC 417, No.5032
 Courant continu et alternatif IEC 417, No.5033-a	 Matériel de classe II IEC 417, No.5172-a	 Courant alternatif triphasé IEC 617-2, No.020206	
 Attention : se reporter à la documentation ISO 3864, No.B.3.1	 Attention : risque de choc électrique ISO 3864, No.B.3.6	 Attention : surface brûlante IEC 417, No.5041	

Tableau 3: Définition des symboles apparaissant sur l'unité

Mesures de sécurité et précautions

Prendre les précautions générales de sécurité suivantes pendant toutes les phases d'exploitation de cet appareil. Le non respect des ces précautions ou des avertissements contenus dans ce manuel constitue une violation des normes de sécurité relatives à l'utilisation de l'appareil et peut diminuer la protection fournie par l'appareil. MKS Instruments, Inc. n'assume aucune responsabilité concernant le non respect des consignes par les clients.

PAS DE SUBSTITUTION DE PIÈCES OU DE MODIFICATION DE L'APPAREIL

Ne pas installer des pièces de substitution ou effectuer des modifications non autorisées sur l'appareil. Renvoyer l'appareil à un centre de service et de calibrage MKS pour tout dépannage ou réparation afin de garantir le l'intégrité des dispositifs de sécurité.

DÉPANNAGE UNIQUEMENT PAR DU PERSONNEL QUALIFIÉ

Le personnel d'exploitation ne doit pas essayer de remplacer des composants ou de faire des réglages internes. Tout dépannage doit être uniquement effectué par du personnel qualifié.

PRÉCAUTION EN CAS D'UTILISATION AVEC DES PRODUITS DANGEREUX

Si des produits dangereux sont utilisés, l'utilisateur est responsable de la prise des mesures de précaution appropriées, de la purge complète de l'appareil quand cela est nécessaire, et de la garantie que les produits utilisés sont compatibles avec les composants de cet appareil, y compris les matériaux d'étanchéité.

PURGE DE L'APPAREIL

Après l'installation de l'unité, ou avant son enlèvement d'un système, purger l'unité complètement avec un gaz propre et sec afin d'éliminer toute trace du produit de flux utilisé précédemment.

UTILISATION DES PROCÉDURES APPROPRIÉES POUR LA PURGE

Cet appareil doit être purgé sous une hotte de ventilation, et il faut porter des gants de protection.

PAS D'EXPLOITATION DANS UN ENVIRONNEMENT EXPLOSIF

Pour éviter toute explosion, ne pas utiliser cet appareil dans un environnement explosif, sauf en cas d'homologation spécifique pour une telle exploitation.

UTILISATION D'ÉQUIPEMENTS APPROPRIÉS ET PROCÉDURES DE SERRAGE

Tous les équipements de l'appareil doivent être cohérents avec ses spécifications, et compatibles avec l'utilisation prévue de l'appareil. Assembler et serrer les équipements conformément aux directives du fabricant.

VÉRIFICATION DE L'ÉTANCHÉITÉ DES CONNEXIONS

Vérifier attentivement toutes les connexions des composants pour le vide afin de garantir l'étanchéité de l'installation.

EXPLOITATION AVEC DES PRESSIONS D'ENTRÉE NON DANGEREUSES

Ne jamais utiliser des pressions supérieures à la pression nominale maximum (se reporter aux spécifications de l'unité pour la pression maximum admissible).

INSTALLATION D'UN DISQUE D'ÉCHAPPEMENT ADAPTÉ

En cas d'exploitation avec une source de gaz pressurisé, installer un disque d'échappement adapté dans le système à vide, afin d'éviter une explosion du système en cas d'augmentation de la pression.

MAINTIEN DE L'UNITÉ À L'ABRI DES CONTAMINATIONS

Ne pas laisser des produits contaminants pénétrer dans l'unité avant ou pendant l'utilisation. Des produits contaminants tels que des poussières et des fragments de tissu, de glace et de métal peuvent endommager l'unité d'une manière permanente ou contaminer le processus.

RESPECT DU TEMPS D'ÉCHAUFFEMENT APPROPRIÉ POUR LES UNITÉS Á TEMPÉRATURE CONTRÔLÉE

Les unités à température contrôlée atteignent leurs spécifications uniquement quand on leur laisse un temps suffisant pour atteindre d'une manière stable la température d'exploitation. Ne pas remettre à zéro ou calibrer l'unité tant que l'échauffement n'est pas terminé.

Medidas de seguridad del transductor de presión

Símbolos usados en este manual de instrucciones

Definiciones de los mensajes de advertencia, precaución y de las notas usados en el manual.

Advertencia

El símbolo de advertencia indica la posibilidad de que se produzcan daños personales. Pone de relieve un procedimiento, práctica, estado, etc. que en caso de no realizarse u observarse correctamente puede causar daños personales.

Precaución

El símbolo de precaución indica la posibilidad de producir daños al equipo. Pone de relieve un procedimiento operativo, práctica, estado, etc. que en caso de no realizarse u observarse correctamente puede causar daños o la destrucción total o parcial del equipo.

Nota

El símbolo de notas indica información de importancia. Este símbolo pone de relieve un procedimiento, práctica o condición cuyo conocimiento es esencial destacar.

Símbolos hallados en la unidad

La tabla siguiente contiene los símbolos que puede hallar en la unidad.

Definición de los símbolos hallados en la unidad			
Encendido (alimentación eléctrica) IEC 417, N° 5007	Apagado (alimentación eléctrica) IEC 417, N° 5008	Puesta a tierra IEC 417, N° 5017	Protección a tierra IEC 417, N° 5019
Caja o chasis IEC 417, N° 5020	Equipotencialidad IEC 417, N° 5021	Corriente continua IEC 417, N° 5031	Corriente alterna IEC 417, N° 5032
Corriente continua y alterna IEC 417, N° 5033-a	Equipo de clase II IEC 417, N° 5172-a	3~ Corriente alterna trifásica IEC 617-2, N° 020206	
Precaución. Consulte los documentos adjuntos ISO 3864, N° B.3.1	Precaución. Riesgo de descarga eléctrica ISO 3864, N° B.3.6	Precaución. Superficie caliente IEC 417, N° 5041	

Tabla 4: Definición de los símbolos hallados en la unidad

Procedimientos y precauciones de seguridad

Las precauciones generales de seguridad descritas a continuación deben observarse durante todas las etapas de funcionamiento del instrumento. La falta de cumplimiento de dichas precauciones o de las advertencias específicas a las que se hace referencia en el manual, constituye una violación de las normas de seguridad establecidas para el uso previsto del instrumento y podría anular la protección proporcionada por el equipo. Si el cliente no cumple dichas precauciones y advertencias, MKS Instruments, Inc. no asume responsabilidad legal alguna.

NO UTILICE PIEZAS NO ORIGINALES O MODIFIQUE EL INSTRUMENTO

No instale piezas que no sean originales ni modifique el instrumento sin autorización. Para asegurar el correcto funcionamiento de todos los dispositivos de seguridad, envíe el instrumento al Centro de servicio y calibración de MKS toda vez que sea necesario repararlo o efectuar tareas de mantenimiento.

LAS REPARACIONES DEBEN SER EFECTUADAS ÚNICAMENTE POR TÉCNICOS AUTORIZADOS

Los operarios no deben intentar reemplazar los componentes o realizar tareas de ajuste en el interior del instrumento. Las tareas de mantenimiento o reparación deben ser realizadas únicamente por personal autorizado.

TENGA CUIDADO CUANDO TRABAJE CON MATERIALES TÓXICOS

Cuando se utilicen materiales tóxicos, es responsabilidad de los operarios tomar las medidas de seguridad correspondientes, purgar totalmente el instrumento cuando sea necesario y comprobar que el material utilizado sea compatible con los materiales del instrumento e inclusive, con todos los materiales de sellado.

PURGUE EL INSTRUMENTO

Una vez instalada la unidad o antes de retirarla del sistema, purgue completamente la unidad con gas limpio y seco para eliminar todo resto de la sustancia líquida empleada anteriormente.

USE PROCEDIMIENTOS ADECUADOS PARA REALIZAR LA PURGA

El instrumento debe purgarse debajo de una campana de ventilación y deben utilizarse guantes protectores.

NO HAGA FUNCIONAR EL INSTRUMENTO EN AMBIENTES CON RIESGO DE EXPLOSIÓN

Para evitar que se produzcan explosiones, no haga funcionar este instrumento en un ambiente con riesgo de explosiones, excepto cuando el mismo haya sido certificado específicamente para tal uso.

USE ACCESORIOS ADECUADOS Y REALICE CORRECTAMENTE LOS PROCEDIMIENTOS DE AJUSTE

Todos los accesorios del instrumento deben cumplir las especificaciones del mismo y ser compatibles con el uso que se debe dar al instrumento. Arme y ajuste los accesorios de acuerdo con las instrucciones del fabricante.

COMPRUEBE QUE LAS CONEXIONES SEAN A PRUEBA DE FUGAS

Inspeccione cuidadosamente las conexiones de los componentes de vacío para comprobar que hayan sido instalados a prueba de fugas.

HAGA FUNCIONAR EL INSTRUMENTO CON PRESIONES DE ENTRADA SEGURAS

No haga funcionar nunca el instrumento con presiones superiores a la máxima presión nominal (en las especificaciones del instrumento hallará la presión máxima permitida).

INSTALE UNA CÁPSULA DE SEGURIDAD ADECUADA

Cuando el instrumento funcione con una fuente de gas presurizado, instale una cápsula de seguridad adecuada en el sistema de vacío para evitar que se produzcan explosiones cuando suba la presión del sistema.

MANTENGA LA UNIDAD LIBRE DE CONTAMINANTES

No permita el ingreso de contaminantes en la unidad antes o durante su uso. Los productos contaminantes tales como polvo, suciedad, pelusa, lascas de vidrio o virutas de metal pueden dañar irreparablemente la unidad o contaminar el proceso.

CALIENTE ADECUADAMENTE LAS UNIDADES CONTROLADAS POR MEDIO DE TEMPERATURA

Las unidades controladas por medio de temperatura funcionarán de acuerdo con las especificaciones sólo cuando se las caliente durante el tiempo suficiente para permitir que lleguen y se estabilicen a la temperatura de operación indicada. No calibre la unidad y no la ponga en cero hasta que finalice el procedimiento de calentamiento.

Chapter One: General Information

Introduction

The MKS Baratron® Type 627D Absolute Pressure Transducer is part of the MKS family of general purpose RoHS (Restriction of Hazardous Substances)-compliant pressure transducers designed to provide accurate, reliable, and repeatable pressure measurements in the range from 1K Torr to as low as 0.02 Torr Full Scale (FS). The instrument operates with ±15 VDC (±5%) input at ≤ 250 mA, and provides 0 to 10 VDC output linear with pressure. The 627D transducer exposes only Inconel® to the process permitting use with corrosive or dirty gases and eliminating contamination of the process with transducer materials. Measurements are independent of gas composition and the unit has a minimum measuring range of four decades.

Using the latest single-sided, dual-electrode Inconel transducer design, coupled with a low impedance, fixed-frequency bridge signal conditioner, these instruments are capable of withstanding high overpressure conditions (45 psia) with minimal or no shifts in output over their range. The advanced bridge signal conditioning technology provides high accuracy and operation which is extremely temperature-stable at operating pressure.

Protection from RF interference and noisy electrical environments is increased by the use of a metal case, by internal design elements, and by the use of surge and ESD suppression networks and RFI filtering on all inputs and outputs. The 627D unit meets the testing standards required for the European CE Mark when used with an overall metal braided shielded cable, properly grounded at both ends.

The 627D transducer is designed specifically to meet the needs of vacuum process systems where environmental and process conditions are particularly demanding. The 627D unit controls its temperature at 45° C (113° F), thereby minimizing the effects of ambient or process temperature variations typically encountered in process line environments.

The 627D transducer is available with optional heater status LEDs, two interface connector lock options, and a variety of fittings. The unit is capable of measuring pressure at ambient temperatures of 15° to 40° C (59° to 104° F).

How This Manual is Organized

This manual is designed to provide instructions on how to set up, install, and operate a Type 627D unit.

Before installing your Type 627D unit in a system and/or operating it, carefully read and familiarize yourself with all precautionary notes in the *Safety Messages and Procedures* section at the front of this manual. In addition, observe and obey all WARNING and CAUTION notes provided throughout the manual.

Chapter One, *General Information*, (this chapter) introduces the product and describes the organization of the manual.

Chapter Two, *Installation*, explains the environmental requirements and describes how to mount the instrument in your system.

Chapter Three, *Overview*, gives a brief description of the instrument and its functionality.

Chapter Four, *Operation*, describes how to use the instrument and explains all the functions and features.

Chapter Five, *Maintenance and Troubleshooting*, lists any maintenance required to keep the instrument in good working condition, and provides a checklist for reference should the instrument malfunction.

Appendix A, *Product Specifications*, lists the specifications of the instrument.

Appendix B, *Model Code Explanation*, describes the model code used to order the instrument.

Customer Support

Standard maintenance and repair services are available at all of our regional MKS Calibration and Service Centers, listed on the back cover. In addition, MKS accepts the instruments of other manufacturers for recalibration using the Primary and Transfer Standard calibration equipment located at all of our regional service centers. Should any difficulties arise in the use of your Type 627D instrument, or to obtain information about companion products MKS offers, contact any authorized MKS Calibration and Service Center. If it is necessary to return the instrument to MKS, please obtain an RMA (Return Materials Authorization) Number from the MKS Calibration and Service Center before shipping. The RMA Number expedites handling and ensures proper servicing of your instrument.

Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Warning **All returns to MKS Instruments must be free of harmful, corrosive, radioactive, or toxic materials.**

Chapter Two: Installation

How To Unpack the Type 627D Unit

MKS has carefully packed the Type 627D unit so that it will reach you in perfect operating order. Upon receiving the unit, however, you should check for defects, cracks, broken connectors, etc., to be certain that damage has not occurred during shipment.

Note Do *not* discard any packing materials until you have completed your inspection and are sure the unit arrived safely.

If you find any damage, notify your carrier and MKS immediately. If it is necessary to return the unit to MKS, obtain an RMA (Return Material Authorization) Number from the MKS Service Center before shipping. Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Unpacking Checklist

Standard Equipment:

- Type 627D Unit
- Type 627D Instruction Manual (this book)

Optional Equipment:

- Electrical Connector Accessories Kit:
  627D-K1 (includes a mate for the I/O connector)
- Most MKS Power Supply/Readouts
- Most MKS Pressure, Flow, Flow Ratio, and Throttling Valve Controllers
- RM-6 Rack Mount Kit:
  19” rack accommodates 1 or 2 readouts and/or controllers
- Interface Cables (refer to Table 5, page 20)

Interface Cables

As of July 20, 2009, most products shipped to the European Community must comply with the EMC Directive 2004/108/EEC, which covers radio frequency emissions and immunity tests. In addition, as of January 1, 1997, some products shipped to the European Community must also comply with the Product Safety Directive 92/59/EEC and Low Voltage Directive 73/23/EEC, which cover general safety practices for design and workmanship. MKS products that meet these requirements are identified by application of the CE Mark.

To ensure compliance with EMC Directive 2004/108/EEC, an overall metal braided shielded cable, properly grounded at both ends, is required during use. No additional installation requirements are necessary to ensure compliance with Directives 92/59/EEC and 73/23/EEC.

Note

1. An overall metal braided, shielded cable, properly grounded at both ends, is required during use to meet CE specifications.
2. To order an overall metal braided shielded cable, add an “S” after the cable type designation. For example, to order a cable to connect a 627D unit to a 651 controller, use part number CB259-5-10; for a metal braided shielded cable use part number CB259S-5-10.

You can purchase interface cables to all MKS companion products from MKS (refer to Table 5), or optionally you can make cables that meet the appropriate specifications. For cables connecting to non-MKS products, MKS can provide normal shielding or braided shielded cable assemblies in a nominal 10’ (3m) length, terminating in flying leads (pigtail) fashion at both ends.

Overall metal braided shielded cable assemblies, properly grounded at both ends, are recommended if the environment contains high EMI/RFI noise.

Interface Cables		
To Connect the 627D Unit To...	**Use the MKS Cable...**	
	Standard	**Shielded**
PDR-C-1C/2C, PDR-5B Power Supply/Readouts	CB127-1-10	CB127S-1-10
146, 186, 651, 652, 660 Controllers	CB259-5-10	CB259S-5-10

Table 5: Interface Cables

Generic Shielded Cable Guidelines

Should you choose to manufacture your own cables, follow the guidelines listed below:

1. The cable must have an overall metal *braided* shield, covering all wires. Neither aluminum foil nor spiral shielding will be as effective; using either may nullify regulatory compliance.
2. The connectors must have a metal case which has direct contact to the cable's shield on the whole circumference of the cable. The inductance of a flying lead or wire from the shield to the connector will seriously degrade the shield's effectiveness. The shield should be grounded to the connector before its internal wires exit.
3. With very few exceptions, the connector(s) must make good contact to the device's case (ground). "Good contact" is about 0.01 ohms; and the ground should surround all wires. Contact to ground at just one point may not suffice.
4. For shielded cables with flying leads at one or both ends; it is important at each such end, to ground the shield *before* the wires exit. Make this ground with absolute minimum length. (A ¼ inch piece of #22 wire may be undesirably long since it has approximately 5 nH of inductance, equivalent to 31 ohms at 1000 MHz). After picking up the braid's ground, keep wires and braid flat against the case. With very few exceptions, grounded metal covers are not required over terminal strips. If one is required, it will be stated in the Declaration of Conformity or in the instruction manual.
5. In selecting the appropriate type and wire size for cables, consider:

   A. The voltage ratings.

   B. The cumulative I^2R heating of all the conductors (keep them safely cool).

   C. The IR drop of the conductors, so that adequate power or signal voltage gets to the device.

   D. The capacitance and inductance of cables which are handling fast signals, (such as data lines or stepper motor drive cables).

   E. That some cables may need internal shielding from specific wires to others; please see the instruction manual for details regarding this matter.

Product Location and Requirements

Ambient Operating Temperature

The acceptable ambient operating temperature range for the 627D transducer is 15° to 40° C (59° to 104° F). The unit is temperature controlled at 45° C (113° F).

Power Requirements

The 627D transducer requires an external power source capable of supplying ±15 VDC (±5%) at ≤ 250 mA.

Noise and ripple should be less than 20 mV peak-to-peak. You may use any readout device which has input capabilities of less than 0 to greater than 10 VDC, and impedance greater than 10K ohms. The power is introduced to the unit through the Interface connector on the top panel of the transducer (refer to Figure 4, page 30).

Setup

Dimensions

Note All dimensions are listed in inches with millimeters referenced in parentheses. The tolerances for the dimensions are ±0.1 inches (X.X) and ±0.01 inches (X.XX).

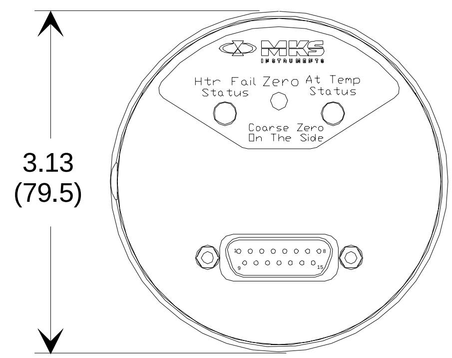


Figure 1: Top View Dimensions
(shown with the optional heater status LEDs)

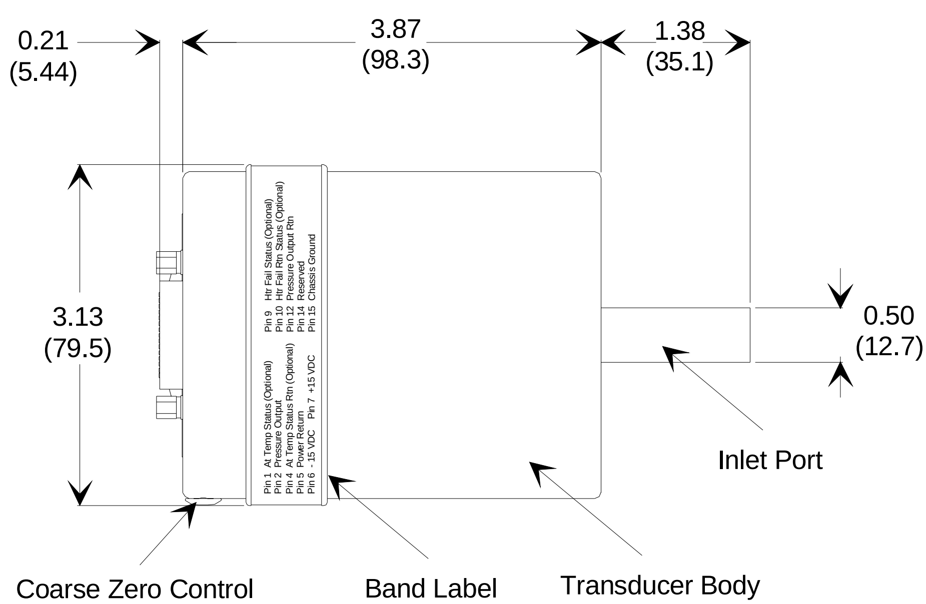


Figure 2: Side View Dimensions

Fittings

The 627D transducer is available with the following fittings:

- ½” diameter (12.7 mm) tubulation
- Swagelok® 8-VCR® (female)
- Mini-CF (rotatable)
- NW16-KF
- NW25-KF
- Swagelok 8-VCO® (female)

Mounting Instructions

Mount the transducer with the inlet port pointing (vertically) downward. The transducer port will easily carry the weight of the transducer.

Although the unit can be mounted in any orientation, mounting it as suggested allows any foreign matter entering the pressure port to fall away from the diaphragm.

Isolate the unit from vibration as much as possible. When not subject to gas damping at low pressure, the diaphragm may become susceptible to resonance. The low range transducers (≤ 1 Torr) are very sensitive and you should isolate them from any vibration that exists. Remember to isolate the vibration through the cable as well as through the port.

Electrical Information

Grounding

Note The ground of any external power supply and readout should be the same as the transducer ground (chassis ground) to minimize any possible ground loops which can affect the performance and stability of the system.

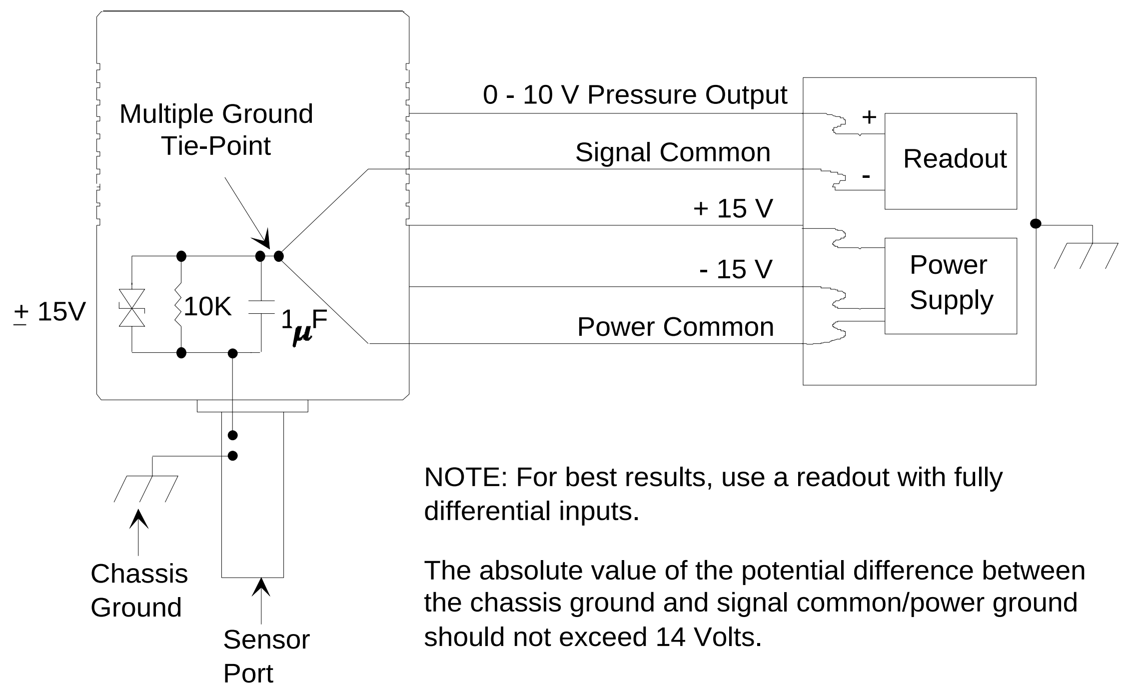


Figure 3: Example Power, Signal, and Chassis Grounding Scheme

Interface Connector

The 15-pin male Type "D" Interface connector on the top of the unit (refer to Figure 4, page 30) provides access to the power input and heater status pins. The pinout is listed in Table 6, page 27. The connector is available with either thread locks or slide locks.

Thread Locks

The 15-pin connector with thread locks utilizes threaded posts onto which the mating connector is mechanically fastened using screws. This is the standard MKS style Type "D" connector.

Slide Locks

The 15-pin connector with slide locks utilizes slotted posts onto which the mating connector is mechanically fastened using a slide mechanism which engages the slots in the posts.

Note Standard MKS interface cables are not available for use with units configured with a slide lock connector.

Interface Connector Pinout	
Pin Number	**Assignment**
1	At Temperature Status* or Reserved
2	Pressure Signal Output
3	No Connection
4	At Temperature Status Return* or Reserved
5	Power Return (Power Common)
6	-15 VDC
7	+15 VDC
8	No Connection
9	Heater Failure Status* or Reserved
10	Heater Failure Status Return* or Reserved
11	No Connection
12	Pressure Signal Output Return (Signal Common)
13	No Connection
14	Reserved
15	Chassis Ground
* *Valid only with the heater status LED option.*	

Table 6: Interface Connector Pinout

Note

The "Reserved" pin assignment refers to a pin with an internal connection that may be assigned a function in the future. The "No Connection" pin assignment refers to a pin with no internal connection.

Start Up

After installation, allow your transducer to warm up until it is stabilized, then check the transducer zero to verify the proper output. Refer to *How To Adjust the Zero*, page 33, for complete instructions on adjusting the zero controls on the 627D unit.

Warm Up Time

Allow sufficient time for your transducer to warm up. The warm up times for 23° C ambient temperature conditions are:

- 2 hours for ≥ 1 Torr units
- 4 hours for < 1 Torr units

Note The transducer must be *fully stabilized* before you make any zero adjustments.

Chapter Three: Overview

General Information

A complete pressure transducer system requires three components to convert pressure to a linear DC voltage output: a sensor, signal conditioner, and power supply. The 627D transducer contains two of the required components: the sensor and signal conditioner.

An MKS or MKS-compatible power supply is required to complete the pressure to DC voltage conversion. For a direct readout of the pressure measurement, a meter (analog or digital) is required.

Sensor

The 627D transducer is a variable capacitance sensor consisting of a pressure inlet tube (port) connected to a small chamber in the transducer body. One wall of this chamber is an elastic metal diaphragm. The front side of the diaphragm is exposed to the gas whose pressure is to be measured. The back, or *reference,* side of the diaphragm faces a rigidly mounted ceramic disc containing two electrodes. The reference side is permanently evacuated (10^{-7} Torr) and its vacuum is maintained with a chemical getter system.

The diaphragm deflects with changing absolute pressure (force per unit area) independently of the gas type or composition of the measured gas. This deflection causes an imbalance of the sensor electrode capacitances since the distance to the diaphragm is now different for each electrode. The imbalance of capacitances is converted to a DC voltage in the bridge. This bridge is excited by a precision constant frequency oscillator. The resultant signal is then linearized, zeroed, and amplified via the signal conditioner electronics, to produce a precise
0 to 10 VDC signal scaled to the range of the transducer.

In the heated 627D transducer, zero and span stability is further increased because the sensor and bridge electronics are temperature controlled. This thermal enclosure reduces the effects of ambient temperature changes by a factor of at least 35 (that is a 35° C change in ambient temperature will produce less than a 1° C change inside the thermal housing).

Signal Conditioner/Electronics

The signal conditioner contains state-of-the-art, RoHS-compliant, low impedance balanced bridge circuitry, self-compensated for thermal stability with ambient temperature changes. The output is a DC voltage which is linear with pressure. The transducer is then calibrated against a traceable reference standard to provide a 0 to 10 Volt DC output over the range of the transducer.

Instrument Components

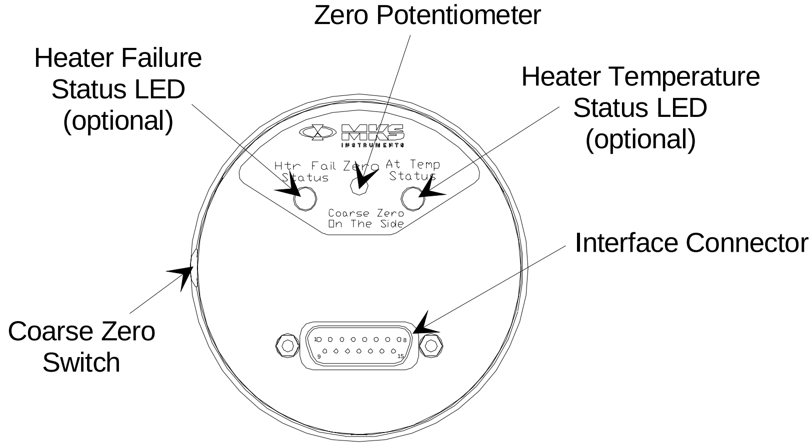


Figure 4: Top View of the 627D Transducer
(shown with the optional heater status LEDs)

Coarse Zero Switch

This multi-position switch adjusts the transducer zero if the ZERO potentiometer fails to provide sufficient zero adjustment. Refer to *How To Adjust the Coarse Zero Switch*, page 35, for more information.

Optional Heater Status LEDs and Semiconductor Switches

When the temperature of the sensor is within the controlled temperature window (47° C ± 2° C) the "At Temperature Status" LED will illuminate green and the corresponding semiconductor switch (pins 1 and 4 on the Interface connector) will turn "on" (close). The transducer must continue to warm up until it reaches thermal equilibrium per the warm-up specifications. If a heater failure occurs, the bi-color "Htr Fail Status" LED will blink red (otherwise it will stay green), and the corresponding semiconductor switch (pins 9 and 10 on the Interface connector) will turn "off" (open). Refer to *Optional Semiconductor Switch Specifications*, page 40, for information.

Zero Potentiometer

This potentiometer adjusts the transducer zero. Refer to *How To Adjust the Zero Potentiometer*, page 34, for more information.

Interface Connector

The 15-pin male Type "D" Interface connector provides access to the power input and heater status pins. Refer to Table 6, page 27, for the connector pinout.

Labels

Note The figures showing the instrument labels (Figures 5 through 7, and Figure 8, page 32) are not drawn to scale.

Top Panel Labels

The label on the top panel of the 627D unit identifies the ZERO potentiometer, and if ordered, the optional Heater Failure and Temperature Status LEDs.

Figure 5: Top Panel Label for Units without the Optional Heater Status LEDs

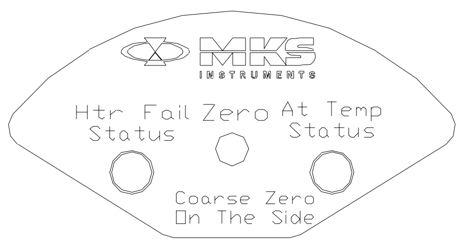


Figure 6: Top Panel Label for Units with the Optional Heater Status LEDs

Band Label

The band label, which is wrapped around the center of the transducer body, lists the pinout for the unit's 15-pin Interface connector (refer to Table 6, page 27). Note that pins 1, 4, 9, and 10 are "Reserved" for units without the optional heater status LEDs.

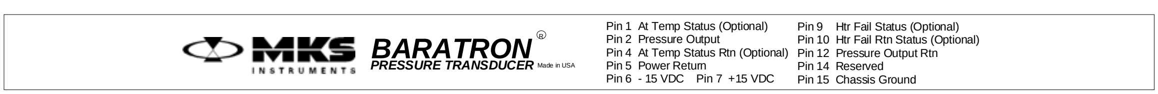


Figure 7: Band Label

Serial Number Label

The serial number label, located on the seam of the band label, lists the unit's serial number, model code, full scale range, input voltage, and output voltage. The label also displays the CE mark signifying compliance with the European CE regulations.

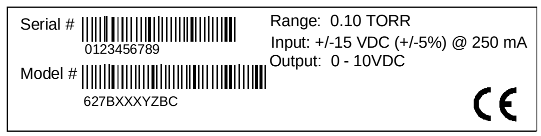


Figure 8: Serial Number Label

The options for your transducer are identified in the model code when you order the unit. Refer to *Appendix B: Model Code Explanation*, page 41, for more information.

Chapter Four: Operation

How To Adjust the Zero

All pressure transducers require initial and periodic zero adjustments. Prior to initial operation and during periodic maintenance you must check the transducer zero to verify the proper output. The zero can be set (or reset) by adjusting the ZERO potentiometer located on the top of the transducer (refer to *How To Adjust the Zero Potentiometer*, page 34) or at the front panel of any MKS Power Supply/Readout being used. If the ZERO potentiometer fails to provide sufficient adjustment, the COARSE ZERO switch may be used (refer to *How To Adjust the Coarse Zero Switch*, page 35).

To achieve the full dynamic range specified for the transducer, the zero adjustment ***must*** be made at a pressure less than the transducer's resolution (0.001% of FS). Low range transducers should be pumped for at least one hour after exposure to air to remove any moisture and to allow the pressure to stabilize. Zeroing a transducer above its stated minimum resolution creates a *zero offset* relative to true absolute pressure. All subsequent readings are then linear and accurate *relative to the offset value*.

Note

If available pressures are not sufficiently low to set the transducer zero, you may use a vacuum leak detector with sufficient vacuum pumping (to achieve proper zeroing pressures). In this case, mount the transducer on the leak detector *in the same plane of orientation as it will be during actual use*.

How To Adjust the Zero Potentiometer

To adjust the ZERO potentiometer:

1. Install the transducer in a system and connect a power supply/readout.

2. Power the transducer and allow it to warm up and stabilize.

Note

Allow 2 hours for ≥ 1 Torr units, and 4 hours for < 1 Torr units to warm up. Ensure that the transducer is *fully stabilized* before you adjust the zero.

3. Pump the unit down to a pressure below its resolution (0.001% of FS).

   For best results, pump the transducer while it is warming up. Refer to Table 7 for the highest recommended pressure levels for proper zero adjustment.

Highest Pressures Suggested for Proper Zero Adjustment	
Full Scale Range (Torr)	**Highest Pressure for Proper Zero Adjustment (Torr)**
0.02	2×10^{-7}
0.05	5×10^{-7}
0.1	1×10^{-6}
1.0	1×10^{-5}
2.0	2×10^{-5}
10	1×10^{-4}
20	2×10^{-4}
100	1×10^{-3}
1000	1×10^{-2}

Table 7: Highest Pressures Suggested for Proper Zero Adjustment

4. Adjust the ZERO pot with a small screwdriver until the readout displays zero (0000).

   Typically, the ZERO potentiometer provides ample control under normal conditions. However, if the ZERO potentiometer fails to provide sufficient adjustment, additional zero range capability is available with the COARSE ZERO switch, located on the side of the unit (refer to Figure 4, page 30). Refer to *How To Adjust the Coarse Zero Switch*, page 35, for more information.

How To Adjust the Coarse Zero Switch

Note Use the COARSE ZERO switch *only* if the ZERO potentiometer fails to provide sufficient adjustment.

To adjust the COARSE ZERO switch:

1. Install the transducer in a system and connect a power supply/readout.

2. Power the transducer and allow it to warm up and stabilize.

Note Allow 2 hours for ≥ 1 Torr units, and 4 hours for < 1 Torr units to warm up. Ensure that the transducer is *fully stabilized* before you adjust the zero.

3. Pump the unit down to a pressure below its resolution.

   For best results, pump the transducer while it is warming up. Refer to Table 7, page 34, for the highest recommended pressure levels for proper zero adjustment.

4. Center the ZERO pot located at the top of the transducer by adjusting the screw to leave an equal amount of adjustment both clockwise and counterclockwise.

5. Remove the plug that covers the COARSE ZERO switch.

   Refer to Figure 4, page 30.

6. Turn the COARSE ZERO switch to a position that produces the output signal closest to 0 Volts.

7. Adjust the ZERO pot to bring the output to exactly 0 Volts.

   Refer to *How To Adjust the Zero Potentiometer*, page 34, for more information.

8. Cover the COARSE ZERO switch with the plug removed in step 5.

Suggested Pressures for Reading and Control

The lowest suggested pressures for reading and control with the 627D transducer are listed in Table 8.

Lowest Suggested Pressures for Reading and Control		
Full Scale Range (Torr)	**Lowest Suggested Pressure for Reading (Torr)**	**Lowest Suggested Pressure for Control (Torr)**
0.02	1×10^{-5}	1×10^{-4}
0.05	2.5×10^{-5}	2.5×10^{-4}
0.1	5×10^{-5}	5×10^{-4}
1.0	5×10^{-4}	5×10^{-3}
2.0	1×10^{-3}	1×10^{-2}
10	5×10^{-3}	5×10^{-2}
20	1×10^{-2}	1×10^{-1}
100	5×10^{-2}	5×10^{-1}
1000	5×10^{-1}	5×10^{0}

Table 8: Lowest Suggested Pressures for Reading and Control

Lowest Suggested Pressure Available for Reading

The pressures listed in the middle column of Table 8 reflect reliable and practical pressures for different range transducers. Lower readings may be obtained in environments which have stable temperature and air flow.

Lowest Suggested Pressure to Use for Control

The pressures listed in the last column of Table 8 are for reference, and represent the pressure reading of the transducer at 50 mV signal output. A DC signal of at least 50 mV is the recommended minimum signal level to use when integrating any transducer into complex processing systems.

Chapter Five: Maintenance and Troubleshooting

General Information

If the 627D transducer fails to operate properly upon receipt, check for shipping damage, and check the cables for correct continuity. Any damage should be reported to the carrier and MKS Instruments immediately.

If there is no obvious damage and the continuity is correct, check your instrument using the troubleshooting chart (refer to Table 9, page 38). If the transducer performance does not improve and it is necessary to return the unit to MKS for service, obtain an ERA Number (Equipment Return Authorization Number) from any MKS Calibration and Service center before shipping. Please refer to the inside back cover of this manual for a list of MKS Calibration and Service Centers.

Maintenance

In general, the 627D transducer requires no maintenance other than proper installation and operation, and an occasional zero adjustment. Periodically, check for wear on the cables and inspect the enclosure for visible signs of damage.

Zero Adjustment

The transducer zero can be set (or reset) by adjusting the ZERO potentiometer on the top panel of the unit (refer to Figure 4, page 30), or at the front panel of any MKS or MKS-compatible power supply being used. Refer to *How To Adjust the Zero*, page 33, for complete instructions on how to adjust the transducer's zero controls.

Note

1. In production operations such as semiconductor manufacturing, verify the transducer zero (and adjust if necessary) each time the equipment is shut down for routine maintenance.
2. The zero adjustments are the ***only*** adjustments that can be made in the field. Return the transducer to MKS Instruments for other adjustments, calibration, or servicing.

Troubleshooting

Troubleshooting Chart		
Symptom	**Possible Cause**	**Solution**
Overrange positive or negative signal	A shorted transducer or a damaged interconnect cable (transducer to electronics module).	Measure supply voltages at the connector. Inspect cable and transducer. Replace if necessary.
Measurement slowly goes positive over time	Overpressure and/or a build-up of contamination in the measurement cavity.	Return to MKS for servicing or transducer replacement.
Unstable zero output	The ambient temperature may be too high. *or* The ambient temperature is varying over a wide range.	Ensure the ambient temperature is within product requirements; refer to *Appendix A: Product Specifications*, page 39.

Table 9: Troubleshooting Chart

Appendix A: Product Specifications

Electrical Specifications

CE Compliance Electromagnetic Compatibility[1] Product Safety Requirements	 EMC Directive 2004/108/EEC Product Safety Directive 92/59/EEC
RoHS (Restriction of Hazardous Substances) Compliance	Fully compliant with Directive 2002-95-EC
Input Power Requirement Voltage Current	 ±15 VDC ±5% ≤ 250 mA
Signal Output	0 to +10 VDC, 110% overrange, active zero

Environmental Specifications

Ambient Operating Temperature Range	15° to 40° C (59° to 104° F)
Maximum External Case Temperature	50° C (122° F)
Storage Humidity Range	25 to 95% Relative Humidity, non-condensing
Storage Temperature Range	-20° to 80° C (-4° to 176° F)

Performance Specifications

Accuracy (non-linearity, hysteresis, and non-repeatability) ≥ 1 Torr units 0.1 and 0.05 Torr units 0.02 Torr units	 ±0.12% of Reading ±0.15% of Reading ±0.25% of Reading
Burst Pressure	5 times full scale or 90 psia, whichever is greater
Internal Volume	6.3 cc
Leak Integrity	Internal to external <10^{-9} scc/sec He
Overpressure Limit Without Damage	45 psia (310 kPa)
Pressure Ranges (Torr FS)	0.02, 0.05, 0.1, 1.0, 2.0, 10, 20, 100, 1000
Resolution	0.001% (1 x 10^{-5}) of FS

[1] An overall metal braided shielded cable, properly grounded at both ends, is required during use.

Performance Specifications *(Continued)*

Temperature Coefficients	
Zero	
≥ 1 Torr units	0.002% FS/ °C
0.1 Torr units	0.005% FS/ °C
0.05 Torr units	0.015% FS/ °C
0.02 Torr units	0.030% FS/ °C
Span (all ranges)	0.02% Reading/ °C
Time Response	< 20 msec (< 40 msec for ≤ 1 Torr units)
Warm Up Time (for 23° C ambient temperature conditions)	
≥ 1 Torr units	2 hours
< 1 Torr units	4 hours
Zero Adjustment Range	
Zero Potentiometer	±1.0%
Coarse Zero Switch	±20%

Physical Specifications

Fittings	½" Diameter (12.7 mm) tubulation, Swagelok® 8-VCR® (female), Mini-CF (rotatable), NW-16-KF, NW-25-KF, Swagelok 8-VCO® (female)
Interface Connector	15-pin male Type "D"
Weight	1.5 lbs (0.68 Kg)
Wetted Materials	Inconel®

Optional Semiconductor Switch Specifications

Current Carrying Capacity	10 mA, maximum
Saturation Voltage	0.4 V, maximum
Open Circuit Voltage	28 V, maximum
Zener Protection	28 V, nominal

Due to continuing research and development activities, these product specifications are subject to change without notice.

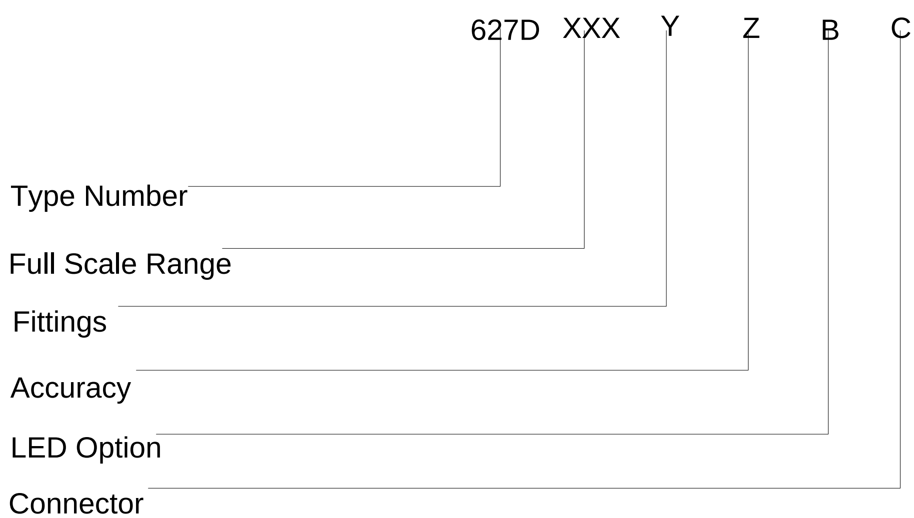
Appendix B: Model Code Explanation

Model Code

The options of your transducer are identified in the model code when you order the unit. The model code is identified as follows:

627D   XXX   Y   Z   B   C

where:



Type Number (627D)

This designates the model number of the instrument.

Full Scale Range (XXX)

The full scale range in Torr is indicated by a two digit / one letter code.

Full Scale Range	Ordering Code
0.02	U2T
0.05	U5T
0.1	.1T
1.0	01T
2.0	02T
10	11T
20	21T
100	12T
1000	13T

Fittings (Y)

Six types of fittings are available, designated by a single letter code.

Fittings	Ordering Code
½” Diameter tubulation	A
Swagelok 8-VCR (female)	B
Mini-CF (rotatable)	C
NW16-KF	D
NW25-KF	Q
Swagelok 8-VCO female	E

Accuracy (Z)

Three specifications for accuracy are available, designated by a single letter code.

Accuracy	Ordering Code
0.12% of Reading (≥ 1 Torr units)	C
0.15% of Reading (0.1 and 0.05 Torr units)	D
0.25% of Reading (0.02 Torr units)	E

LED Option (B)

The unit is available with or without the heater status LEDs, designated by a single letter code.

LED Option	Ordering Code
Standard (No status LEDs)	A
Heater Failure / Heater Temperature Status LEDs	B

Connector (C)

Two configurations of the 15-pin Type “D” connector are available, designated by a single letter code.

Connector	Ordering Code
15-pin Type “D” connector with thread locks	B
15-pin Type “D” connector with slide locks	P

Index

CONTROL CONCEPTS INC.

INSTRUCTION MANUAL
MODEL 1029B

CONTROL
CONCEPTS
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WARNING: The Control Concepts, Inc. power controllers use power thyristors to switch voltage to the connected load. Line voltage must be assumed at the output terminals at all times, even when the control signal has been removed and the load voltage appears to be off. It has been mandated by the National Electrical Code and the Occupational Safety and Health Act of 1970 that a physical disconnect be opened ahead of all remotely actuated controls before performing any maintenance work on the controller or its connected load.

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<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>

Publication Number 95-1001

DESCRIPTION:

MODEL COVERED:

This instruction manual covers the model 1029B controller with the following ratings:
CURRENT: 50 AMPS to 1000 Amps.
VOLTAGE: 120 Vac to 575 Vac. @ 50 / 60 Hz.
Other voltage and current ratings may be available, contact factory for information

GENERAL DESCRIPTION:

The model 1029B is a single-phase, phase-angle power controller.
The model 1029B has selectable feedback, dual command signals, adjustable current limiting, over-current trip, shorted SCR detection, estimated output voltage metering and output current metering.

FEATURES:

STATUS INDICATORS:

COMMAND - The intensity of the command indicator is proportional to the command signal and the "ON" time of the SCRs.

LOAD - The intensity of the load indicator is proportional to the SCR and load current.

SHORTED SCR - When "ON" an SCR has failed in the shorted mode and full power is applied to the load.

OVER CURRENT - When "ON" indicates that the SCRs have been locked "OFF" and that the reset switch must be closed or power removed from the input to re-enable the controller.

RUN OR IDLE INPUT SELECTION:

Closure of a remote contact, connected to pins 10 and 11 on the command connector, transfers control from the "IDLE" command input to the "RUN" command input (See Fig. 9, 10 or 11).
A current or voltage command signal or a potentiometer may be connected to the IDLE command input while another current or voltage command signal or a potentiometer is connected to the RUN command input.
Using this feature provides a convenient means by which the controller output can be operated alternately from either of two process signals. The feature provides a convenient means to maintain the load at a predetermined level during idle or standby condition.

SOFT START AND MISSING CYCLE DETECTION:

On initiation of power, or if the supply power is momentarily interrupted for 1/2 cycle or more, the load voltage is set to zero and increased to the desired value at a rate equal to a time constant of approximately 0.2 seconds. This feature allows adequate time for variable resistance loads T-3 lamps to stabilize and prevents saturation of transformers used to couple power between the controller and the load.

CHOICE OF FEEDBACK:

The feedback choices are: Current, External, power (if installed at factory) or Voltage.
External choices are 0-5 Vdc or 0-100 uA applied to terminals P1-14(com) and P1-18 j(input).
Power may be selected if the Power option was installed at the factory.
Voltage is True RMS unless the Average voltage option was installed at the factory.
True RMS or Average Voltage use a feedforward technique.
Current feedback may be selected by moving a jumper on P2.

OUTPUT METERING:

CURRENT: A filtered 0 to 5Vdc (5mA max. load) output signal, proportional to the value of the load current.

VOLTAGE: A filtered 0 to 5Vdc (5mA max load) output signal, proportional to the estimated value of the load voltage.

Note: If *average voltage* feedforward technique is installed, the voltage metering output will be proportional to the estimated Average value of the load voltage.

SHORTED SCR DETECTION:

In the event an SCR fails by shorting, the SHORTED SCR LED will light and a relay with form C contacts rated for 5 amps at 120Vac is energized. These contacts may be used to activate an alarm or remove system power. Connections to these contacts are available on the command connector. (Fig. 6, Pg. 8)

FEATURES: cont

CURRENT LIMITING:

Prevents the load current from exceeding the rating of the SCRs and prevents excessive load current from occurring when variable impedance loads are used. A potentiometer on the printed circuit board allows adjustment of the current limiting setting from 20% to 105% of the controller's rating. The CURRENT LIMIT potentiometer is factory set at 105% of the rated current.

OVERCURRENT TRIP:

If the SCR current exceeds a preset value of approximately one and one half times the rated current, the SCRs will be latched off, the OVER CURRENT LED will light and a relay with form C contacts rated for 5 amps at 120Vac will be energized. These contacts may be used to activate an alarm or cause system power to be removed. Connections to these contacts are on the command connector. (Fig. 7, Pg. 12)

RESET SWITCH:

Momentary closure of a remote reset switch (Fig. 7, Pg. 12) or a momentary interruption of the AC supply will reset the over current relay and allow the controller to reapply power to the load. Closure of the reset switch during normal operation prevents the SCRs from operating but does not cause the over current relay to energize. The reset switch may be used as an ON-OFF switch.

THEORY OF OPERATION

THE SCR

The heart of the SCR power controller is the SCR (silicon controlled rectifier, sometimes referred to as a thyristor).

The SCR has two states, ON and OFF, and allows current to flow in only one direction when turned on. SCRs can remain in the off state even though the applied potential may be several thousand volts; in the on state, they can pass several thousand amperes. When a small signal is applied between the gate and cathode terminals (Figure 1), the SCR will turn on within 10-100 microseconds. Once turned on, it will remain on until the current through it is reduced below a very low value, referred to as the holding current.

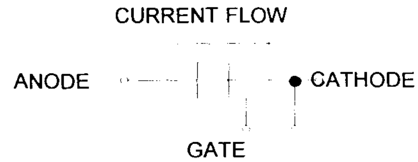


Figure 1. SCR SYMBOL

Because the SCR allows current to flow in only one direction, two SCR's are connected in an "inverse parallel" configuration to control AC current (Figure 2).

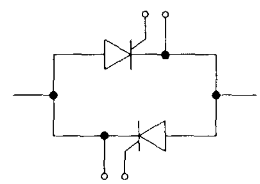


Figure 2. "AC SWITCH "

PHASE-ANGLE OPERATION

In phase-angle control, each SCR of the back-to-back pair is turned on for a variable portion of the half-cycle that it conducts (Figure 3a & b). Power is regulated by advancing or delaying the point at which the SCR is turned ON within each half cycle. Light dimmers are an example of phase-angle control. Phase-angle control provides a very fine resolution of power and is used to control fast responding loads such as tungsten-filament lamps or loads in which the resistance changes as a function of temperature. Phase-angle control is required if the load is transformer-coupled, capacitive or inductive.

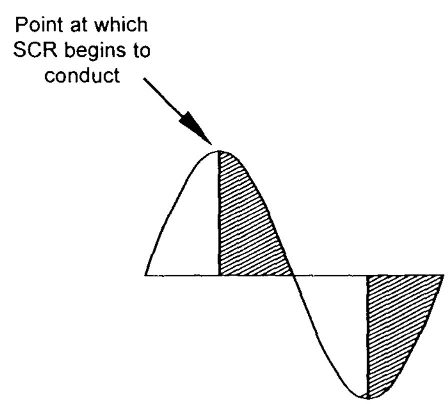


Figure 3. SCR "ON" time,
shown by shaded area,
is varied to achieve the desired load voltage.

SPECIFICATIONS:

The following specifications apply over an ambient temperature of 0 to 55°C and a supply voltage of 85% to 110% of the nominal supply voltage rating.

CONTROL MODE:	SCR phase-angle control of the voltage applied to a single phase load.
FRAME SIZE:	The "[AMPS]A" term within the model number specifies the maximum continuous RMS current rating at the maximum operating ambient temperature of 55°C.
RUN COMMAND SIGNAL:	Input Impedance: 1/5mA 1200 ohms 4/20mA 300 ohms 0-5Vdc 100K ohms Potentiometer 100K ohms (1K, 1/4watt pot recommended for optimum linearity, up to 20K permissible) The potentiometer is excited by 5Vdc, supplied by the circuit. **Other ranges are available. Check with factory for special applications**
IDLE COMMAND SIGNAL:	Input Impedance: 1/5mA 1200 ohms 4/20mA 300 ohms 0-5Vdc 100K ohms Potentiometer 100K ohms (1K, 1/4 watt pot recommended for optimum linearity, up to 20K permissible) The potentiometer is excited by 5Vdc, supplied by the circuit. **Other ranges are available. Check with factory for special applications**
RUN/IDLE CONTROL:	Control of the output can be switched between the idle command signal and the run command signal by a remote single pole single throw switch.
OPERATING VOLTAGE:	208, 240, 380, 480 or 575Vac +10 -15% 50/60 Hertz Other voltages available - consult factory.
ENVIRONMENT:	Operating temperature 0 to 55°C (32 to 132°F) Storage temperature: -40 to 80°C (-4 to 176°F) Humidity: 0 to 95%, non-condensing
SCR RATINGS:	Peak forward and reverse voltage 1400 volts

SPECIFICATIONS:	
OVER CURRENT TRIP INDICATOR:	An LED indicates if the over current limit has occured.
LOAD CURRENT INDICATOR:	An LED indicates when current is applied to the load.
COMMAND INDICATOR:	An LED indicates when the SCRs are turned on.
SHORTED SCR INDICATOR:	An LED indicates if either SCR is shorted.
SCR SURGE CURRENT RATINGS :	(peak one cycle non-repetitive I_{TSM} @ 125°C)

Controller Rating	Surge Current Rating
50, 100 & 150 Amp:	**1750 Amps Peak**
200 Amp:	**4500 Amps Peak**
250 Amp:	**5200 Amps Peak**
300 Amp:	**5200 Amps Peak**
380 Amp:	**10,000 Amps Peak**
425 Amp:	**13000 Amps Peak**
500 Amp:	**10,000 Amps Peak**
600 Amp:	**13000 Amps Peak**
750 Amp:	**16500 Amps Peak**

ELECTRICAL CONNECTIONS:	Aluminum compression lugs for line and load connections are provided for use with either aluminum or copper wire from 500 MCM to No. 6 ga.
ELECTRICAL ISOLATION:	Heatsink to supply and load voltage: - 2500 Volts Peak. Command signal to supply and load voltage: - 1500 Volts Peak.
ZERO AND SPAN:	Potentiometers on the circuit board allow zero and span adjustments of $\pm$ 25% of span for run and idle.
CURRENT LIMITING:	A potentiometer on the circuit board allows adjustment of the current limiting setting from 20% to 105% of the controller rating. (The current limit potentiometer is factory set for 105% of the rated current unless otherwise specified.)
VOLTAGE METER OUTPUT:	A filtered 0 to 5Vdc signal proportional to the percentage of load voltage output. (True RMS or Average depending on type of feedback.)
CURRENT METER OUTPUT:	A filtered 0 to 5Vdc signal proportional to the true RMS current.

SPECIFICATIONS:	
GATE DRIVE:	An optical coupled current source of 250mA with a maximum compliance of 20 volts provides the gate drives to the SCRs. Duration or "back porch" is approximately 1.4 milliseconds (60 electrical degrees).
CONTROL RANGE:	0 to 98% of supply voltage.
VOLTAGE COMPENSATION:	The load power remains constant independant of supply voltage changes within + 10%, -15% 50/60 Hz.
WEIGHT:	50 & 100 Amp controllers 13 pounds 150 Amp controllers 15 Pounds 225 to 425 Amp controllers 25 Pounds 500 to 1000 Amp controllers 40 Pounds
POWER DISSIPATION:	1.5 Watts per amp of load current.
INTERNAL FEEDBACK:	User has choice of: *True RMS Voltage, or True RMS Current. Power* feedback can be factory installed if desired. Only one type of feedback may be selected at any time.
EXTERNAL FEEDBACK:	An external 0 to 5Vdc or 0 to 50uA signal, (derived from the load,) may be used for external feedback into the controller.
LINEARITY:	The controlled variable is linear within 2% of Span with respect to the command signal.
SCR PROTECTION:	dV/dT rating = 200 volts/microsecond. dV/dT circuit consists of a capacitor in series with a noninductive resistor. This circuit is in parallel with the SCRs. SCRs are protected from voltage transients by a Metal Oxide varistor.

WARNING: the Control Concepts, Inc, model 1029B power controller uses power thyristors to switch voltage to the connected load. Line voltage must be assumed at the output terminals at all times, even when the control signal has been removed and the load voltage appears to be off. It has been mandated by the National Electrical Code and the Occupational Safety and Health Act of 1970 that a physical disconnect be opened ahead of all remotely actuated controls before performing any maintenance work on the controller or its connected load.

INSTALLATION:

TRANSFORMER TAP:

Prior to mounting the controller, place the spade terminal on the transformer tap that corresponds with the supply voltage to be used.

MOUNTING AND LOCATION:

The 50 and 100 amp controller must be mounted on a vertical surface with the heat dissipating fins oriented so that air may flow vertically over them. All other controllers are forced air cooled and may be mounted in any direction.

COMMAND:

The 1029B has two command inputs, which are selected by a contact closure. A potentiometer, a DC voltage or a DC current may be used as a command signal into either input. These connections are made to the command connector as described below.

NOTE: Terminal 13 (run input) is the normally active input. To use alternate terminal 15 (idle input), the jumper between terminals 10 & 11 must be disconnected. See figures 9 & 10 on page 10.

Potentiometer:

A 1000 ohm to 20,000 ohm potentiometer, 1/4 watt or higher, may be used to adjust the load voltage. A 1000 ohm potentiometer provides the maximum linearity. Connect terminal 12 to the clockwise end of the potentiometer, terminal 13 (run) or terminal 15 (idle) to the potentiometer wiper, and terminal 14 (common) to the counterclockwise end of the potentiometer.

Current:

The positive current connection is to terminal 13 (run) or 15 (idle). The negative or return current connection is to terminal 14 (common).

Voltage:

A 0 to 5 Vdc signal may be used as the command signal by connecting the positive signal to terminal 13 (run) or terminal 15 (idle) and the negative or common signal to terminal 14 (common) (See fig. 10, Pg 10). Higher DC voltages may be used by placing an external resistor in series with terminal 13 such that the maximum voltage between terminals 13 and 14 (or 14 and 15), is 5 volts.

OVER CURRENT TRIP RELAY:

Connections to the form C contacts of the over current relay are as shown on the cover of the controller and in Figure 6, on page 8. The contacts are rated for 5 Amps at 120 Vac and are intended for activating an alarm and/or removing power from the system.

OVER CURRENT RESET:

Momentary closure of a switch connected between terminals 9 and 10 on the command connector will reset the over current relay and will release the SCRs from the locked off state. The reset switch can also be used as an on off control. Closure of the switch causes the SCRs to be immediately turned OFF. When the switch is opened the SCRs begin operation at zero conduction angle and slew at the soft start rate to the desired output.

SHORTED SCR RELAY:

Connections to the 5 Amp 120 Vac form C contacts are shown on the cover of the controller and in fig. 6, on page 7. This relay energizes if an SCR fails in the shorted mode and is intended to activate an alarm and/or cause power to be removed from the system by operating a contactor or a circuit breaker.

RUN/IDLE:

A remote switch can be used, as shown on page 10, to cause the controller to be controlled by either the run or idle inputs. Connecting terminal 10 to terminal 11 causes the run input to be in control. Opening the connection between terminal 10 and terminal 11 causes the idle input to be in control.

POWER CONNECTIONS:

Figures 15 & 16 on page 13 shows the electrical connections. The line and load connectors are rated for wire sizes from #6 to 500 MCM. The recommended torques as a function of wire size are:

WIRE SIZE:	TORQUE
6	100 IN-LBS
4	100
2	125
1	125
1/0	150
2/0	150
3/0	200
4/0	200
250MCM	250
500MCM	300

ADJUSTMENTS:

The I Span and V Span pots (and Power Span and Zero pots, when factory installed), are sealed at the factory. They are identified with an X in Figure 4.
Under no circumstances should the adjustment of these four pots be tampered with. The setting of these potentiometers is critical to the proper operation of the controller.

The potentiometers labeled *RUN ZERO & SPAN*, and *IDLE ZERO & SPAN* have been calibrated at the factory and adjustment should not be attempted without first consulting a factory representative.
The zero potentiometer adjusts the controller to provide the desired minimum output when the command signal is at minimum.
The span potentiometer adjusts the controller to provide the desired maximum output when the command signal is at maximum.
If it is agreed that the adjustment should be made, the following procedure must be followed.
It is assumed that the load is resistive.

To adjust the Run Zero and Span:
Short pin P1-11 (Run/Idle) to pin P1-10 (Common).
Make sure that the command signal is connected to the Run input P1-13 (Run/Wiper) and P1-14 (Common).

1. Set the command signal to minimum and adjust the Run zero potentiometer until the output is zero.
2. Set the command signal to maximum and adjust the Run span potentiometer until the output is at the desired maximum value.
3. The span and zero adjustments may interact, making it necessary to repeat steps 1 and 2.

To adjust the Idle Zero and Span:
Remove the Short between P1-11 (Run/Idle) and P1-10 (Common).
Make sure that the command signal is connected to the Idle input P1-15 (Idle/Wiper) and P1-14 (Common).
Repeat steps 1,2 and 3 above.

It is important that equipment capable of accurately measuring the output of the controller be used.
True RMS meters should be used for accurate measurements of; True RMS Voltage, Current or Power (RMS Volts times RMS current into a resistive load).
Average responding meters should be used for measurements of; Average A.C. Voltage, or DC voltage.

To adjust the Current Limit:
(Current limit is factory set at 105% unless specified differently by the (**IL**) term in the model number.)
Clockwise rotation of the Current limit potentiometer raises the point at which the load current is affected.
Note: Loads whose variable resistance increases slowly, may cause the current limiting feature to limit the output of the controller. This would appear as though the span is not adjusted properly.
If it is suspected that the current limit adjustment is causing the output of the controller to be lower than desired, rotate the current limit pot 1 turn clockwise. If the load current increases, the current limit adjustment is controlling the output.

To adjust the Over Current Trip:
(Factory set at 150% of rated current) Clockwise rotation raises the point at which the over current trip activates the Over Current Trip LED and relay. When necessary, this potentiometer may be adjusted to suit the requirements of the application. The range of adjustment is approximately 50% to 200% of rated current.

FEEDBACK SELECTION:

Connector P2 on the circuit board allows the selection of feedback type. (See Figure 5 on Page 8).
Unless Average Voltage was installed by request, True RMS Voltage is the default voltage selection. Average voltage and True RMS voltage are of the feedforward technique.
Voltage is selected when the jumper is placed on pins P2-4 and P2-7.

Current feedback may be selected by placing the jumper on P2-3 and P2-8.

Power feedback, if factory installed, may be selected by placing the jumper on P2-5 and P2-6.

External feedback may be connected between terminals P1-14 and P1-18 on the command connector (See Figure 6).
A 0-5Vdc signal may be used for external feedback when the jumper is placed on pins P2-2 and P2-9.
A 0-100uA signal may be used for external feedback when the jumper is placed on pins P2-1 and P2-10.

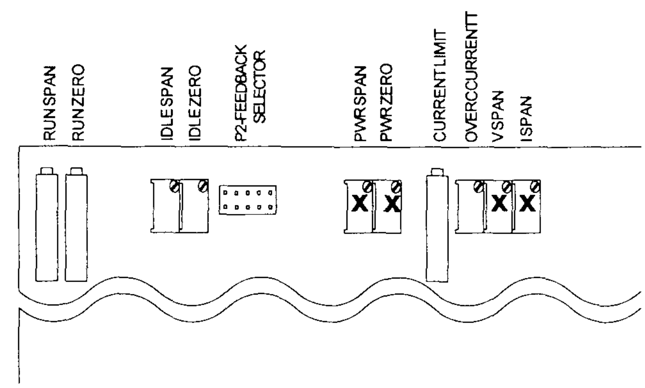


Figure 4. 1029B Circuit Board Adjustments.
Under no circumstances should any attempt be made to adjust the pots marked with an X

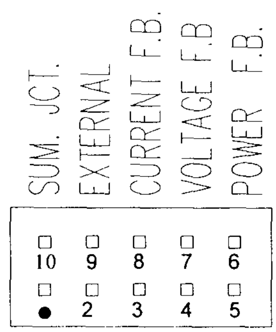


Figure 5. P2 Detail

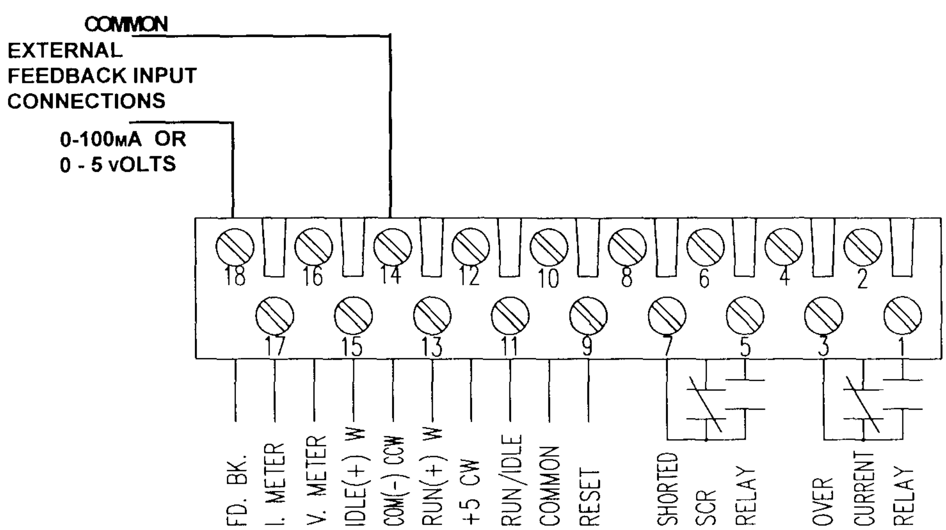


Fig. 6. External feedback connections.

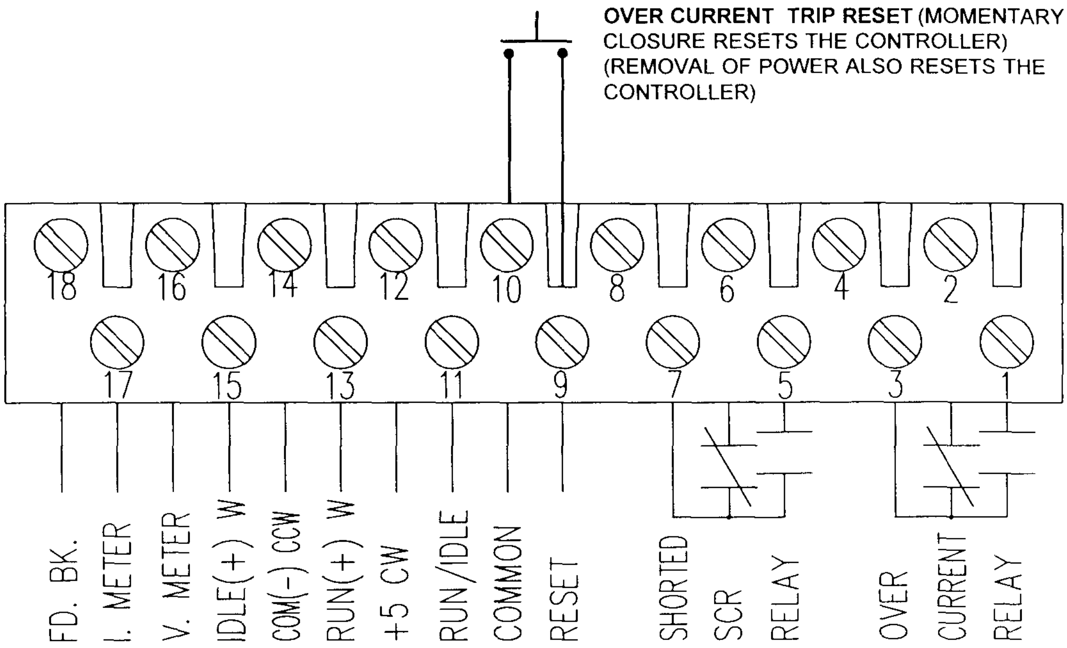


Figure 7. Shorted SCR, Over current relay and reset switch connections.

RELAY CONTACTS CHANGE STATE WHEN AN OVERCURRENT CONDITION OCCURS OR IF AN SCR FAILS IN THE SHORTED MODE.

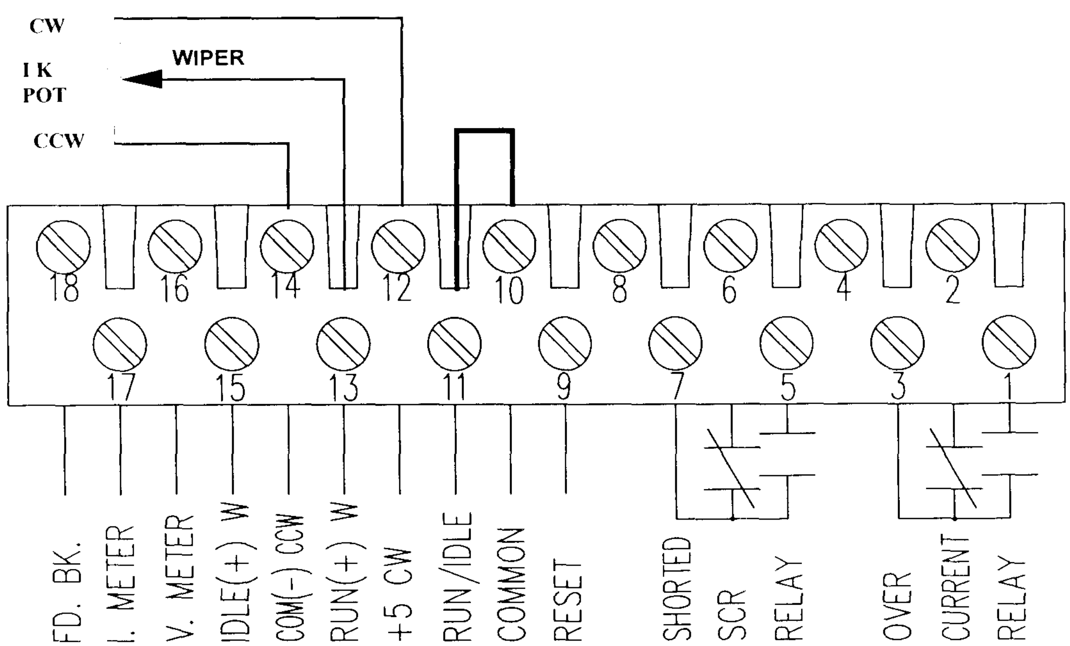


Figure 8. Single potentiometer connections.

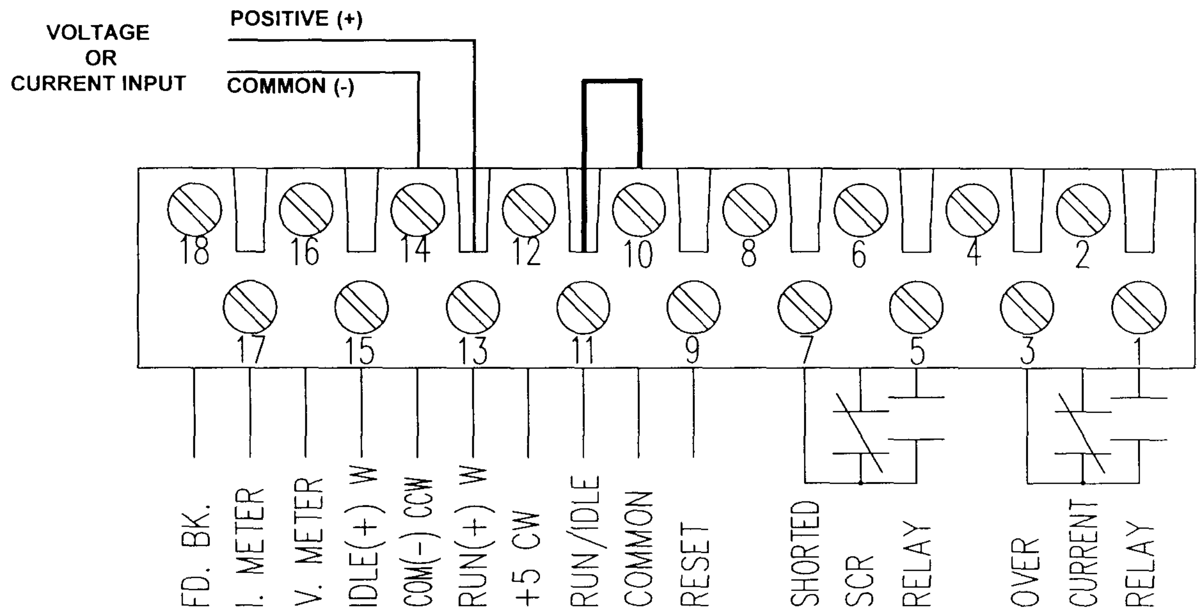


Figure 9. Single voltage or mA current connections.
(Terminals 10 & 11 must be connected.)

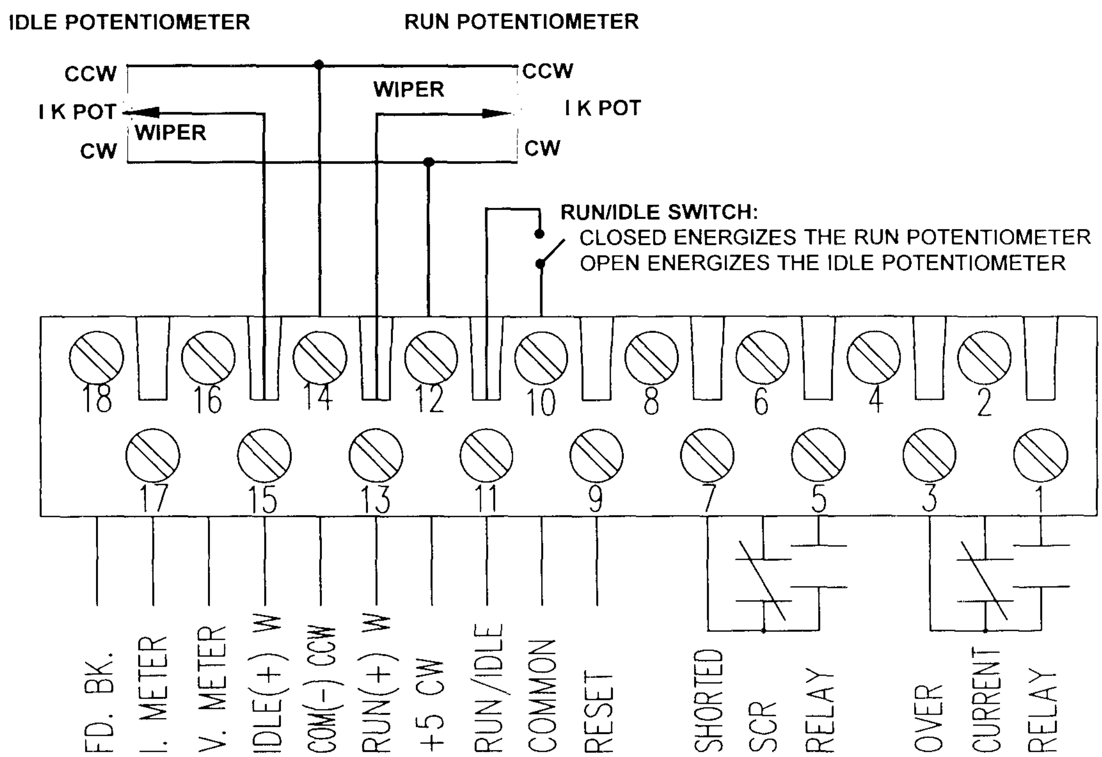


Figure 10. Run and Idle potentiometer connections

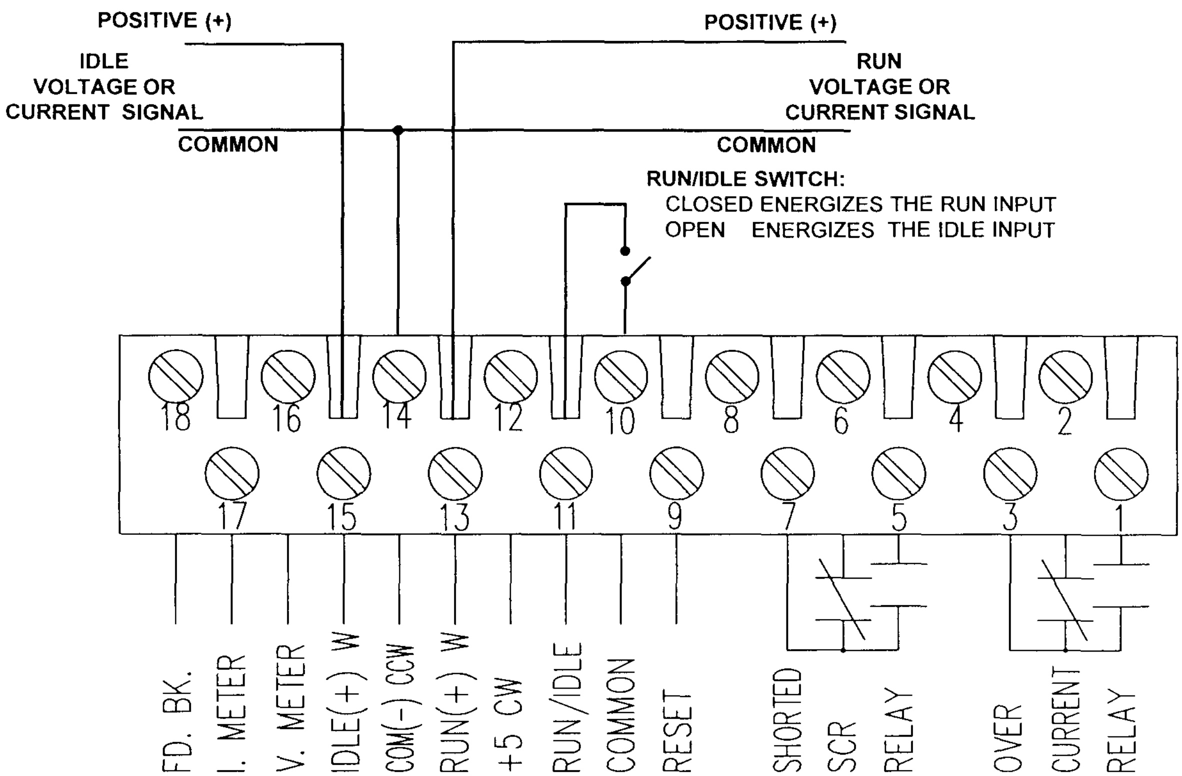


Figure 11. Run and Idle voltage or current connections

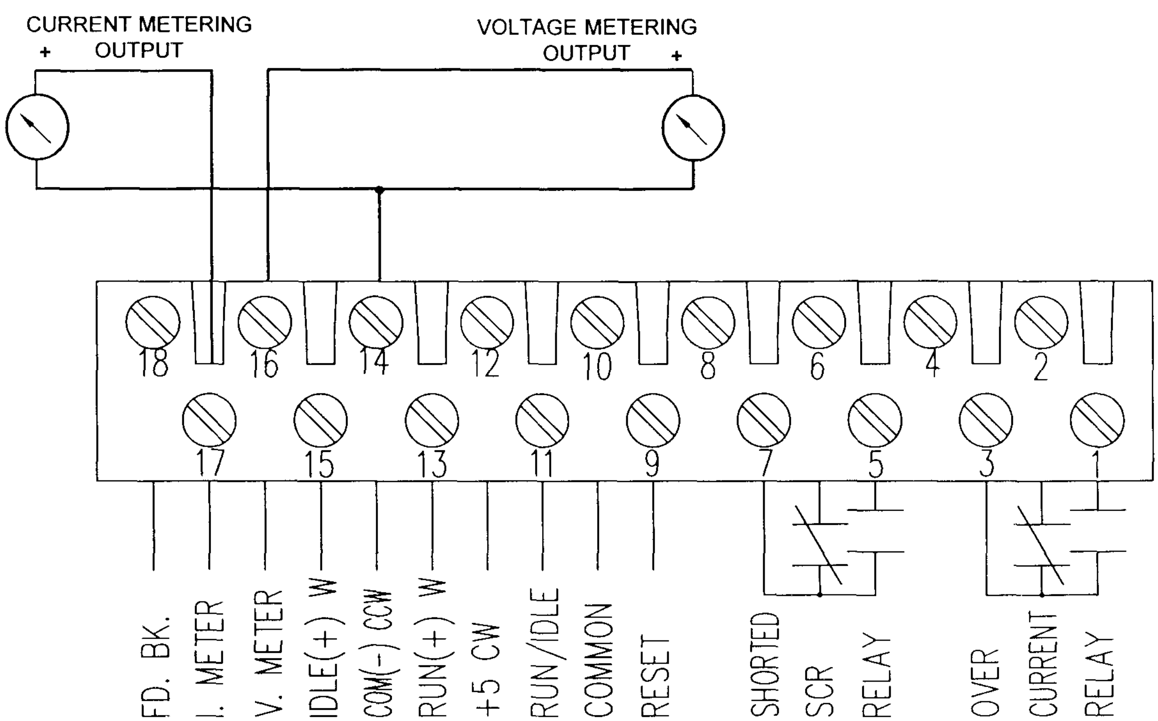


Figure 12. Output metering connections

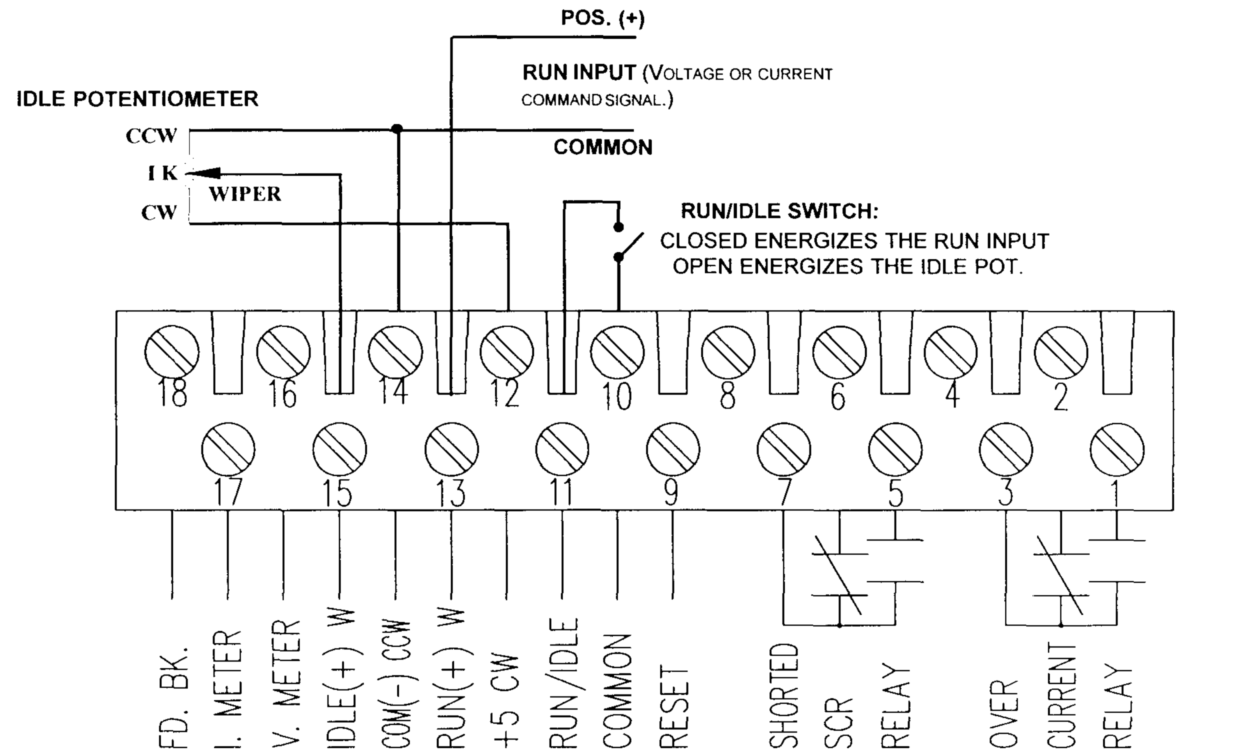


Figure 13. - Combination command-signal/potentiometer input connections

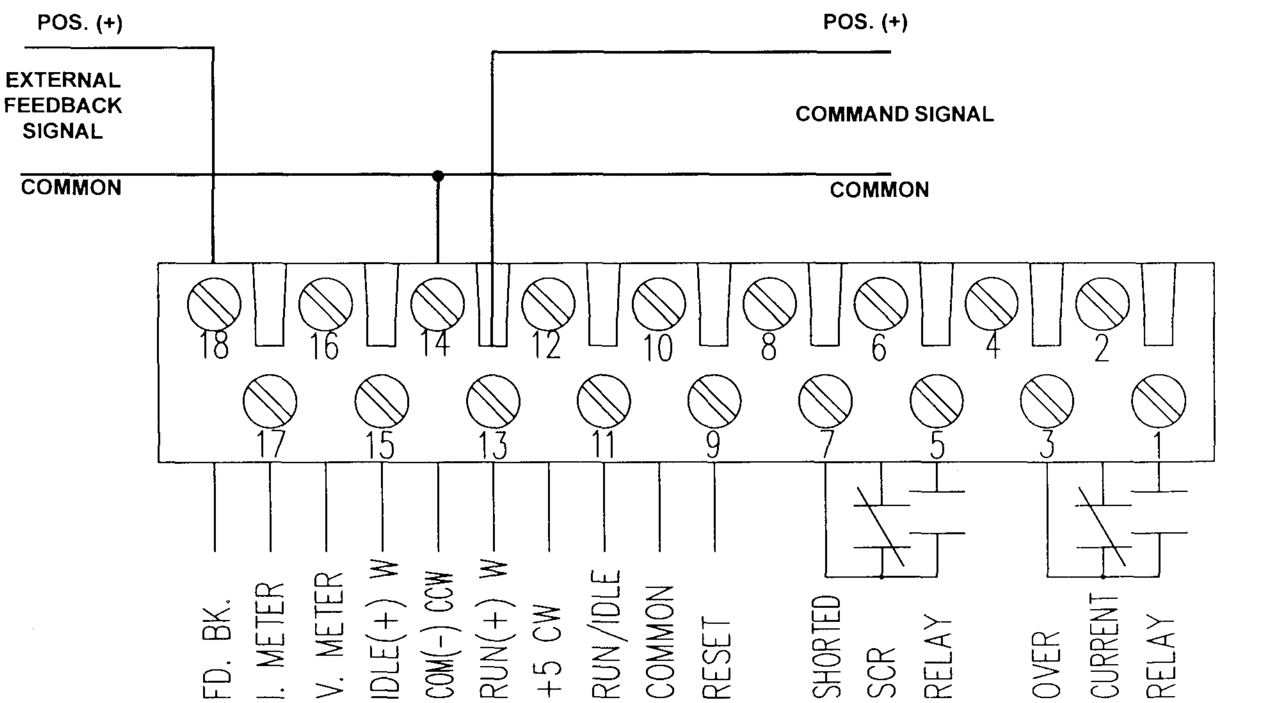


Figure 14. Feedback and signal connections
0 TO 5Vdc or 0 to 100uA external feedback

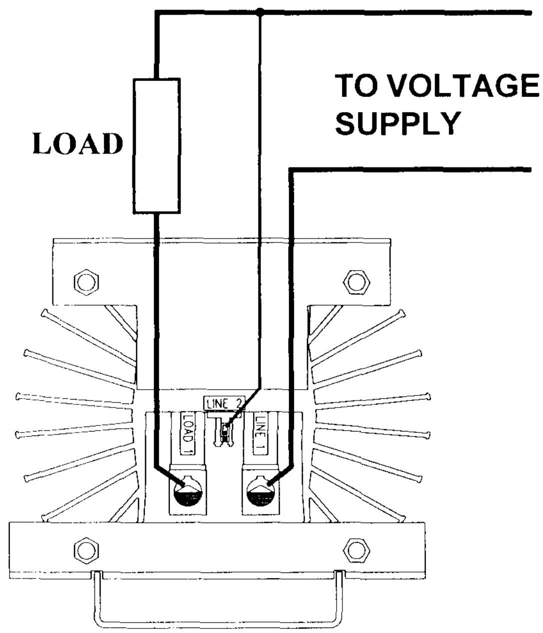


Figure 15. Power connections

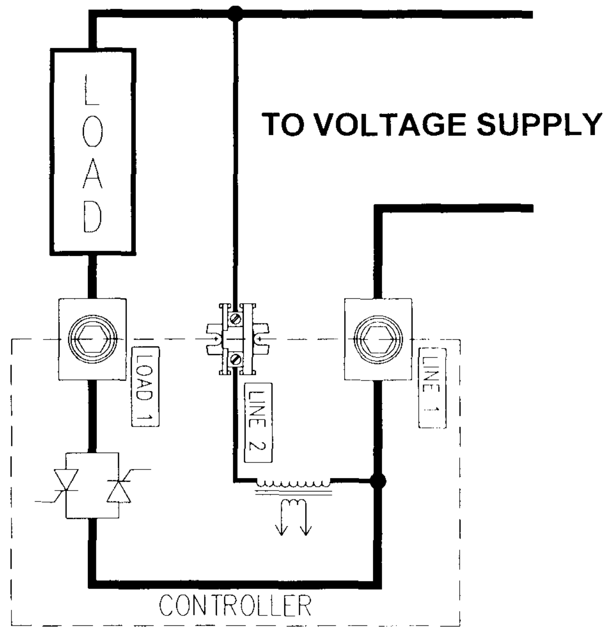


Figure 16. Power path

MODEL No IDENTIFICATION:

1029B-(FB)-(VOLTS)V-(AMPS)A-IL(AMPS)-R(CS)-I(CS)

The characteristics of the 1029B SCR power controller are defined by the terms in the model number as follows:

1029B The model 1029B specifies a single phase, phase-angle SCR firing circuit featuring: current limit, over current trip, shorted SCR detection and electrical isolation of the command signal from the line and load voltages.

-(FB) (A, V, E, I or P[XXXAMPS])

A - Specifies *average voltage* feedback. With *average voltage* feedback, the controller varies the conduction angle (or ON time) of the SCRs such that the average voltage applied to the load is proportional to the command signal.

V - Specifies *RMS voltage* feedback. With *RMS* voltage feedback, the controller varies the conduction angle (or ON time) of the SCRs such that the RMS voltage applied to the load is proportional to the command signal.

E - Specifies *external* feedback. The *external* feedback being proportional to some parameter such as speed, current, etc. that is ultimately being controlled by the action of the controller.

I - Specifies *RMS current* feedback. The load *current* is linearly controlled with respect to the command signal.

P(XXXAMPS) - The letter P specifies *power* feedback and therefore the load *power* is linearly controlled with respect to the command signal. XXX equals amp level for control of power.

MAX LOAD POWER = (VOLTS)V x P(AMPS)

-(VOLTS)V - Specifies the supply voltage the controller has been calibrated to operate at. Note: the standard controller has voltage taps on the transformer for operation at 240, 480 or 575 volts, 50/60 hertz.

-(AMPS)A - Specifies the continuous RMS current rating.

-IL(AMPS) - Specifies the current limit in Amps.

-R(CS) - Specifies the run command signal. **R**0/5V, **R**4/20mA or **R**POT

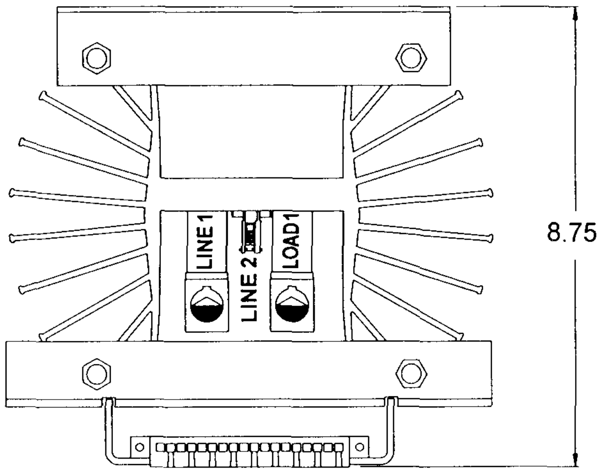
-I(CS) - Specifies the idle command signal. **I**0/5V, **I**4/20mA or **I**POT.

Specify special command signals: **I**1.2/6Vdc, etc.

For example:

1029B-A-480V-100A-IL75-R0/5V-IPOT

Will order a 1029B controller with average voltage feedback, rated @ 480 Volts, 100 Amps, current limit set at 75 Amps, run command signal of 0 to 5Vdc and a potentiometer option on the idle command input.



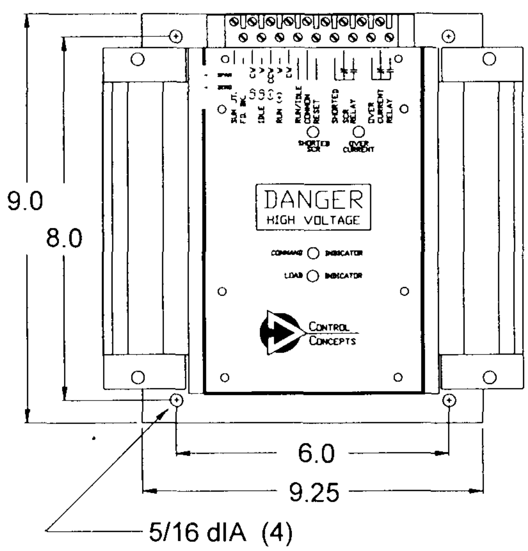
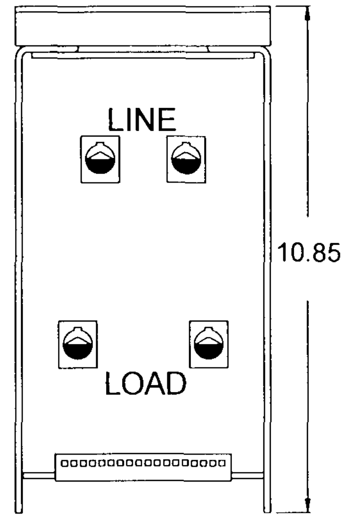


Fig. 17. - Installation drawing
50, 100 & 150 Amp

150 Amp controller has a fan. (not shown)



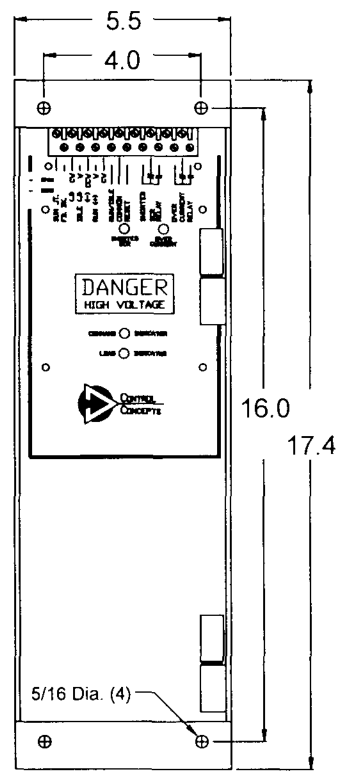


Fig. 18. - Installation drawing
200, 250, 300, 380 & 425 Amp

RECOMMENDED SPARE PARTS:

TO ORDER A SPARE FIRING CIRCUIT: 1029B-(FB)-IL()-R(cs)-I(cs)-FC-FR(xx)

1029B: The model number of the controller
(FB) The type of feedback used
A = Average voltage feedback
V = True RMS voltage feedback
E = External feedback
IL ( ) The current limit in Amps
R(cs) The run command signal
I (cs) The idle command signal
(cs = 4/20mA, 0-5V, 0-10V or POT)
FC Firing circuit
FR(xx) The current rating of the frame
(xx) = 50 (50 Amp frame),
100 (100 Amp frame) or
150 (above 100 Amp frame)

1029B-V-IL100-R4/20mA-IPot-FC-FR100
would be the correct number to order a firing circuit with True RMS voltage feedback, calibrated for 100A limit with a 4/20mA run signal and a potentiometer idle signal, to be used on a 100 amp frame.

TO ORDER A SPARE SCR MODULE:

CONTROLLER CURRENT RATING:	ORDER CONTROL CONCEPTS PART No.
50 Amps	28325-0395-514
100 "	28325-0395-514
150 "	28325-0395-514
200 "	28000-0424-514
250 "	28000-0434-514
300 "	28000-0449-514
380 "	28011-0460-514
425 "	28011-0476-514
500 "	28011-0460-514
600 "	28011-0476-514
750 "	28013-0514-514

REFERENCE DWGs:

CCI No. D1000589B - SCHEMATIC

IT IS RECOMMENDED THAT THE CONTROLLER AND THE LOAD BE PROTECTED BY FUSES:

CONTROLLER CURRENT RATING:	RECOMMENDED BUSS CLASS T FUSE: JJS -	CCI PART NUMBER:
50 Amps	60 Amps	42110-0460-360
100 "	125 "	42110-0460-412
150 "	175 "	42110-0460-417
200 "	250 "	*42110-0460-425
250 "	300 "	42110-0460-430
300 "	350 "	42110-0460-435
380 "	450 "	42110-0460-445
425 "	500 "	42110-0460-450
500 "	600 "	*42110-0460-460
600 "	700 "	*42110-0460-470
750 "	800 "	*42110-0460-480

* not normally stocked.
Contact factory for other components as desired.
Control Concepts stocks controller replacement parts.

CONTROL CONCEPTS INC.

INSTRUCTION MANUAL
MODEL 1029C

CONTROL CONCEPTS
7870 PARK DRIVE
CHANHASSEN, MN 55317
(952)-474-6200
1-800-765-2799
FAX (952) 474-6070

CONTROL CONCEPTS, INC. 2 YEAR Limited Warranty

CONTROL CONCEPTS, INC. warrants that the products delivered will be as described in the sales order or contract.

CONTROL CONCEPTS, INC. warrants to the original user that CONTROL CONCEPTS, INC. products will be free from defects in materials and workmanship for a period of two (2) years after the date CONTROL CONCEPTS, INC. ships such products.

If any CONTROL CONCEPTS, INC. product is found to be defective in material or workmanship during the applicable warranty period, CONTROL CONCEPTS, INC.'s entire liability, and the purchasers sole and exclusive remedy, shall be the repair or replacement of the defective product at CONTROL CONCEPTS, INC.'s election. CONTROL CONCEPTS, INC. shall not be liable for any costs or expenses, whether direct or indirect, associated with the installation, removal or re-installation of any defective product. All shipping and freight costs are the responsibility of the customer. CONTROL CONCEPTS, INC.'s limited warranty shall not be effective or actionable unless there is compliance with all installation and operating instructions furnished by CONTROL CONCEPTS, INC., or if the products have been modified or altered without the written consent of CONTROL CONCEPTS, INC., or if such products have been subject to accident, misuse, mishandling, tampering, negligence or improper maintenance. Any warranty claim must be submitted to CONTROL CONCEPTS, INC. in writing within the stated warranty period.

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By purchasing CONTROL CONCEPTS, INC.'s products, the purchaser agrees to the terms and conditions of this limited warranty.

WARNING: The Control Concepts, Inc. power controllers use power thyristors to switch voltage to the connected load. Line voltage must be assumed at the output terminals at all times, even when the control signal has been removed and the load voltage appears to be off. It has been mandated by the National Electrical Code and the Occupational Safety and Health Act of 1970 that a physical disconnect be opened ahead of all remotely actuated controls before performing any maintenance work on the controller or its connected load.

CONTROL CONCEPTS, INC.

7870 PARK DRIVE

CHANHASSEN, MN 55317

PHONE: (952) 474-6200

FAX: (952) 474-6070

TOLL FREE: (800) 765-2799

TABLE OF CONTENTS:

Publication Number 5000095-1100

DESCRIPTION:

MODEL COVERED:

This manual describes the Control Concepts' model 1029C controller with the following ratings:
CURRENT: 50 Amps to 750 Amps.
VOLTAGE: 120 Vac to 575 Vac. @ 50/60 Hz.

GENERAL DESCRIPTION:

The model 1029C is a single-phase, phase-angle power controller.

The model 1029C has selectable feedback, dual command signals, adjustable current limiting, over-current trip, shorted SCR detection, estimated output voltage metering and output current metering.

FEATURES:

CURRENT LIMITING:

A user adjustable setting prevents the load current from exceeding a preset value.

OVER CURRENT TRIP:

If the SCR current exceeds this preset value, a relay with form C contacts is energized, an LED is lighted and the SCR's are prevented from turning on.

This provides a means to initiate an alarm or to remove system power in the event that excessive current occurs. Momentary closure of a remote switch or momentary interruption of main power will reset the O.C.T. circuit.

SOFT START AND MISSING CYCLE DETECTION:

The output voltage is ramped from zero to the desired output at a ramp rate equivalent to a time constant of 0.2 seconds on power interuptions of 1/2 cycle or more.

This feature prevents inrush currents when controlling variable resistance loads or inductive coupled loads.

SHORTED SCR DETECTION:

A relay with form C contacts and an LED is energized in the event an SCR fails in the ON state.

This provides a means to initiate an alarm or to remove system power in the event an SCR fails in the "ON" state.

STATUS INDICATORS:

Command - The intensity of the command indicator is proportional to the command signal and the "ON" time of the SCRs.

Load - The intensity of the load indicator is proportional to the load current.

Shorted SCR - When "ON", an SCR has failed in the shorted mode.

Over Current Trip - When "ON" indicates that load current has exceeded the preset Over Current Trip level.

RUN OR IDLE INPUT SELECTION:

With this feature, either of two command signals can be selected by a remote switch.

This allows the controller to be conveniently switched from a "RUN" to an "IDLE" state, or from an "AUTOMATIC" to a "MANUAL" control.

CHOICE OF FEEDBACK:

The Average value of the load voltage, the RMS value of the load voltage or the RMS value of the load current can be linearly controlled with respect to the command signal.

The power (watts) applied to the load can also be linearly controlled with respect to the command signal. (Power feedback is an option that must be factory installed.)

The controller will also accept external feedback signals of 0/5 Vdc or 100 uA representing other process parameters.

OUTPUT METERING:

A filtered 0/5 Vdc signal representing the load voltage and a 0/5 Vdc signal representing the load current are provided for remote monitoring.

THEORY OF OPERATION

THE SCR

The heart of the Control Concepts, Inc. power controller is the SCR (silicon controlled rectifier, sometimes referred to as a thyristor).

The SCR has two states, ON and OFF, and allows current to flow in only one direction when turned on. SCRs can remain in the off state even though the applied potential may be up to 1400 volts.

In the on state, they can pass several thousand amperes. When a small signal is applied between the gate and cathode terminals (Figure 1), the SCR will turn on within 10-100 microseconds.

Once turned on, it will remain on until the current through it is reduced below a very low value, referred to as the holding current.

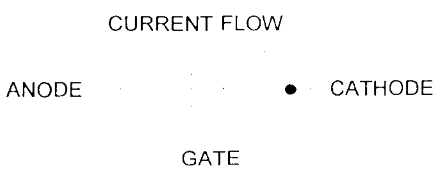


Figure 1. SCR SYMBOL

Because the SCR allows current to flow in only one direction, two SCR's are connected in an "inverse parallel" configuration to control AC current (Figure 2).

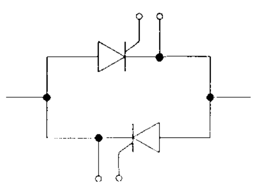


Figure 2. "AC SWITCH "

PHASE-ANGLE OPERATION

In phase-angle control, each SCR of the back-to-back pair is turned on for a variable portion of the half-cycle that it conducts. (Figure 3).

Power is regulated by advancing or delaying the point at which the SCR is turned ON within each half cycle. Light dimmers are an example of phase-angle control.

Phase-angle control provides a very fine resolution of power and is used to control fast responding loads such as tungsten-filament lamps or loads in which the resistance changes as a function of temperature.

Phase-angle control is required if the load is transformer-coupled, capacitive, inductive or a variable resistance load requiring current limiting.

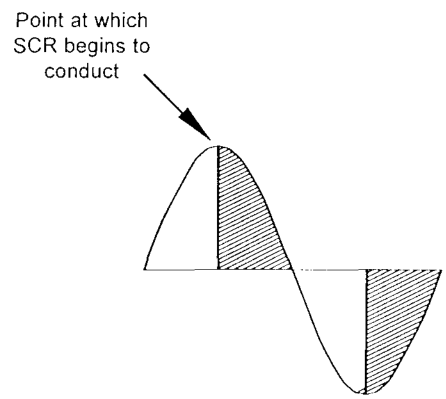


Figure 3. SCR "ON" time,
shown by shaded area,
is varied to achieve the desired load voltage.

WARNING: the Control Concepts, Inc, model 1029C power controller uses power thyristors to switch voltage to the connected load. Line voltage must be assumed at the output terminals at all times, even when the control signal has been removed and the load voltage appears to be off.
It has been mandated by the National Electrical Code and the Occupational Safety and Health Act of 1970 that a physical disconnect be opened ahead of all remotely actuated controls before performing any maintenance work on the controller or its connected load.

SPECIFICATIONS:

The following specifications apply over an ambient temperature of 0 to 55°C and a supply voltage of 85% to 110% of the nominal supply voltage rating.

CONTROL MODE:	Single phase SCR phase-angle control.
FRAME SIZE:	The "[AMPS]A" term within the model number specifies the maximum continuous RMS current rating at the maximum operating ambient temperature of 55°C.
RUN & IDLE COMMAND SIGNAL:	Command signal / Input Impedance: 1/5mA — 1200 ohms 4/20mA — 300 ohms 0-5Vdc — 200K ohms Potentiometer — 200K ohms (1K, 1/4watt pot recommended for optimum linearity, up to 20K permissible) The potentiometer is excited by 5Vdc, supplied by the circuit. Other ranges may be available. Check with factory for special applications **If it is desired to use a current command in both the run and idle command input, the signals must either be common sourcing, or they must be isolated from one another. Contact factory for details.**
OPERATING VOLTAGE:	The standard control transformer has three user selectable voltage taps; 240, 480 & 575 Vac. Other voltages are available: 120, 240 & 480 Vac **or** 120, 277 & 480 Vac **or** 208, 380 & 480 Vac, 50/60 Hertz. Other voltages may be available - consult factory.
SCR RATINGS:	Peak forward and reverse voltage 1400 volts
SCR SURGE CURRENT RATINGS : (peak one cycle non-repetitive I_{TSM} @ 125°C)	Controller Rating — Surge Current Rating 50 & 80 Amp: — 1750 Amps Peak 120 Amp: — 1900 Amps Peak 160 Amp: — 4000 Amps Peak 200 Amp: — 4500 Amps Peak 250 Amp: — 5200 Amps Peak 300 Amp: — 7000 Amps Peak 380 Amp: — 10,000 Amps Peak 425 Amp: — 13,000 Amps Peak 500 Amp: — 10,000 Amps Peak 600 Amp: — 13,000 Amps Peak **750 Amp: — 16,500 Amps Peak**
SCR PROTECTION:	dV/dT rating = 200 volts/microsecond. dV/dT circuit consists of a capacitor in series with a noninductive resistor. This circuit is in parallel with the SCRs. The SCRs are protected from voltage transients by a Metal Oxide Varistor.

SPECIFICATIONS: (Continued)

RUN/IDLE CONTROL:	Output can be selected to be proportional to either the run command or the idle command by remote contacts. See figure 10 on Page 11.
ELECTRICAL CONNECTIONS:	Connectors for line and load are provided for copper wire from 6 ga to 250MCM on controllers rated 50 to 425 Amps. Connectors for line and load are provided for copper wire from 1/0 to 500MCM on controllers rated 500 to 750 Amps.
ELECTRICAL ISOLATION:	Heatsink to supply and load voltage: 2500 Volts Peak. Command signal to supply and load voltage: 1500 Volts Peak.
ZERO AND SPAN:	Potentiometers on the circuit board allow zero and span adjustments of ± 25% of span for run and idle.
CURRENT LIMITING:	A potentiometer on the circuit board allows adjustment of the current limit setting from 20% to 105% of the controller rating. (The current limit potentiometer is factory set for 105% of the rated current unless otherwise specified.)
VOLTAGE METER OUTPUT:	A filtered metering signal equals 5.0 Vdc when the nominal line voltage is applied to the load. Metering load = 5mA max.
CURRENT METER OUTPUT:	A filtered metering signal equals 5.0 Vdc when the frame rating current is applied to the load. Metering load = 5mA max.
GATE DRIVE:	An optical coupled current source of 250mA with a minimum compliance of 10 volts provides the gate drives to the SCRs. Duration or "back porch" is approximately 1.4 milliseconds (60 electrical degrees).
VOLTAGE COMPENSATION:	When using voltage feedback, the load voltage remains constant, independent of supply voltage changes within + 10%, -15%.
POWER DISSIPATION:	1.5 Watts per amp of load current, per phase.
APPROVALS:	The Control Concepts, Inc. model 1029C, rated 120 to 575 Volts, at 50 to 750 Amps, is U.L. listed. U.L. File No. E136219. Call factory for information.

SPECIFICATIONS: (Continued)	
INTERNAL FEEDBACK:	User has choice of: True RMS Voltage, or True RMS Current. Power feedback can be factory installed if desired. Only one type of feedback may be selected.
EXTERNAL FEEDBACK:	An external 0 to 5Vdc or 0 to 50uA signal, (derived from the load,) may be used for external feedback into the controller. See fig. 6 on Page 5 for connections.
LINEARITY:	The controlled variable is linear within 2% of Span with respect to the command signal.
COMMAND INDICATOR:	The intensity of this green LED is proportional to the command signal.
LOAD CURRENT INDICATOR:	The intensity of this green LED is proportional to the load current.
OVER CURRENT TRIP INDICATOR:	This amber LED, when lighted, indicates the over current limit has been exceeded and the Over Current Trip relay has been energized. The SCR's will be prevented from turning on while this circuit is active.
SHORTED SCR INDICATOR:	This red LED, when lighted, indicates a shorted SCR.
O.C.T. & SHORTED SCR RELAY CONTACT RATINGS:	The Over Current Trip, and the Shorted SCR circuits, each control a relay which has form C contacts rated for 5 Amps @ 120Vac. The contacts are available on the command connector.
CONTROL RANGE:	0 to 98% of supply voltage.
ENVIRONMENT:	Operating temperature 0°C to 55°C (32°F to 132°F) Storage temperature: -40°C to 80°C (-40°F to 176°F) Humidity: 0 to 95%, non-condensing
WEIGHT:	50 & 80 Amp controllers 16 pounds 120 & 160 Amp controllers 17 Pounds 200 to 425 Amp controllers 21 Pounds 500 to 750 Amp controllers 40 Pounds
LINE 2 REQUIREMENTS:	The Line 2 connection is used for the internal control transformer which has a rating of approximately 50 VA.

INSTALLATION:

TRANSFORMER TAP:

Place the removable terminal on the transformer tap that corresponds with the supply voltage to be used.

MOUNTING AND LOCATION:

The 50 and 80 amp controller must be mounted on a vertical surface with the fins oriented so that air may flow vertically between them. The preferred orientation of forced air cooled controllers is on a vertical surface with the fan blowing the air up through the heatsink.

COMMAND INPUTS:

The 1029C has two command inputs which are selected by a contact closure. They are designated RUN and IDLE. A potentiometer, a DC voltage or a DC current may be used as a command signal into either input. These connections are made to the command connector as described below.

NOTE:

The controller is shipped from the factory with the run input (terminal 13) as the active input. If it is desired to use the idle input, (terminal 15), the electrical connection between terminals 10 & 11 must be removed. (See figures 8, 9, & 14.)

Run/Idle:

A remote switch can be used, as shown in figure 10 on Page 11, to cause the controller to be controlled by either the run or idle inputs. Connecting terminal 10 (COM) to terminal 11 (RUN/IDLE) on the command connector causes the run signal input to be in control. Opening the connection between terminal 10 and terminal 11 causes the idle signal input to be in control.

COMMAND SIGNAL OPTIONS:

Voltage:

A 0 to 5 Vdc signal may be used as the command signal by connecting the positive signal to terminal 13 (run), or terminal 15 (idle). The negative (common) signal is always connected to terminal 14 (common) (See fig. 9 or 11).

Current:

The positive current connection is to terminal 13 (run) or terminal 15 (idle). The negative or return current connection is to terminal 14 (common). See fig. 9 or 11.

When using a current command in both the run and idle command input, they must either be sourcing, or they must be isolated from one another. Contact factory for details.

Potentiometer:

A 1000 ohm to 20,000 ohm potentiometer, 1/4 watt or more, may be used to adjust the load voltage. (A 1000 ohm potentiometer provides the maximum linearity.) Connect terminal 12 to the clockwise end of the potentiometer, terminal 13 (run) or terminal 15 (idle) to the potentiometer wiper, and terminal 14 (common) to the counterclockwise end of the potentiometer. See fig. 8 or 10.

Consult factory for other options.

POWER & SAFETY CONNECTIONS:

Over Current Trip Relay:

Connections to the form C contacts of the over current relay are shown in Figure 7. The contacts are rated for 5 Amps at 120 Vac and are intended for activating an alarm and/or removing power from the system by operating a contactor or a circuit breaker.

Over Current Trip Reset:

Momentary closure of a switch connected between terminals 9 and 10 on the command connector will reset the over current relay and will release the SCRs from the locked off state. The reset switch can also be used as an on off control. Closure of the switch causes the SCRs to be immediately turned OFF. When the switch is opened, the SCRs begin operation at zero conduction angle and slew at the soft start rate to the desired output.

The Over Current Trip circuit may also be reset by a momentary interruption of supply power.

Shorted SCR Relay:

Connections to the 5 Amp 120 Vac form C contacts are shown in fig. 7. This relay energizes if an SCR fails in the shorted mode and is intended to activate an alarm and/or cause power to be removed from the system by operating a contactor or a circuit breaker.

Power Connections:

Figures 15 & 16 show typical electrical connections. The LINE 1 and LOAD 1 connectors are approved for wire sizes from 6ga to 500 MCM.

TIGHTENING TORQUE FOR LINE AND LOAD TERMINALS:

WIRE SIZE:	TORQUE
6 ga	100 IN-LBS
4 ga	100 "
2 ga	125 "
1 ga	125 "
1/0	150 "
2/0	150 "
3/0	200 "
4/0	200 "
250 MCM	250 "
500 MCM	300 "

FEEDBACK SELECTION:

Connector P2 on the circuit board allows the selection of feedback type. (See Figure 5). True RMS is the default voltage feedback mode. Average voltage feedback mode may be requested when ordering the controller.

Voltage feedback may be selected by placing the jumper across pins P2-4 and P2-7. (VFB)

Current feedback may be selected by placing the jumper across P2-3 and P2-8. (IFB)

Power feedback, if factory installed, may be selected by placing the jumper across P2-5 and P2-6. (PFB)

External feedback may be connected between terminals P1-14 (Common) and P1-18 (FD. BK.) on the command connector (See Figure 6).
A 0-5Vdc signal may be used for external feedback when the jumper is placed across pins P2-2 and P2-9 (EXT).
A 0-100uA signal may be used for external feedback when the jumper is placed across pins P2-1 and P2-10 (SJ).
Average voltage and True RMS voltage are of the feedforward technique.

START-UP:

Determine that the selected transformer tap corresponds to the line voltage.

If the customer wishes to determine that the controller and the command signals are wired and operating correctly before applying power to the load, the following procedure may be followed.

A load capable of drawing at least one amp must be connected for the controller to operate properly.

1. Move the feedback jumper to pins P2-4 & P2-7 to select Voltage FB. (See fig. 5.)

2. Determine that terminals P1-10 & P1-11 are electrically connected. Apply a command signal to the run command signal input.

3. Set the command signal to zero before applying system power. The load voltage should start at zero and increase as the command signal is increased, reaching optimum line output when command signal is maximum.

4. Remove system power from controller. Remove electrical connection from between P1-10 & P1-11. Apply a command signal to the idle command signal input and repeat step 3.

The load voltage and current may be measured with any meter. However, for accurate RMS voltage measurements use a True RMS responding meter. Use an average responding meter for average voltage measurements.

5. When start-up tests have been completed, move the feedback jumper to select the desired operating feedback.

The controller was calibrated at the factory. If adjustments appear necessary, see the zero and span adjustment instructions on page 8.

Care is urged whenever working near high voltages, and it is recommended that installation and service be done by a licensed electrician or experienced technician.

ADJUSTMENTS:

The I Span and V Span pots (and Power Span and Power Zero pots, when factory installed), are sealed at the factory. They are identified with an X in Figure 4.
Under no circumstances should adjustment of these four pots be attempted.
The setting of each of these potentiometers is critical to the proper operation of the controller.

The potentiometers labeled Run Span, Run Zero, Idle Span & Idle Zero have been calibrated at the factory and readjustment should not be necessary.
The zero pots are adjusted to provide zero output when the command signal is at minimum.
The span pots are adjusted to provide full output when the command signal is at maximum.
If it is determined that the adjustment should be changed, the following procedure should be followed.
It is assumed that the load is resistive and can draw at least one or more amps.

RUN ZERO AND RUN SPAN:

Determine that pin P1-11 (Run/Idle) is electrically connected to pin P1-10 (Common).
Make sure that the command signal is connected between the Run input P1-13 (Run/Wiper) and P1-14 (Common).

1. Set the command signal to minimum and adjust the Run zero potentiometer until the output is zero.
2. Set the command signal to maximum and adjust the Run span potentiometer until the output is at the desired maximum value.
3. The span and zero adjustments may interact, making it necessary to repeat steps 1 and 2.

IDLE ZERO AND IDLE SPAN:

Remove the electrical connection from between P1-11 (Run/Idle) and P1-10 (Common).
Make sure that the command signal is connected between the Idle input P1-15 (Idle/Wiper) and P1-14 (Common).
Repeat steps 1,2 and 3 (above) on the idle zero and span potentiometers.

It is important that meters capable of accurately measuring the output of the controller be used.
True RMS meters should be used for accurate measurements of True RMS Voltage, Current or Power (RMS Volts times RMS current into a resistive load).
Average responding meters should be used for measurements of; Average A.C. Voltage, or DC voltage.

CURRENT LIMIT:

(The current limit pot is factory set at 105% of rated current unless specified differently by the (**IL**) term in the model Number.)
Proper calibration of the current limit feature requires a True RMS current meter.

If it becomes desirable to reset the current limit level:

1. Rotate the current limit pot fully counter-clockwise. (This is a multiple turn pot.)
2. Carefully increase the command signal to maximum.
3. Slowly rotate the current limit pot in a clockwise direction until the desired load current is reached.

If it is suspected that the current limit adjustment is causing the output of the controller to be lower than desired, rotate the current limit pot clockwise. If the load voltage increases, the current limit adjustment has been controlling the output.
Follow the steps above to set current limit to the desired level.

OVER CURRENT TRIP:

This potentiometer has been factory set at 150% of rated frame current.
For optimum protection, the customer may wish to reduce the level at which Over Current Trip occurs.

1. Adjust command signal to maximum.
2. Slowly rotate the Over Current Trip pot counterclockwise until the Over current Trip occurs.
3. Rotate the Over Current Trip pot about 1/2 turn clockwise.
4. Reset the Over Current Trip circuit.

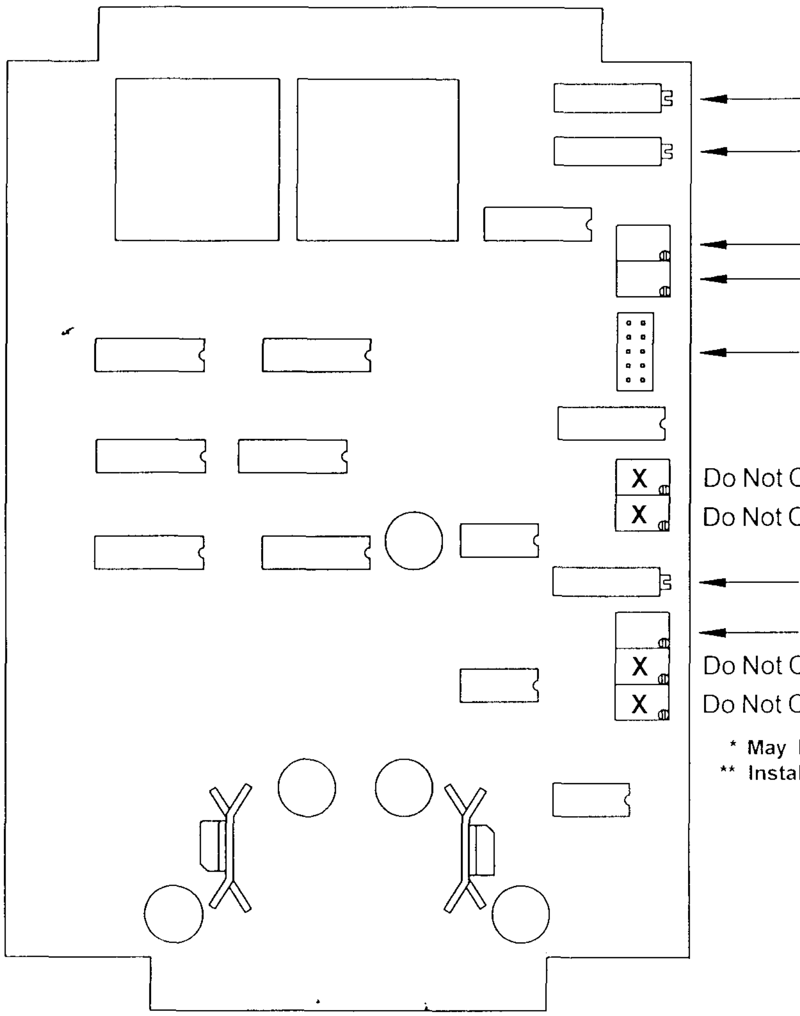


Figure 4. 1029C circuit board showing adjustment locations.

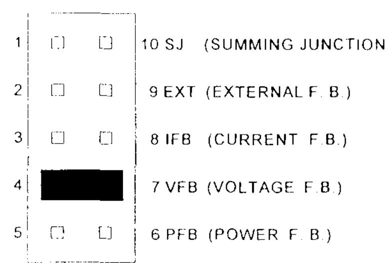


Figure 5. P2 Detail

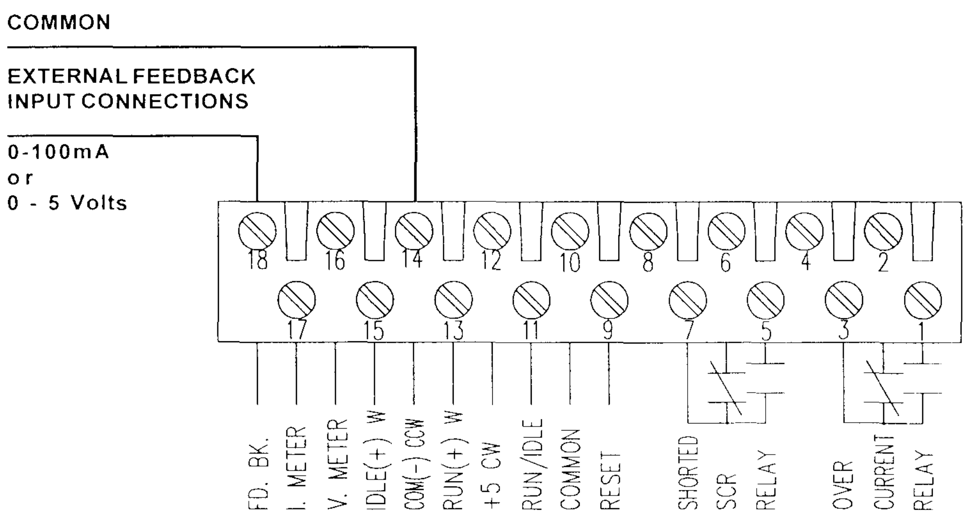


Fig. 6. External feedback connections.

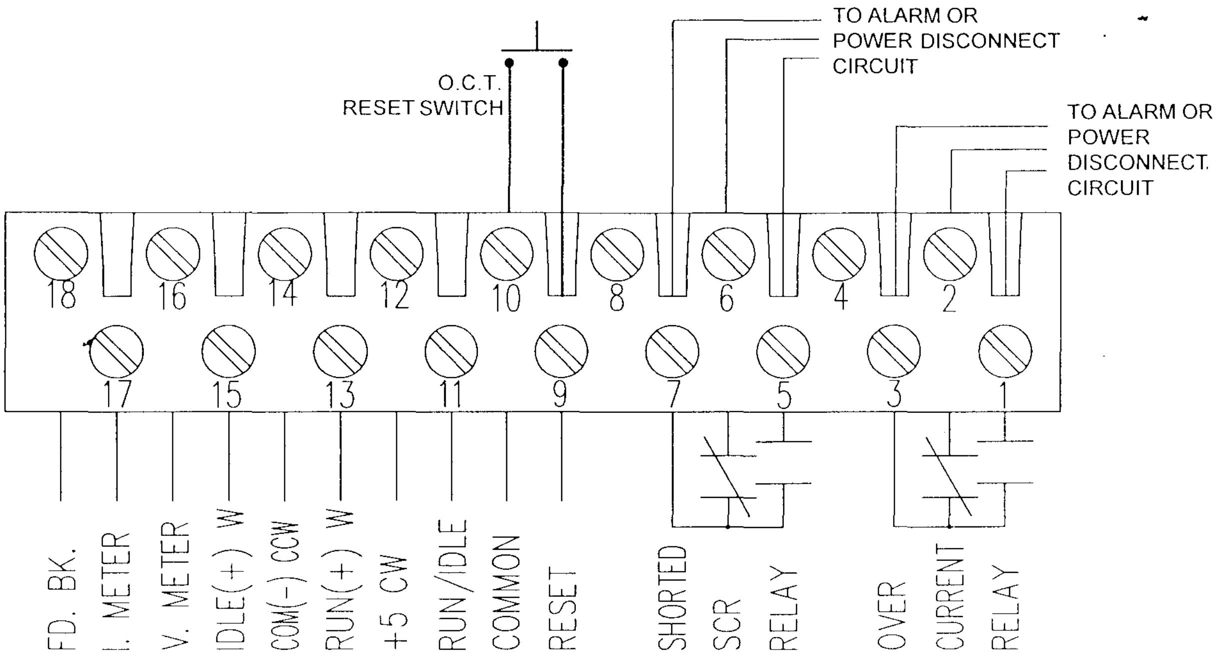


Figure 7. Shorted SCR, Over current relay and reset switch connections.

OVER CURRENT RELAY CONTACTS CHANGE STATE WHEN AN OVERCURRENT CONDITION OCCURS SHORTED SCR RELAY CONTACTS CHANGE STATE WHEN AN SCR FAILS IN THE SHORTED MODE.

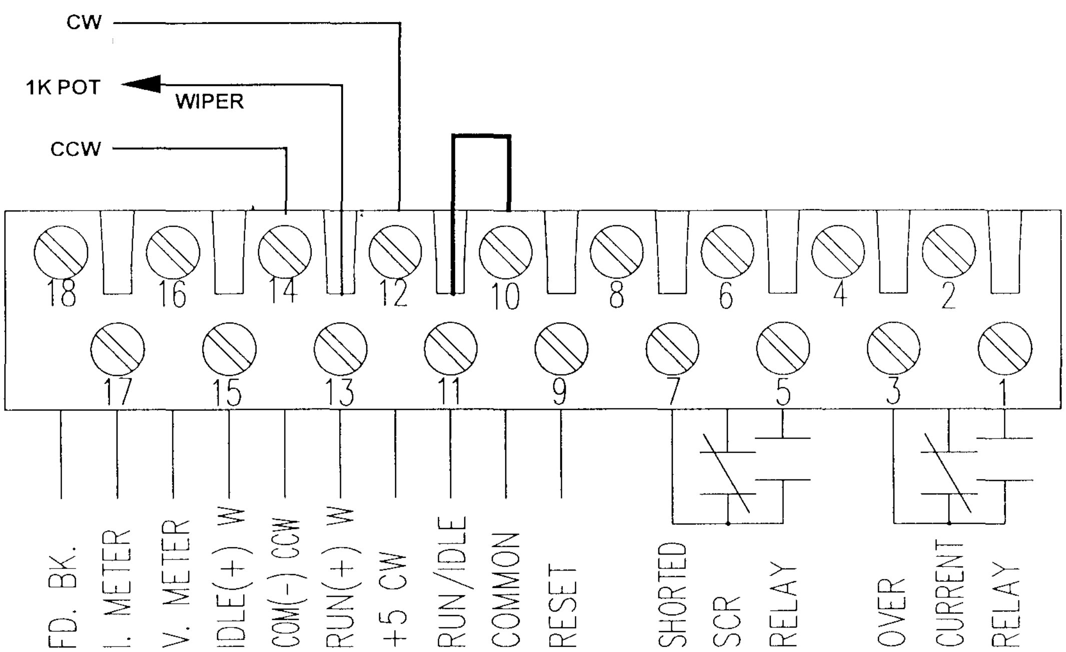


Figure 8. Single potentiometer applied to the run input connections.
(Terminals 10 & 11 must be connected to enable the run input.)

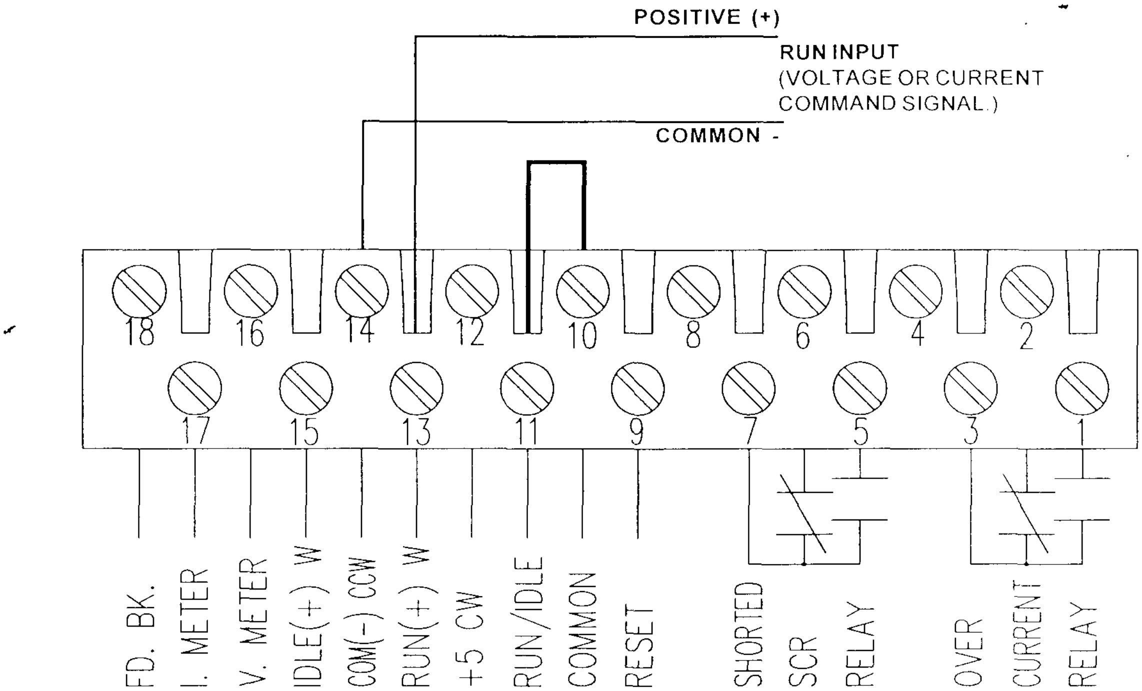


Figure 9. Single voltage or mA current applied to the run input connections.
(Terminals 10 & 11 must be connected to enable the run input.)

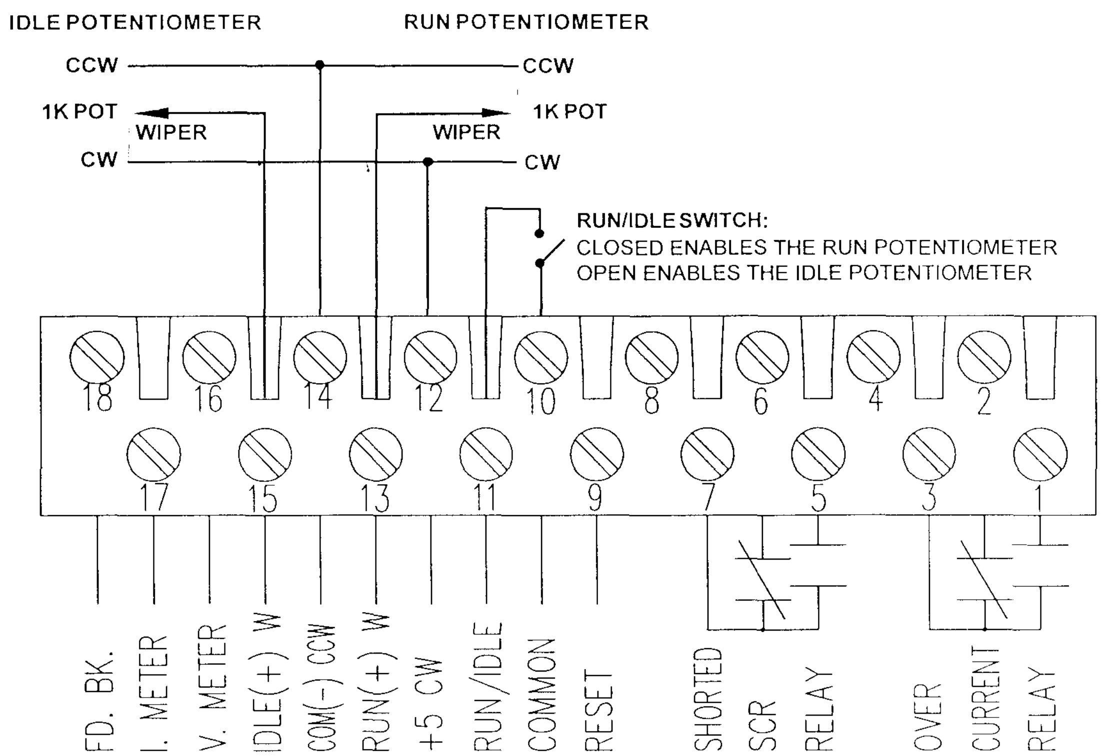


Figure 10. Run and Idle potentiometer connections

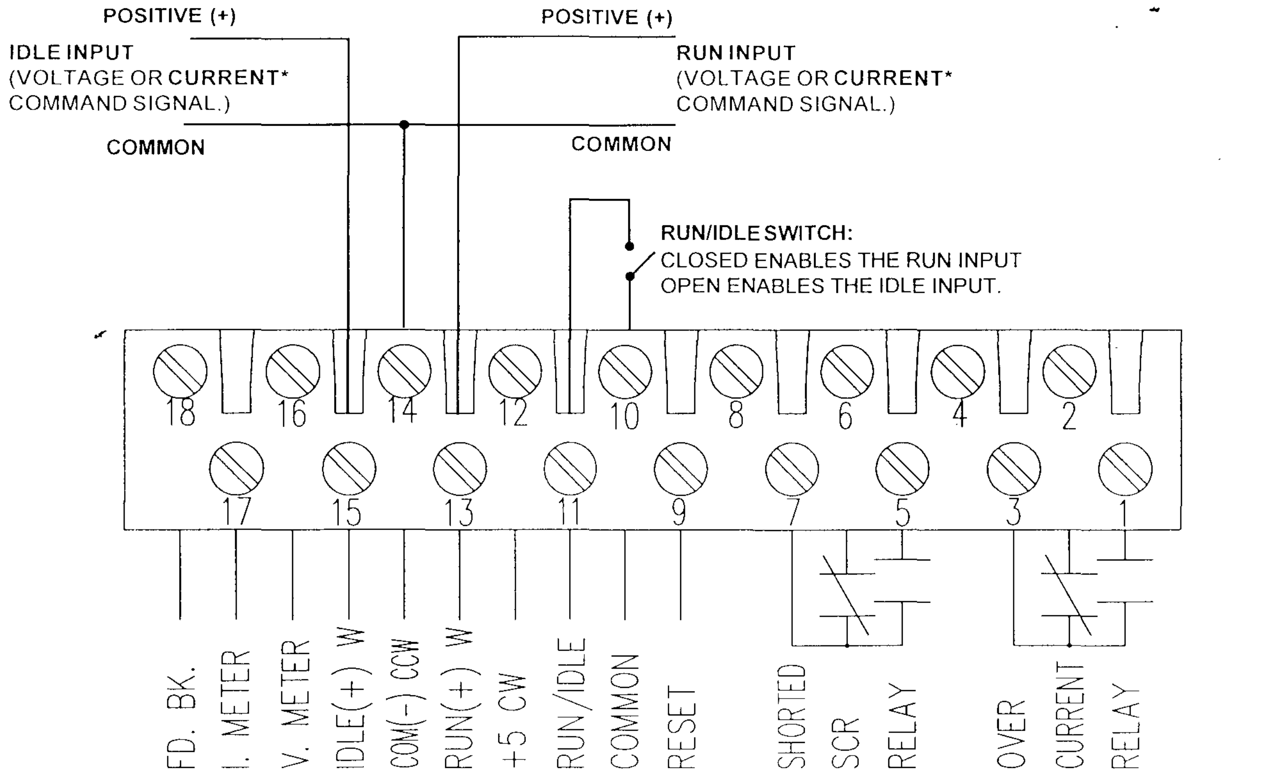


Figure 11. Run and Idle voltage and current connections.

*** If it is desired to use a current command in both the run and idle command input, the signals must either be common sourcing, or they must be isolated from one another. Contact factory for details.**

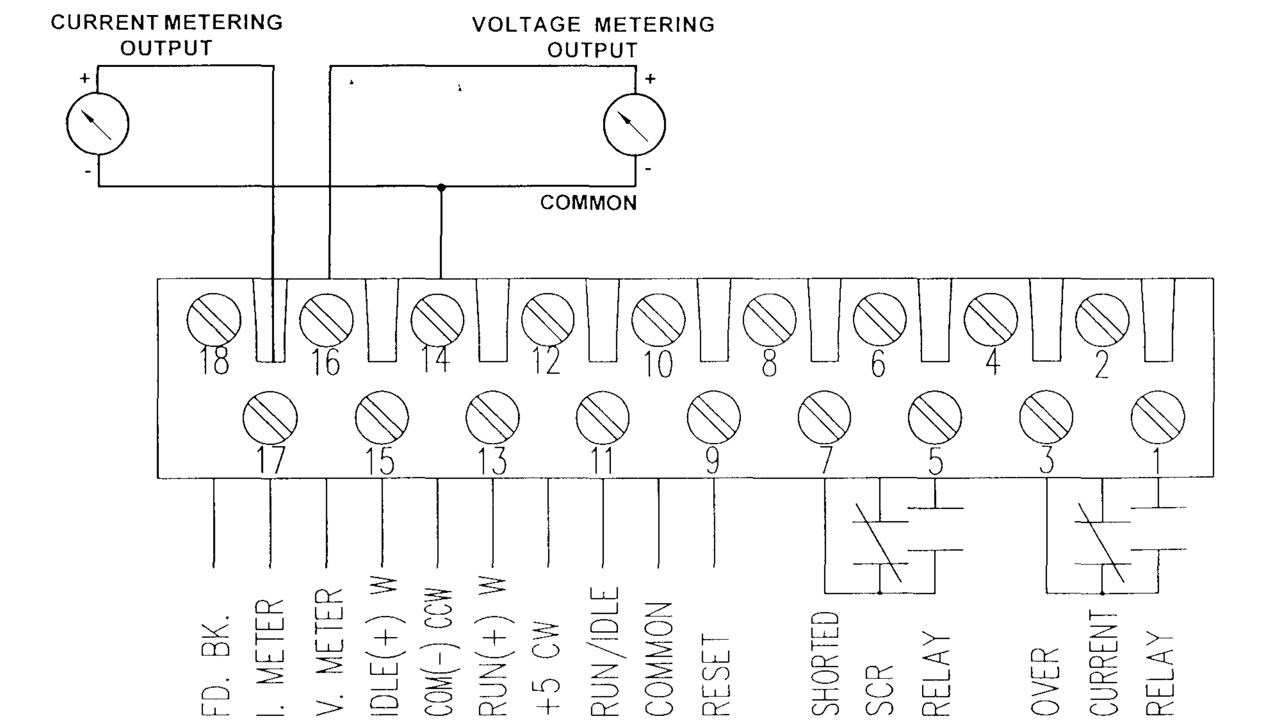


Figure 12. Output metering connections

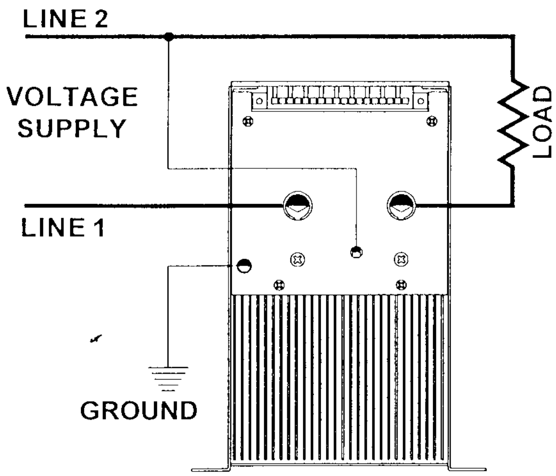


Figure 15. Power connections

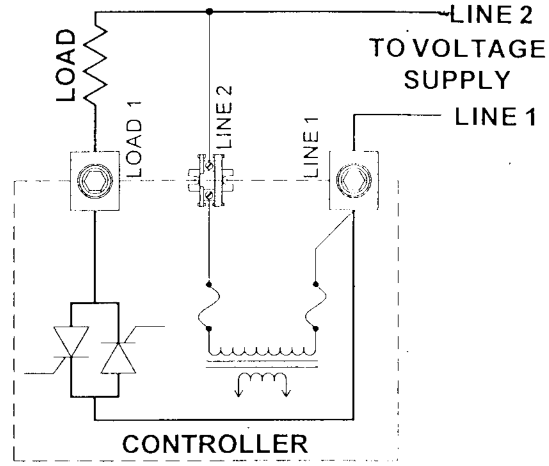


Figure 16. Power path
Note: Fuses and a disconnect are recommended. in the voltage supply lines.

MODEL No IDENTIFICATION:

1029C-(FB)-(VOLTS)V-(AMPS)A-OCT(AMPS)-IL(AMPS)-R(CS)-I(CS)

The characteristics of the 1029C SCR power controller are defined by the terms in the model number as follows:

1029C The model 1029C specifies a single phase, phase-angle SCR firing circuit featuring: current limit, overcurrent trip, shorted SCR detection and electrical isolation of the command signal from the line and load voltages.

-(FB) (A, V, E, I or P[XXXAMPS])

A - Specifies *average voltage* feedback. With *average voltage* feedback, the controller varies the conduction angle (or ON time) of the SCRs such that the average voltage applied to the load is proportional to the command signal.

E - Specifies *external* feedback. The *external* feedback being proportional to some parameter such as speed, current, etc. that is ultimately being controlled by the action of the controller.

I - Specifies *RMS current* feedback. The load *current* is linearly controlled with respect to the command signal.

P(XXXAMPS) - The letter P specifies *power* feedback and therefore the load *power* is linearly controlled with respect to the command signal. XXX equals amp level for control of power.

V - Specifies *RMS voltage* feedback. With *RMS* voltage feedback, the controller varies the conduction angle (or ON time) of the SCRs such that the RMS voltage applied to the load is proportional to the command signal.

MAX LOAD POWER = (VOLTS)V x P(AMPS)

-(VOLTS)V - Specifies the supply voltage the controller has been calibrated to operate at.

Note: unless otherwise specified, the controller is equipped with a transformer that has primary voltage taps at: 240, 480 or 575 volts, 50/60 Hz. Other voltages are available: 120, 208, 277 or 380 Vac.

-(AMPS)A - Specifies the continuous RMS current rating.
50, 80, 120, 160, 200, 250, 300, 380, 425, 500, 600 or 750 Amps.

-IL(AMPS) - Specifies the current limit in Amps.

-OCT-(AMPS) - Specifies the over current trip in Amps.

-R(CS) - Specifies the run command signal. **R**0/5V, **R**4/20mA or **R**POT

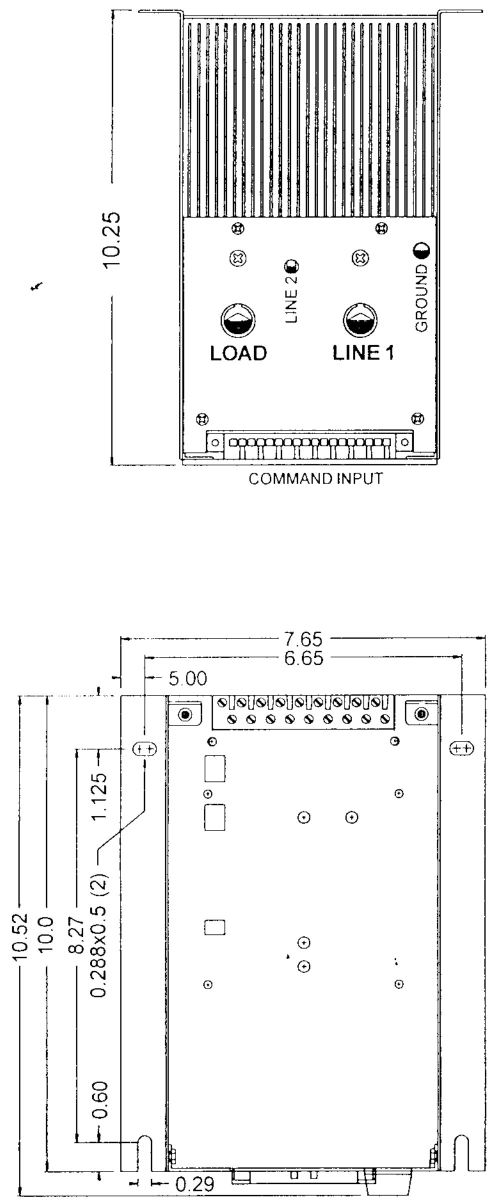
-I(CS) - Specifies the idle command signal. **I**0/5V, **I**4/20mA or **I**POT.

Contact factory for special applications.

Example:

1029C-A-480V-80A-IL75-R0/5V-IPOT

Will order a 1029C controller with average voltage feedback, rated @ 480 Volts, 80 Amps, current limit set at 75 Amps, run command signal of 0 to 5Vdc and a potentiometer on the idle command input.



NOTE: THE 50 and 80 AMP UNITS ARE NOT FAN COOLED. THEY MUST BE MOUNTED ON A VERTICAL SURFACE WITH THE FINS ORIENTED VERTICALLY SO THAT AIR MAY FLOW FREELY BETWEEN THE FINS.

Fig. 17. - Installation drawing
50, 80, 120 & 160 Amp

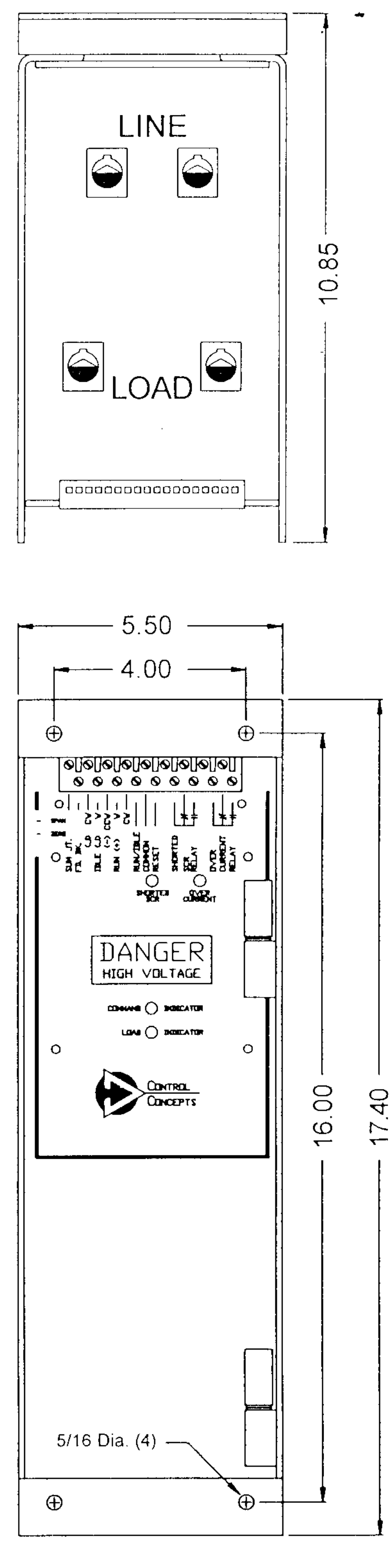


Fig. 18. - Installation drawing
200, 250, 300, 380 & 425 Amp

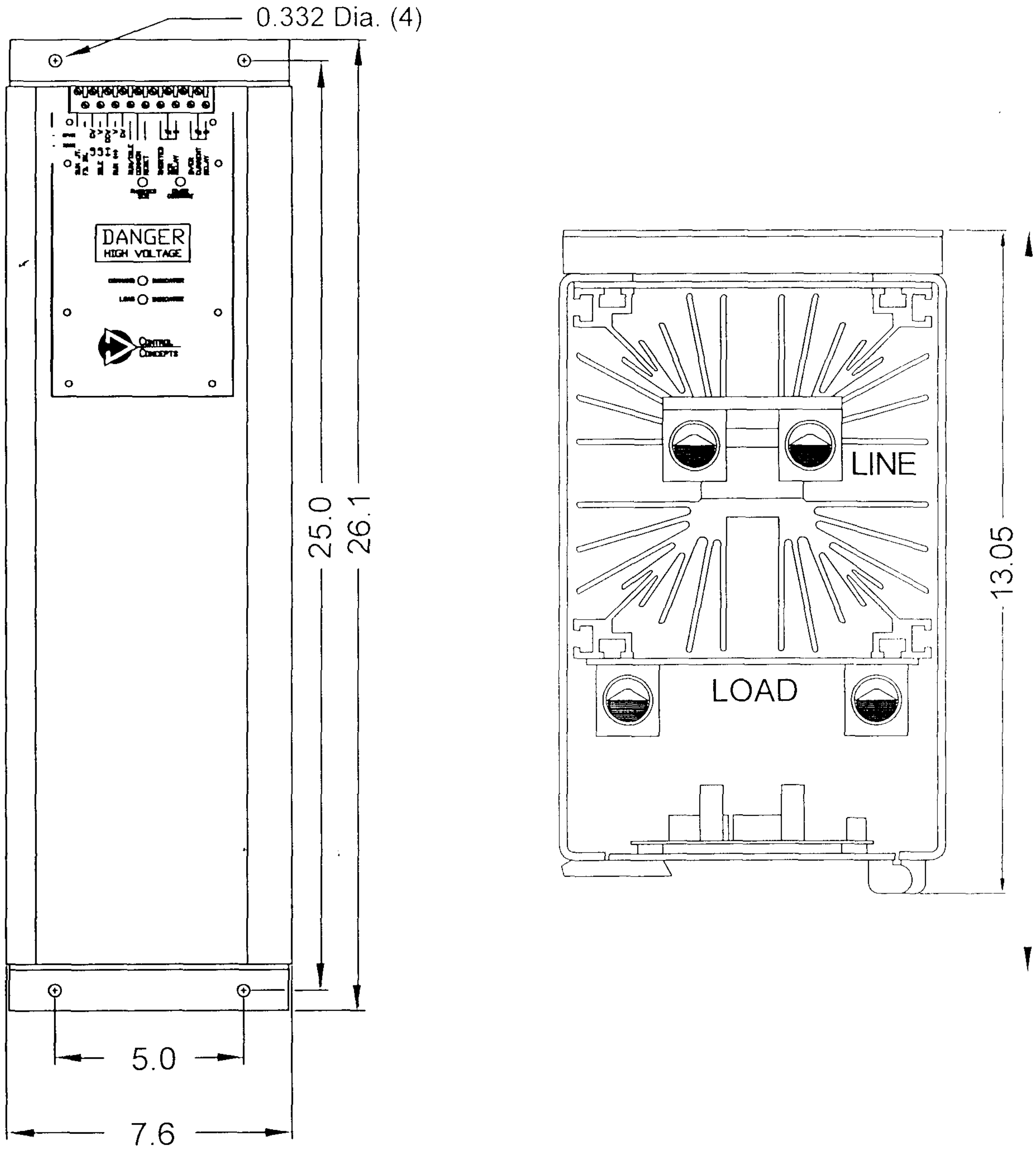


Fig. 19. - Installation drawing
500, 600 AND 750 Amp Controllers

TROUBLE SHOOTING:

CAUTION: HIGH VOLTAGES ARE PRESENT ON THIS CONTROLLER AND ON PORTIONS OF THE PRINTED CIRCUIT BOARD. USE EXTREME CARE TO AVOID ELECTRICAL SHOCK.

Notes: The indicator LED's provide a convenient method of determining the general location of controller problems.

The LOAD LED lites when 10% or more of rated load current is present. LOAD LED intensity should increase as the command signal is increased.

The COMMAND LED indicates the operation of a large part of the circuitry. The intensity of the command indicator should be proportional to the command signal.

The OCT LED is a fault indicator to warn that an Over Current Trip has occurred.

The Shorted SCR LED is a fault indicator to warn that one or more SCR's may be shorted.

NO LOAD VOLTAGE:

Determine that the command light varies with the command signal.

If the command light does not vary.

Determine that the following conditions exist:
(Measure voltages at screw terminals to ensure good electrical connections.)

- Determine if over current trip **LED** is **ON**.
- Voltage between COM (Pin 14) and +5CW (Pin 12) is 5 Volts ±1. If not; Circuit is not receiving power or command connections are shorting out supply.
  Determine that line voltage exists between Line 1 and Line 2.
  Determine that fuses on controller are OK.
  Remove connections to CW (terminal 12).
- Voltage or potentiometer inputs.
  Determine that voltage from COM (pin 14) to IDLE (W) or RUN (W) changes from 0 to 5 Vdc as command is changed from zero to 100%.
- 4/20 mA inputs:
  Determine that voltage from COM (pin 14) to IDLE (W) or RUN (W) changes from 1.2 to 6 Vdc as command is changed from 4 to 20 mA.
- Determine that there is no connection between terminals 9 & 10.

If command light can be varied:

- Determine that the load fuses are OK and that the load has continuity. Load continuity (including load fuses can be confirmed by determining that the supply voltage exists between terminals Line 1 and Load 1 when the command signal is zero.

LOAD VOLTAGE WILL NOT GO TO ZERO:

If RMS value of the load voltage is greater than 10 percent of the supply voltage.

- Determine Shorted SCR LED status while varying the command signal.
- With power removed and the load disconnected from terminal Load 1 the resistance between terminals Line 1 and Load 1 should be greater than 1000 ohms.
- If the resistance between Line 1 and Load 1 is less than 1000 ohms the SCR module has failed.
- If the shorted SCR led is ON & the resistance between Load 1 and Line 1 is greater than 1000 ohms, the failure is likely associated with the circuit board. Determine by removing the circuit board and applying power.
- Determine that the supply to line 2 and the load are connected to the same supply.

If the RMS value of the load voltage is less than 10 percent of the supply voltage.

- Determine that the command signal is correct.

Adjust the zero and span potentiometers to achieve the desired output.
(Note: The Zero and span potentiometers are factory set. Adjustment should be made with caution.

FULL VOLTAGE CANNOT BE OBTAINED:

- Determine that the control signal is at maximum
- Determine that the controller is not in current limit. Decrease the current limit by rotating the current limit potentiometer counterclocklwise, the controller is in current limit if the load voltage decreases.
- The DC voltage from terminals Line 1 to Load 1 should be less than 1 volt. If the voltage is greater than 1 volt, either the circuit card or the SCR module has failed.
- If the problem occurs on initial start up, determine that line 2 and the load are connected to the same supply.

CONTROL CONCEPTS
7870 PARK DRIVE
CHANHASSEN, MN 55317
(952)-474-6200
1-800-765-2799
FAX (952) 474-6070

SPARE / REPLACEMENT PARTS:

TO ORDER A SPARE FIRING CIRCUIT: 1029C - (FB) - IL() - R(**CS**) - I(**CS**) - FC - FR(XX)

1029C: The model number of the controller

(FB) The type of feedback used
- A = Average voltage feedback
- V = True RMS voltage feedback
- E = External feedback
- P = Power feedback (optional)

IL ( ) The current limit in Amps

R(cs) The run command signal

I (cs) The idle command signal
(cs = 4/20mA, 0-5V, 0-10V or POT)

FC Firing circuit

FR(xx) The current rating of the frame
(xx) = 50, 80, 120,160, 200, 250, 300, 380, 425, 500, 600 or 750 Amps

1029C - V - IL100 - R4/20mA - IPot - FC - FR120
Would be the correct number to order a firing circuit with True RMS voltage feedback, calibrated for 100A limit with a 4/20mA run signal and a potentiometer idle signal, to be used on a 120 amp frame.

TO ORDER A SPARE SCR MODULE:

CONTROLLER CURRENT RATING:	ORDER CONTROL CONCEPTS PART No.
50 Amps	28325-0395-514
80 "	28325-0395-514
120 "	28325-0410-514
160 "	28345-0413-514
200 "	28000-0424-514
250 "	28000-0434-514
300 "	28000-0449-514
380 "	28011-0460-514
425 "	28011-0476-514
500 "	28011-0460-514
600 "	28011-0476-514
750 "	28013-0514-514

REFERENCE DWG:

CCI No. D1000589B - Schematic

IT IS RECOMMENDED THAT THE CONTROLLER AND THE LOAD BE PROTECTED BY 600 VOLT SEMICONDUCTOR FUSES:

CONTROLLER CURRENT RATING:	RECOMMENDED BUSS CLASS T FUSE TYPE JJS	CCI PART NUMBER:
50 Amps	60 Amps	42110-0460-360
80 "	100 "	42110-0460-410
120 "	150 "	42110-0460-415
160 "	200 "	42110-0460-420
200 "	250 "	42110-0460-425
250 "	300 "	42110-0460-430
300 "	350 "	42110-0460-435
380 "	450 "	42110-0460-445
425 "	500 "	42110-0460-450
500 "	600 "	42110-0460-460
600 "	700 "	42110-0460-470
750 "	800 "	42110-0460-480

The control transformer is protected by two fast acting class CC fuses

50 & 80 AMPS	BUSS FNQ-R-1/4	42130-0460-125
120 AMPS & UP	BUSS FNQ-R-1/2	42130-0460-150A
500-750 A FU1	BUSS FNQ-R-1	42130-0460-210

CONTROL CONCEPTS INC.

INSTRUCTION MANUAL
MODELS 1822 & 1825

CONTROL CONCEPTS

7870 PARK DRIVE
CHANHASSEN, MN 55317
(612)-474-6200
1-800-765-2799
FAX (612) 474-6070

CONTROL CONCEPTS, INC. 2 YEAR Limited Warranty

CONTROL CONCEPTS, INC. warrants that the products delivered will be as described in the sales order or contract.

CONTROL CONCEPTS, INC. warrants to the original user that CONTROL CONCEPTS, INC. products will be free from defects in materials and workmanship for a period of two (2) years after the date CONTROL CONCEPTS, INC. ships such products.

If any CONTROL CONCEPTS, INC. product is found to be defective in material or workmanship during the applicable warranty period, CONTROL CONCEPTS, INC.'s entire liability, and the purchasers sole and exclusive remedy, shall be the repair or replacement of the defective product at CONTROL CONCEPTS, INC.'s election. CONTROL CONCEPTS, INC. shall not be liable for any costs or expenses, whether direct or indirect, associated with the installation, removal or re-installation of any defective product. All shipping and freight costs are the responsibility of the customer. CONTROL CONCEPTS, INC.'s limited warranty shall not be effective or actionable unless there is compliance with all installation and operating instructions furnished by CONTROL CONCEPTS, INC., or if the products have been modified or altered without the written consent of CONTROL CONCEPTS, INC., or if such products have been subject to accident, misuse, mishandling, tampering, negligence or improper maintenance. Any warranty claim must be submitted to CONTROL CONCEPTS, INC. in writing within the stated warranty period.

CONTROL CONCEPTS, INC.'s limited warranty is made in lieu of, and CONTROL CONCEPTS, INC. disclaims all other warranties, whether expressed or implied, including but not limited to any IMPLIED WARRANTY OF MERCHANTABILITY, ANY IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, any implied warranty arising out of a course of dealing or of performance, custom or usage of trade.

CONTROL CONCEPTS, INC. SHALL NOT, UNDER ANY CIRCUMSTANCES BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, LOSS OF PROFITS, REVENUE OR BUSINESS) OR DAMAGE OR INJURY TO PERSONS OR PROPERTY IN ANY WAY RELATED TO THE MANUFACTURE OR THE USE OF ITS PRODUCTS. The exclusion applies regardless of whether such damages are sought based on breach of warranty, breach of contract, negligence, strict liability in tort, or any other legal theory, even if CONTROL CONCEPTS, INC. has notice of the possibility of such damages.

By purchasing CONTROL CONCEPTS, INC.'s products, the purchaser agrees to the terms and conditions of this limited warranty.

WARNING: The Control Concepts, Inc. power controllers use power thyristors to switch voltage to the connected load. Line voltage must be assumed at the output terminals at all times, even when the control signal has been removed and the load voltage appears to be off. It has been mandated by the National Electrical Code and the Occupational Safety and Health Act of 1970 that a physical disconnect be opened ahead of all remotely actuated controls before performing any maintenance work on the controller or its connected load.

CONTROL CONCEPTS, INC.
7870 PARK DRIVE
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FAX: (612) 474-6070
TOLL FREE: (800) 765-2799

DESCRIPTION:

The models 1822 and 1825 are single phase DC power controllers. The 1822 controller responds to command signals of 0-5Vdc, 0-10Vdc or a potentiometer signal. The model 1825 controller responds to a 4-20mA current command signal.

Both models control the average DC voltage to the load proportional to the command signal.

Features:

Soft start & missing cycle detection.

Both controllers include soft-start and missing cycle detection. If a line voltage interruption of one half cycle or more occurs, this feature will set the output to zero, then ramp the DC output back to the desired voltage. This process takes about 3 to 5 seconds. In-rush currents that can occur in loads with low cold resistance are reduced.

Isolation

The command signal is electrically isolated from the line and load voltages and all signals and voltages are electrically isolated from the heat sink.

MODEL No. IDENTIFICATION:

MODEL NUMBER:1822-[v-a]-[V]-[fb]-[cs]-SC[xxx]
1825-[v-a]-[V]-[fb]-[cs]-SC[xxx]

1822 (0-5Vdc, 0-10Vdc or potentiometer control)
1825 (4-20mA input)

[v-a] = Input voltage & output current rating:
- **12-10** = 120 Vac & 10 Amps DC.
- **12-20** = 120 Vac & 20 Amps DC.
- **24-10** = 240 Vac & 10 Amps DC.
- **24-20** = 240 Vac & 20 Amps DC

[V] = Output voltage
- **95VDC** = 95 Volts D.C. output rating
- **190VDC** = 190 Volts D.C. output rating

[fb] = feedback
- **AVG** = average feedback
- **FAVG** = fast average feedback
- **RMS** = True RMS voltage feedback

[cs] = command signal
- 1822, could be 0-5, 0-10 or pot
- 1825, could be 4/20mA

-SC[xxx] = optional.
The addition of "**-SCxxx**" specifies that the controller has been modified to have a different input command. For example, "**-SC1/5Vdc**" means the controller will operate with a 1 to 5 Volt DC control signal.

For example **1825 - 24-10 - 190VDC - FAVG** specifies a phase-angle controlled DC power source requiring 240 Volts AC input, controls 190 Volts DC@ 10 Amps to the load and has a fast average response.

THEORY OF OPERATION:

The model 1822 and 1825 are phase-angle controllers with full wave bridges to provide a DC output. The load voltage is controlled by turning the appropriate SCR on for a portion of each electrical half cycle of the line voltage as shown in figure 1.

The waveform shown as E_S represents the Source voltage.

The waveform shown as E_C represents the "ON" time of the SCRs in each half cycle and therefore represents the voltage waveform applied to the bridge rectifier.

The waveform shown as E_L represents the rectified voltage which is applied to the load.

To increase the load voltage, the SCRs are turned ON earlier in the cycle. To decrease the load voltage, the SCRs are turned on later in the cycle. The DC load voltage can be varied from 0 to full output.

Output voltages are limited to 95 Volts DC max. for a 120 Volt AC line and 190 Volts DC max. for a 240 Volt AC line.

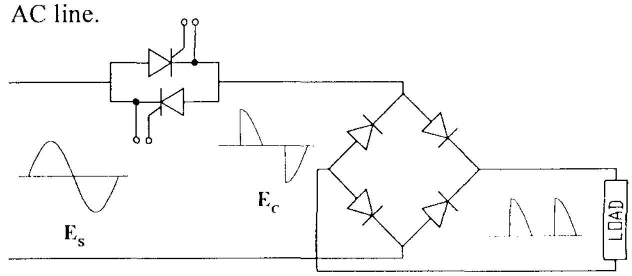


Figure 1. Phase angle control at 50% power

INSTALLATION:

The controller must be mounted on a vertical surface such that the heat radiating fins on the heatsink are vertical and located in an environment that will not exceed 135°F and that is protected from dirt and dust.

The wiring must be per local electrical codes. The supply and load terminals will accept # 14 to # 2 wire.

TORQUE TABLE

WIRE SIZE	INCH-LBS
12 TO 8	20
6 TO 4	35
2	50

The terminals for the control signals will accept # 30 to # 14 wire.

NOTE: It is recommended that the controller and the load be protected with fast acting class "T" fuses such as Bussmann type JJN.

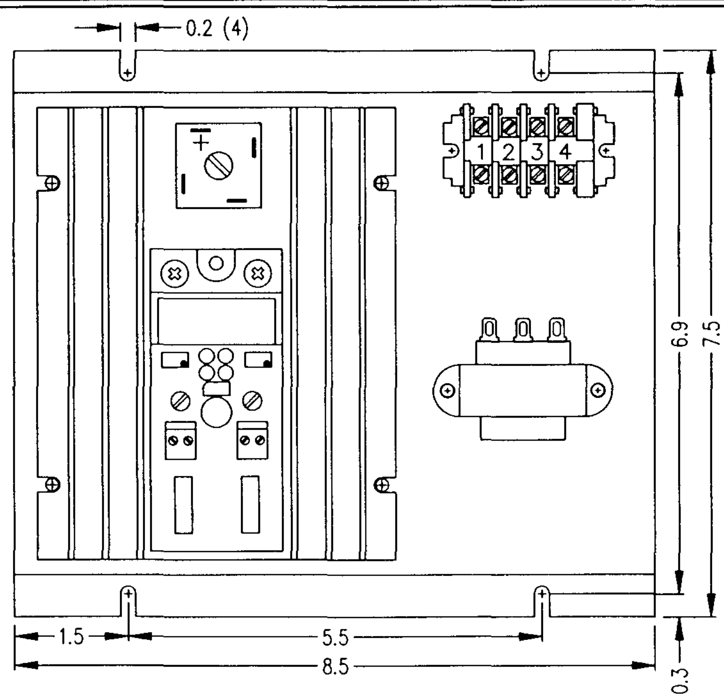
Control Concepts stocks a complete line of fuses and fuseholders for your convenience.

Fuse	CCI Stock No.
15 Amp, 300 Volt fuse	42110-0430-315
25 Amp, 300 Volt fuse	42110-0430-325
2 pole Fuse holder	
30A max, 300 Volts	43112-0430-330

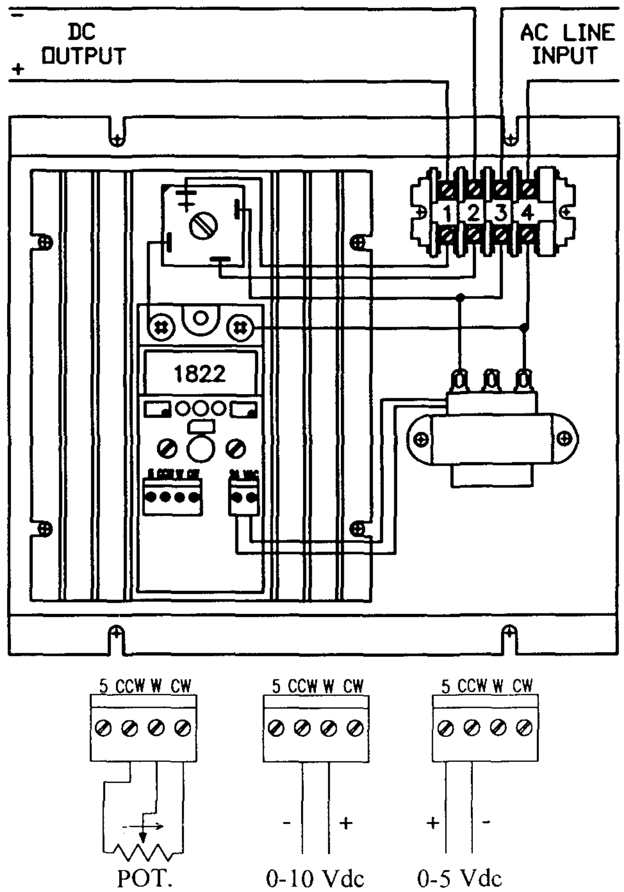
SPECIFICATIONS:

Control Mode	Single-phase; Phase-angle, with a rectifier to apply DC voltage to the load.
Command Signal	Model / Signal / Input impedance 1822: 0-5Vdc 100K Ω 0-10VDC & Pot 200K Ω 1825: 4-20mA; 200 Ω
Control Range	0 to 95 Volts DC or 0 to 190 Volts DC
Linearity	Average DC load voltage is linear within 2% of span of the command signal.
Zero and Span Adjustment	Adjustable over range of ±20% of span
Isolation	Dielectric strength input/line & load voltage/heatsink 2500V(RMS) Insulation resistance input/line & load voltage/heatsink 10^{10} ohms. Maximum capacitance input to output 8pf.
Cooling	Convection
Mounting	Must be mounted on vertical surface with fins vertical. Units may be mounted adjacent to each other. Heat sink is electrically isolated.
Line voltage	120 or 240 Vac +10%,-15% 50/60 Hertz
Diagnostic Indicator	The intensity of an LED varies as a function of the command signal. Feature provides a quick and safe means to check controller operation.
Physical	Weight: approximately 4 lbs Dimensions: Refer to installation drawing below
Environment	Operating: 0 to 55°C (32 to 131°F) Storage: -40 to 80°C (-40 to 176°F) Humidity: 0 to 95% Non-condensing
dv/dt & Transient Voltage	200 volts/usec minimum A dv/dt snubber and a metal oxide varistor (MOV) are provided to protect against high frequency transients (dv/dt) and voltage spikes.
Dissipation	1.5 watt per amp of controlled current

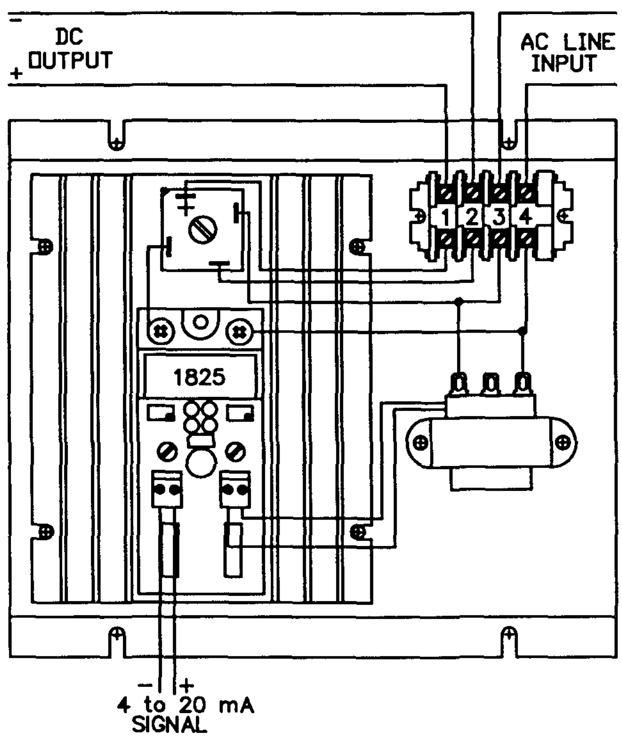
INSTALLATION DIMENSIONS:



MODEL 1822 ELECTRICAL CONNECTIONS:



MODEL 1825 CONNECTIONS:



TROUBLE SHOOTING:

CAUTION: High voltage exists on the supply and load terminals of this controller and may exist on other equipment located near the controller. Use extreme caution to avoid electrical shock.

The LED located on the controller circuit can be used to aid in determining problems. This LED varies in intensity proportional to the command signal and therefore should be proportional to the load voltage.

THE FOLLOWING ARE SYMPTOMS AND POSSIBLE CAUSES:

NO LOAD POWER: LED not ON:

Determine that the command signal wires are applied to the correct terminals on the command connector and that the command signal is not at minimum. Determine that 24 volts AC is applied to the circuit. Circuit card may have failed.

NO LOAD POWER: LED intensity can be varied:

Determine that line voltage is present. Set command signal to maximum, if the voltage across the SCR module is equal to the line voltage, the SCR module has probably failed.

LOAD POWER IS MAXIMUM AND CANNOT BE REDUCED: LED is ON:

Determine that the command signal is at zero. An easy way to do this is to remove either of the green connectors from the circuit board. If the LED remains on, the circuit board may have failed.

LOAD POWER IS MAXIMUM AND CANNOT BE REDUCED: LED is OFF:

The SCR module has probably failed as a short allowing full power at be applied to the load.

To confirm a shorted SCR module, remove the circuit board and measure the voltage across the line and load terminals on the SCR module. If the voltage is less than 2 Volts the SCR module has failed.

NOTE: If a replacement SCR module is ordered, specify the voltage and current rating of the controller and the serial number of the failed unit as well as the number on the SCR module. (see spare parts section of this manual)

CONTROLLER BLOWS FUSES WHEN COMMAND SIGNAL IS INCREASED.

Determine if the bridge rectifier has failed. **Remove power from controller**. Disconnect all the wires that go to the bridge. Use an ohmmeter to measure the resistance across the AC input of the bridge rectifier. Observe the reading, then reverse the leads. If the resistance is less than 100K ohms either way, the bridge has failed.

ZERO AND SPAN ADJUSTMENTS:

The zero and span adjustments have been factory calibrated. Further adjustment of these settings should not be necessary. If it is desired to readjust the zero and span settings, the following procedure should be followed.

1 Adjust the zero potentiometer with the minimum command signal applied, so that the load voltage is just zero.

2. Adjust the span potentiometer with the maximum command signal applied so that load voltage equals the rated voltage of the controller (95 or 190 Volts DC).

It may be necessary to repeat these steps due to interaction between the zero and span pots.

(Clockwise rotation of both the span and zero potentiometer increase the load voltage.)

These controllers have line voltage compensation. If the supply voltage goes above the nominal rating, the controller will supply the calibrated voltage to the load. For example, a controller is rated for 240Vac line input with 190Vdc output: The line goes to 260Vac when a maximum command signal is applied; the controller will supply no more than 190 Volts DC to the load. This feature reduces the effects of line voltage changes.

SUGGESTED SPARE PARTS:

CONTROLLER	REPLACEMENT
MODEL NUMBER	SCR MODULES:
1822-12-10 or 1825-12-10	1612-12-10-T
1822-12-20 or 1825-12-20	1612-12-20-T
1822-24-10 or 1825-24-10	1612-24-10-T
1822-24-20 or 1825-24-20	1612-24-20-T
	BRIDGE RECTIFIER
ALL MODELS	20050-0325-460

NOTE: If replacement parts are ordered, specify the voltage, current rating and serial number of the controller as well as the numbers for the parts.

REFERENCE DRAWINGS:

Model 1822: Schematic	B1000466
Model 1825: Schematic	B1000324

MANUFACTURED BY:

CONTROL CONCEPTS

ANGSTROM SCIENCES
ONYX-3513I™
MAGNETRON SPUTTERING CATHODE

PROCEDURES OF OPERATION

Effective Date: January, 2001

Angstrom Sciences
40 South Linden Street
Duquesne, PA 15110
(412) 469-8466
(412) 469-8511
www.angstromsciences.com

ATTENTION

Do not disassemble magnetron.

This will void all warranties.

Special procedures and/or tools are required to assemble and disassemble.

ANGSTROM SCIENCES is not responsible for misuse by customers.

Please consult ANGSTROM SCIENCES for any technical questions.

PRODUCT WARRANTY

Cooling Water Connection:

CAUTION: If the source is mounted in a sputter down configuration, then proceed to operation specifications. However, if the source is mounted in any other configuration (ie. side sputter or sputter up), the cathode will have to be purged of any trapped air inside the cathode body. To do this, first, place the source in a sputter down orientation and fill with water until all air is removed from the source. Any trapped air can be further removed by tilting the source from side to side. Next, proper fittings should be connected to ensure that source can be installed without air entering the cathode. If this procedure is not followed the source may run at high temperature and damage may occur to the source and/or target material. Failure to follow this procedure will void any or all warranties stated or implied.

Manufacturer's Declaration:

The manufacturer warrants that the accuracy of the data listed in this manual for the ONYX-3513I™ is within the tolerances given. The manufacturer reserves the right to alter other data of the equipment. The customer will be informed about occasional alterations as may be appropriate. Any alteration by customer of the ONYX-3513I™ may only be performed if the main parameters of the equipment will be kept or improved.

Warranted Data:

The following data are warranted:

-identification of the equipment and its manufacturer;
-main and characteristic dimensions and weights of the equipment;
-main and technical parameters of the equipment;
-characteristic dimensions, features and quantity of accessories;
-optional accessories according to delivery contract.

Statement of Warranty:

Angstrom Sciences warrants that all equipment manufactured by it shall be free from defects in materials and workmanship under normal use and service for a period of twenty-four (24) months from the date of shipment from the Angstrom Sciences production facility. This warranty is subject to the Angstrom Sciences equipment being installed, maintained and operated in accordance with the operating and maintenance instructions accompanying each item manufactured by Angstrom Sciences. Warranty shall be void if the Angstrom Sciences equipment is modified by customer or used in other than recommended manner or applications. Purchased equipment incorporated into any item supplied by Angstrom Sciences will be covered by manufacturer's warranty.

The liability of Angstrom Sciences for any claims of customer arising out of damages alleged to result from the use or failure of equipment manufactured by Angstrom Sciences shall be limited to the original invoice cost as adjusted by generally accepted accounting practices for useful life expectancy.

OPERATION SPECIFICATIONS ONYX-3513I™

Maximum Sputtering Power	11 Kilowatts DC 3.5 Kilowatts RF
Cathode Voltage	100 to 1500 Volts
Discharge Current	0.1 to 18 Amps
Operating Pressure	1 to 50 milliTorr
Cooling Requirements	
Flow Rate	3 Gallons per Minute At Maximum Power
Maximum Input Temperature	20°C
Input Pressure (open drain)	60 psi
Target	
Form	Planar
Length	13" (± 0.005")
Width	3.5" (± 0.005")
Thickness	0.250"
Cooling	Direct/Indirect
Magnetic Enhancement	Permanent (NdFeB) Encapsulated
Source Dimensions	
Outside Width	6.0"
Length	15.5"
Height	3"
Weight	55 Pounds
Mounting	(2) 1.25" Dia Tubes
Maximum Temperature	100°C
Source-to-Substrate Distance	2 - 12"
Uniformity	±5% across center of target area with a 4" source-to-substrate distance
Construction	
Cathode Body	OFHC Copper
Anode	304 SS
Insulator	Teflon (PTFE)

INSTALLATION PROCEDURE

The ONYX-3513I™ is supplied with an external flange that can be mounted in any vacuum system. All utilities are maintained at atmosphere and are accessed from the rear of the cathode assembly. All ONYX-3513I™ cathodes are supplied with utilities (water and electric) properly fitted to the cathode which allow the customer to access these without disassembly of the source.

The ONYX-3513I™ is supplied with 0.500" OD water lines (water in/water out). In order to function properly, the ONYX-3513I™ requires a water flow rate of two gallons per minute of 30°C water with an open drain (input pressure should be 60 psi). Proper flow and water temperature must be maintained to allow effective use of the ONYX-3513I™; and any deviation can constitute a loss of product warranty. All ONYX-3513I™ cathodes should be fitted with a water flow inter-lock switch in the exit line which is wired to prevent operation of the power supply in the event that water flow falls below the minimum operation specifications. Operation of the ONYX-3513I™ sputtering source without proper water flow will damage the magnet array and the target and void the product warranty.

The ONYX-3513I™ operates with either Direct Current (DC) or Radio Frequency (RF) power supplies. Maximum power levels for the ONYX-3513I™:

Direct Current————	11 Kilowatts
Radio Frequency————	3.5 Kilowatts

The ONYX-3513I™ is supplied standard with a power coupling which is fastened to the cathode body. A sufficient ground line should be attached to the cathode mounting plate. Please consult Angstrom Sciences if any questions arise. The anode is maintained at ground potential. BECAUSE THE ONYX-3513I™ IS A HIGH VOLTAGE DEVICE, EXTREME CARE MUST ALWAYS BE TAKEN DURING OPERATION. To protect the operator, safety interlocks should be added to the vacuum system prior to powering of the ONYX-3513I™. These interlocks should include and not be limited to the following:

-a vacuum interlock preventing operation of the power supply without a minimum vacuum level within the chamber working environment (preventing operation of the ONYX-3513I™ with the chamber open and the source exposed to the operator).

-mechanical door interlocks on all system panels to prevent operation of the high voltage power supply with the doors open or removed, exposing the operator to the high voltage.

-a water flow switch must be installed in the drain line of the ONYX-3513I™ and wired to prevent operation of the power supply in the event that the water flow drops below 1 gallon per minute.

Once all interlocks are installed, operation of the ONYX-3513I™ may be initiated (see Operation Procedures).

NOTE:

The ONYX-3513I™ is factory pretested for vacuum integrity, electrical circuit and water circuit integrity. There is no reason to disassemble the ONYX-3513I™ prior to installation. In the event of failure of the source, please contact the factory prior to disassembly for proper procedure, or, if possible, return the source to the factory for repair.

OPERATION PROCEDURE

Target Installation:

The ONYX-3515I™ utilizes a 3.5" x 13" x 0.250" thick target which can be fabricated of elemental metals, dielectrics (oxides, nitrides, carbides, etc.), precious metals, composite alloys, stoichiometric oxide superconductors, etc. Angstrom Sciences manufactures a complete range of sputtering targets for the ONYX line of Magnetrons and for most commercial sputtering and evaporation equipment. Please consult the sales department for a quotation. Actual fabrication tolerance on the target is:

3.5" wide x 13" long x 0.250" thick all (±.005")

Target is to be flat to within 0.005" to ensure the proper seating in the cathode.

Once a target has been fabricated to the above tolerances, remove the anode/dark space shield from the source, then remove the target clamp. Place target on the cathode body or bond to backing plate target and fasten with target clamp onto cathode. Target clamp should be tightened to rest on the target and secure the target to the cathode (do not overtighten - maximum torque should not exceed 3 foot-pounds). Tighten the anode/dark space shield onto the source.

Initial Operation:

Make certain all interlocks (as defined in Installation Procedure section of manual) are functional. The system chamber should be vacuum pumped down to a minimum of 5×10^{-6} Torr. Backfill the system chamber with a high purity working gas (typically Argon; Oxygen or Nitrogen for reactive sputtering applications) to a pressure between 2 and 20 microns. If available, place source shutter in front of the source to prevent deposition of the target material onto the substrate during target break-in. Turn on the power supply. Slowly increase the power to the source (voltage should increase with no increase in the current - an increase in current indicates a short circuit in the source and the power supply should immediately be turned off). The ONYX-3513I™ should ignite a plasma at approximately 100 watts depending upon the target material (metals which readily oxidize, i.e. Ti, Al may require a higher voltage if operated by DC to penetrate the existing surface oxide layer).

Operate the source at 200-500 watts for approximately ten (10) minutes to "clean" the target surface (some plasma irregularity may exist during break-in, allow the plasma to stabilize prior to increasing the power. Slowly increase the power to a level consistent with the levels outlined for continuous operation in the Standard Specification Section of this manual. In the event that the plasma extinguishes, it may necessary to either ramp the power slower and/or increase the working pressure in the chamber and repeat the above procedure. Open the source shutter and deposition begins on the substrate (to obtain the maximum deposition rate and uniformity characteristics of the ONYX-3513I™, the substrate should be positioned approximately 4" from the target surface). At the completion of the deposition process, reduce the power to zero, turn off the power supply, turn off the working gas flow, vent the chamber. Allow water to flow for approximately 15 minutes after power shutdown.

NOTES:

ALLOW WATER TO FLOW FOR A MINIMUM OF FIFTEEN MINUTES AFTER POWER HAS BEEN TURNED OFF TO SUFFICIENTLY COOL CATHODE BODY AND PREVENT MAGNET OVERHEATING.

ANGSTROM SCIENCES
ONYX-3™
MAGNETRON SPUTTERING CATHODE

PROCEDURES OF OPERATION

Effective Date: July 2000

Angstrom Sciences
40 South Linden Street
Duquesne, PA 15110
Phone: (412) 469-8466
Fax: (412) 469-8511
www.angstromsciences.com

ANGSTROM SCIENCES, INC.

Target Thickness Guide

		1	2	3	4	5	6	8
Standard	**Standard**	0.0625"	0.250"	0.250"	0.250"	0.250"	0.250"	0.250"
	Metric	1.5875 mm	6.35 mm	6.35 mm	6.35 mm	6.35 mm	6.35 mm	6.35 mm
	Magnetic	0.005"	0.020"	0.020"	0.020"	0.020"	0.020"	0.020"
	Metric	0.127 mm	0.508 mm	0.508 mm	0.508 mm	0.508 mm	0.508 mm	0.508 mm
Stage I Magnetic	**Standard**	X	0.250"	0.250"	0.250"	0.250"	0.250"	0.250"
	Metric		6.35 mm	6.35 mm	6.35 mm	6.35 mm	6.35 mm	6.35 mm
	Magnetic	X	0.060"	0.060"	0.060"	0.060"	0.060"	0.060"
	Metric		1.524 mm	1.524 mm	1.524 mm	1.524 mm	1.524 mm	1.524 mm
Stage II Magnetic	**Standard**	0.125"	0.250"	0.250"	0.250"	0.250"	0.250"	0.250"
	Metric	3.175 mm	6.35 mm	6.35 mm	6.35 mm	6.35 mm	6.35 mm	6.35 mm
	Magnetic	0.060"	0.125"	0.125"	0.125"	0.187"	0.250"	0.250"
	Metric	1.524 mm	3.175 mm	3.175 mm	3.175 mm	4.75 mm	6.35 mm	6.35 mm
High Utilization / Uniformity	**Standard**	X	0.125"	0.125"	0.125"	0.250"	0.250"	0.250"
	Metric		3.175 mm	3.175 mm	3.175 mm	6.35 mm	6.35 mm	6.35 mm
	Magnetic	X	0.005"	0.010"	0.020"	0.020"	0.020"	0.020"
	Metric		0.127 mm	0.254 mm	0.508 mm	0.508 mm	0.508 mm	0.508 mm
UHV	**Standard**	0.125"	0.125"	0.125"	0.250"	0.250"	0.250"	0.250"
	Metric	3.175 mm	3.175 mm	3.175 mm	6.35 mm	6.35 mm	6.35 mm	6.35 mm
	Magnetic	0.005"	0.020"	0.020"	0.020"	0.020"	0.020"	0.025"
	Metric	0.127 mm	0.508 mm	0.508 mm	0.508 mm	0.508 mm	0.508 mm	0.508 mm
UHV Stage II Magnetic	**Standard**	0.125"	0.250"	0.250"	0.250"	0.250"	0.250"	0.250"
	Metric	3.175 mm	6.35 mm	6.35 mm	6.35 mm	6.35 mm	6.35 mm	6.35 mm
	Magnetic	0.030"	0.060"	0.060"	0.125"	0.125"	0.125"	0.125"
	Metric	0.762 mm	1.524 mm	1.524 mm	3.175 mm	3.175 mm	3.175 mm	3.175 mm

* The above numbers reflect recommended material thickness for optimal performance and are not indicative of maximum thickness capability.

** Magnetic material calculations are optimized with Nickel targets.

March 2001

ATTENTION

Do not disassemble magnetron.

This will void all warranties.

Special procedures and/or tools are

required to assemble and disassemble.

ANGSTROM SCIENCES is not responsible for

misuse by customers.

Please consult ANGSTROM SCIENCES for

any technical questions.

PRODUCT WARRANTY

WARRANTY REGISTRATION: Please complete and return the enclosed Warranty Registration Card or register your warranty on-line at: http://www.angstromsciences.com in the "Products" link within 30 days to ensure immediate and proper warranty service and to receive important notifications regarding your magnetron.

Cooling Water Connection:

CAUTION: If the source is mounted in a sputter down configuration, then proceed to operation specifications. However, if the source is mounted in any other configuration (ie. side sputter or sputter up), the cathode will have to be purged of any trapped air inside the cathode body. To do this, first, place the source in a sputter down orientation and fill with water until all air is removed from the source. Any trapped air can be further removed by tilting the source from side to side. Next, proper fittings should be connected to ensure that source can be installed without air entering the cathode. This procedure is extremely important for the proper functioning of the cathode. If this procedure is not followed the source may run at high temperature and damage may occur to the source and/or target material. Failure to follow this procedure will void any or all warranties stated or implied.

Manufacturer's Declaration:

The manufacturer warrants that the accuracy of the data listed in this manual for the ONYX-3™ is within the tolerances given. The manufacturer reserves the right to alter other data of the equipment. The customer will be informed about the occasional alteration as may be appropriate. Any alteration by the customer of the ONYX-3™ may only be performed if the main parameters of the equipment will be kept or improved.

Warranted Data:

The following data are warranted:
- identification of the equipment and its manufacturer;
- main and characteristic dimensions and weight of the equipment;
- main technical parameters of the equipment;
- characteristic dimensions, features and quantity of accessories;
- optional accessories according to delivery contract.

Statement of Warranty:

Angstrom Sciences warrants that all equipment manufactured by it shall be free from defects in materials and workmanship under normal use and service for a period of twenty four (24) months from the date of shipment from the Angstrom Sciences production facility. This warranty is subject to the Angstrom Sciences equipment being installed, maintained and operated in accordance with the operating and maintenance instructions accompanying each item manufactured by Angstrom Sciences. Warranty shall be void if the Angstrom Sciences equipment is modified by the customer or used in other than the recommended manner or applications. Purchased equipment incorporated into any item supplied by Angstrom Sciences will be covered by the manufacturer's warranty.

The liability of Angstrom Sciences for any claims of customer arising out of damages alleged to result from the use or failure of equipment manufactured by Angstrom Sciences shall be limited to the original invoice cost as adjusted by generally accepted accounting practices for useful life expectancy.

OPERATION SPECIFICATIONS ONYX-3

SPECIFICATIONS ONYX -3

Maximum Sputtering Power	1500 Watts DC 900 Watts RF
Cathode Voltage	100 to 1500 volts
Discharge Current	.1 to 1 amp
Operating Pressure	1 to 200 milliTorr
Cooling Water Requirement	
Flow Rate	1 gallon/minute
Maximum Input Temperature	30°C
Input Pressure (open drain)	60 psi
Target	
Form	Circular/Planar
Diameter	3.0" (+/-.010")
Thickness	0.010" - 0.375"
Cooling	Indirect
Magnetic Enhancement	Permanent (NdFeB)
Source Dimensions	
Outside Diameter	3.812"
Cathode Length	2.25"
Weight	5 pounds
Mounting	
Source	1" dia. "o"-ring seal
Water	.250" OD tubing
Power	Type N Connector
Maximum Temperature	100°C
Source-to-Substrate Distance	4 - 12"
Uniformity	+/-5% across 3" substrate at 4"
Construction	
Cathode Body	OFHC Copper
Anode	304/316 Stainless Steel
Insulator	High density PTFE

INSTALLATION PROCEDURE

The ONYX-3™ is supplied standard with a ¾" OD stainless steel tube utilities line and can be mounted in any vacuum systems which has a standard 1" diameter "o" ring compression fitting. All utilities are maintained at atmosphere and accessed from the rear of the cathode assembly. All ONYX-3™ cathodes are supplied with utilities (water and electric) properly fitted to the cathode and sufficient cable/tubing runs to allow the customer to access these without disassembly of the source.

The ONYX-3™ is supplied with 1/4" OD convoluted teflon water lines (water in/ water out). The cuffs on the customer connection end are suitable for use with standard compression tube fittings. In order to function properly, the ONYX-3™ requires a minimum water flow rate of 1 gallon per minute of 30°C water with an open drain (input pressure should be 60 psi). Proper flow and water temperature must be maintained to allow effective use of the ONYX-3™; any deviation can constitute a loss of product warranty. All ONYX-3™ cathodes should be fitted with a water flow inter-lock switch in the exit line which is wired to prevent operation of the power supply in the event that water flow falls below the minimum operation specification. Operation of the ONYX-3™ sputtering source without proper water flow will damage the magnet array and the target and void the product warranty.

The ONYX-3™ operates with either Direct Current (DC) or Radio Frequency (RF) power supplies. Maximum power levels for the ONYX-3™ are:

Direct Current ———— 1500 Watts
Radio Frequency ———— 900 Watts

The ONYX-3™ is supplied standard with a Type N fully insulated power connector which is pre-wired by the factory to the cathode body minimizing impedance loss. The anode is maintained at ground potential. BECAUSE THE ONYX-3™ IS A HIGH VOLTAGE DEVICE, EXTREME CARE MUST ALWAYS BE TAKEN DURING OPERATION. To protect the operator, safety interlocks should be added to the vacuum systems prior to powering the ONYX-3™. These interlocks should include and not be limited to the following:

-a vacuum interlock preventing operation of the power supply without a minimum vacuum level within the chamber working environment (preventing operation of the ONYX-3™ with the chamber open and the source exposed to the operator)

-mechanical door interlocks on all system panels to prevent operation of the high voltage power supply with the doors open or removed, exposing the operator to the high voltage

-a water flow switch must be installed in the drain line of the ONYX-3™ and wired to prevent operation of the power supply in the event that the water flow drops below 1 gallon per minute.

Once all interlocks are installed, operation of the ONYX-3™ may be initiated. (See Operation Procedures)

NOTE: The ONYX-3™ is factory pretested for vacuum integrity, electrical circuit and water circuit integrity. There is no reason to disassemble the ONYX-3™ prior to installation. In the event of failure of the source, please contact the factory prior to disassembly for proper procedure, or, if possible, return the source to the factory for repair.

OPERATION PROCEDURE

Target Installation:

The ONYX-3™ utilizes a 3" diameter target which can be fabricated of elemental metals, dielectrics (oxides, nitrides, carbides etc.), precious metals, composite alloys, stoichiometric oxide superconductors, etc. Angstrom Sciences manufactures a complete range of sputtering targets for the ONYX™ line of magnetrons and for most all commercial sputtering and evaporation equipment. Please consult the sales department for a quotation. Target thickness can range from thin foils (0.010") up to 3/8" thick. Actual fabrication tolerance on the target diameter is:

3.000" diameter +/-0.010"

Target thickness is variable, but the target is to be flat to within 0.010" to ensure proper seating in the cathode.

If a target is less than .060" thick, the foil spacer ring should be placed between the target and the target clamping ring to ensure good thermal contact of the target to the cathode body.

Once a target has been fabricated to the above tolerances, remove the threaded anode/dark space shield from the source, remove the threaded target clamping ring with adjustable dark space slip ring, remove the stainless steel foil clamping spacer, place the target in the cavity on the cathode body (if target is foil, place foil clamping spacer on the target; if target is not a foil, store clamping spacer for future use.), thread target clamping ring onto cathode, target clamp should be tightened to rest on the target and secure the target to the cathode (do not overtighten - maximum torque should not exceed 2 foot-pounds), adjust dark space slip ring until it rests on the step at the base of the copper cathode block and completely shield the threads on the cathode body, thread the anode/dark space shield onto the source, place the anode/dark space shield spacing tool between the target clamping ring and the anode/dark space shield and tighten the dark space shield down to that level, remove the spacing adjustment tool, adjust the anode shield locking ring until anode shield is tight. The source is ready for operation.

Initial Operation:

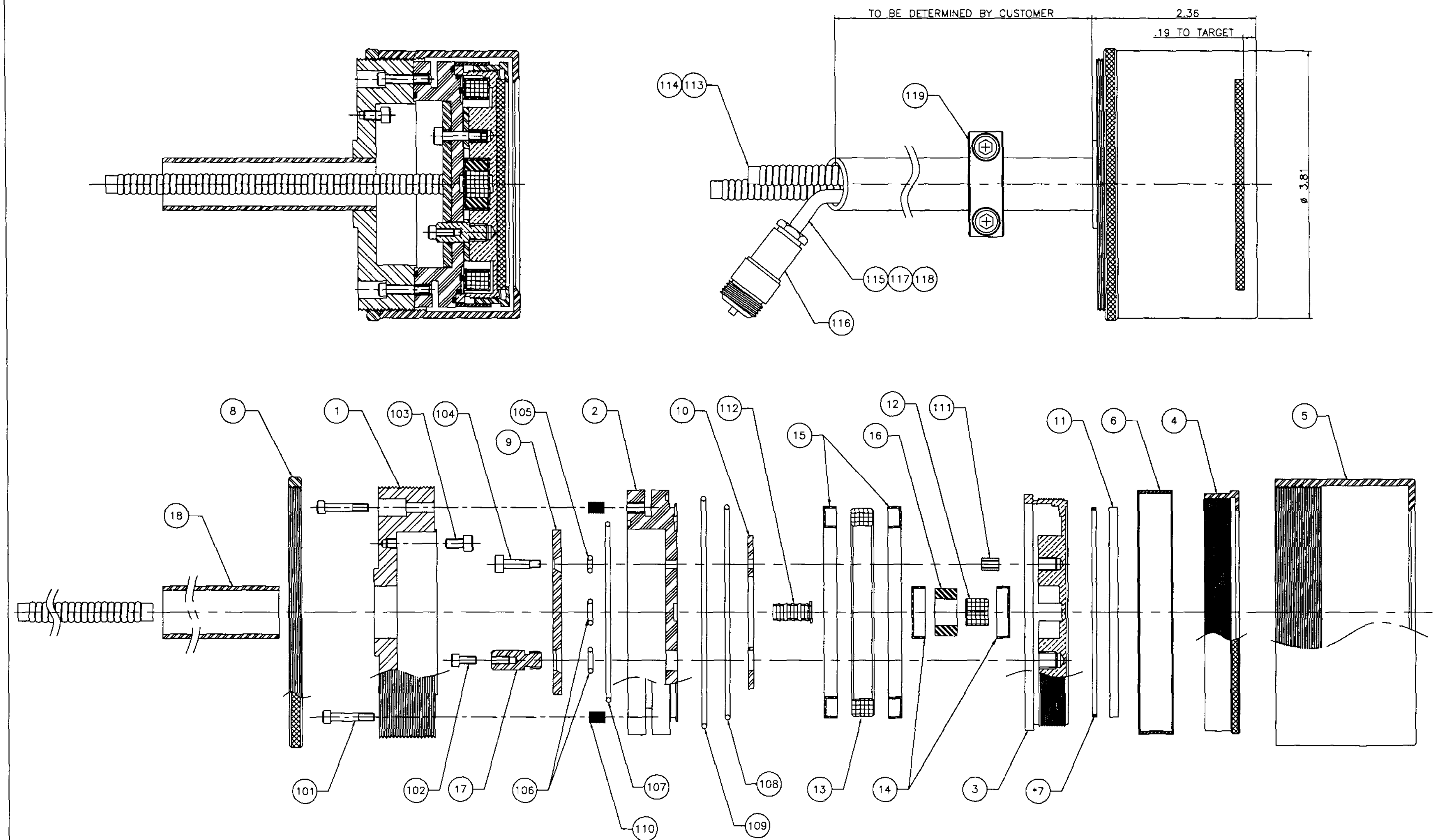
Make certain that all interlocks (as defined in Installation Procedure Section of manual) are functional. The system chamber should be vacuum pumped down to a minimum of 5×10^{-6} Torr. Backfill the system chamber with a high purity working gas (typically Argon: Oxygen or Nitrogen for reactive sputtering applications) to a pressure between 2 and 20 microns. If available, place source shutter in front of the source to prevent deposition of the target material onto the substrate during target break in. Turn on the power supply. Slowly increase the power to the source (voltage should increase with no increase in the current - an increase in current indicates a short circuit in the source and the power supply should immediately be turned off.) ONYX-3™ should ignite a plasma at approximately 50 watts in this pressure range depending upon the target material (metal which readily oxidize, i.e. Ti, Al may require a higher voltage if operated by DC to penetrate the existing surface oxide layer). Operate the source at 50 - 100 watts for approximately ten (10) minutes to "clean" the target surface (some plasma irregularity may exist during break-in, allow the plasma to stabilize prior to increasing the power).

Slowly increase the power to a level consistent with the levels outlined for continuous operation in the Standard Specification Section of this manual. In the event that the plasma extinguishes, it may be necessary to either ramp the power slower and/or increase the working pressure in the chamber and repeat the above procedure. Open the source shutter and deposition begins on the substrate (to obtain the maximum deposition rate and uniformity characteristics of the ONYX-3™, the substrate should be positioned approximately 100mm from the target surface). At the completion of the deposition process, reduce the power to zero, turn off the power supply, turn off the working gas flow, vent the chamber.

NOTES:

ALLOW WATER TO FLOW FOR A MINIMUM OF FIFTEEN MINUTES AFTER POWER HAS BEEN TURNED OFF TO SUFFICIENTLY COOL CATHODE BODY AND PREVENT MAGNET OVERHEATING.

DRAWING NUMBER: ON03-MAN1



NOTE: (*) DENOTES OPTIONAL- FOR USE WITH THIN TARGETS

ONYX 3 STANDARD

ASSEMBLY

NOTES:
1. BREAK ALL SHARP CORNERS .005 MAX
2. 63 UNLESS OTHERWISE SPECIFIED
3. ALL SURFACES MUST BE HELD ⏥ AND // ±.003
4. ONLY WATER SOLUBLE CUTTING FLUIDS PERMITTED
5. CFC SOLVENTS ARE PROHIBITED
6. METAL WORKING LUBRICANTS WHICH CONTAIN SULFUR OR SILICONE ARE PROHIBITED
7. ALL DRILL DEPTHS ARE TAKEN FROM FLAT OF DRILL

NO.	DATE	REVISION	BY	AP'D

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TOLERANCES
(UNLESS OTHERWISE SPECIFIED)
LINEAR (IN.)
FRACTIONAL = ±1/64
2 PLACE DECIMAL = ±0.01
3 PLACE DECIMAL = ±0.005
4 PLACE DECIMAL = ±0.0005
'AR
DEGRE
DEGS, ,30'
DEGS, = ±00',00', 30"

CONFIDENTIAL

NOTICE: THE INFORMATION CONTAINED HEREIN IS PROPERTY OF ANGSTROM SCIENCES, INC. DUQUESNE, PA AND CONTAINS PROPRIETARY INFORMATION WHICH HAS BEEN SUBMITTED TO YOU IN CONFIDENCE FOR A SPECIFIC PURPOSE. COPYING, USING, OR DISCLOSING THIS DRAWING OR THE INFORMATION ON IT WITHOUT ANGSTROM SCIENCES PRIOR WRITTEN CONSENT BY AN APPROVED REPRESENTATIVE IS PROHIBITED AND MAY BE GROUNDS FOR LEGAL ACTION. PATENTABLE DESIGN FEATURES ARE PROTECTED BY UNITED STATES PATENT LAWS.

SCALE: 1 : 1
DWN BY: C. WOLFE DATE: 07/11/00
CH'D BY: DATE:
AP'D BY: DATE:
SHEET: 1 OF 1
PART NO:

ANGSTROM SCIENCES, INC.
TITLE: ONYX - 3 INDIRECT COOLED ASSSEMBLY
DRAWING NUMBER: ON03-MAN1
REV: 0
SIZE: C

0N03-MAN2
DRAWING NUMBER:

ITEM	TITLE	DESCRIPTION	SPECIFICATIONS	QTY.
1	STEM	304 STAINLESS STEEL	ø 3.598 x .900	1
2	INSULATOR	KEL-F	ø 3 1/2 x .708	1
3	CATHODE BODY	OFHC COPPER	ø 3.38 x .621	1
4	TARGET CLAMP RING	304 STAINLESS STEEL	ø 3.48 (2.920 ID) x 1/2	1
5	ANODE SHIELD	304 STAINLESS STEEL	ø 3.81 (2.910 ID) x 2	1
6	INTERNAL PLASMA SHIELD	304 STAINLESS STEEL	ø 3.49 (3.402 ID) x .59	1
7*	FOIL RING	304 STAINLESS STEEL	ø 3.000 (2.92 I.D.) x .06	1
8	LOCKING RING	304 STAINLESS STEEL	ø 3 7/8 (3.558 ID) x .19	1
9	SEAL PLATE	304 STAINLESS STEEL	ø 2.36 x .125	1
10	WATER INLET	304 STAINLESS STEEL	ø 2.19 x .078	1
11	TARGET	T.B.D.	ø 3.000 x .125	1
12	CENTER MAGNET	NEO 38 MGO (MAGNETIZED)	ø .375 x .325	1
13	OUTER MAGNET	NEO 38 MGO (MAGNETIZED)	ø 2.975 (2.475 ID) x .325	1
14	CENTER MAGNET COVER	PVC	ø .740 x .190	2
15	OUTER MAGNET COVER	PVC	ø 3.025 x (2.420 ID) x .190	2
16	CENTER MAGNET BUSHING	PTFE	ø .680 x (.378 ID) x .318	1
17	POWER STANDOFF	OFHC COPPER	ø .281 x .72	1
18	STEM TUBE	304 STAINLESS STEEL	ø .750 (.625 ID) x ___	1
19	ANODE SPACING TOOL	304 STAINLESS STEEL	ø .045 x 6" LG (PRE BEND)	1
20*	STRAIN RELIEF			

ITEM	TITLE	DESCRIPTION	SPECIFICATIONS	QTY.
101	SHCS	STAINLESS STEEL	#4-40 x 5/8 LG.	8
102	SHCS	STAINLESS STEEL	#4-40 x 1/4 LG.	1
103	SHCS	STAINLESS STEEL	#6-32 x 1/4 LG.	1
104	Socket Hd Shlder Screw	STAINLESS STEEL	#4-40 x 3/8 LG. BODY x .150 THREAD LENGTH	4
105	"O"-RING	PARKER #2-006	VITON 70 DUROMETER 1/16" NOM. O.D. (.070 ACT.)	4
106	"O"-RING	PARKER #2-010	VITON 70 DUROMETER 1/16" NOM. O.D. (.070 ACT.)	3
107	"O"-RING	PARKER #2-037	VITON 70 DUROMETER 1/16" NOM. O.D. (.070 ACT.)	1
108	"O"-RING	PARKER #2-041	VITON 70 DUROMETER 1/16" NOM. O.D. (.070 ACT.)	1
109	"O"-RING	PARKER #2-042	VITON 70 DUROMETER 1/16" NOM. O.D. (.070 ACT.)	1
110	HELICOIL	McMASTER CARR #91732A701	#4-40 x .228 LG.	8
111	THREADED INSERT	McMASTER CARR #90248A016	T-303 STNLS STEEL x .25 THK #10-32 (ext) #4-40 (int)	4
112	BARBED WATER FITTING	SWAGELOK #SS-505-4	STAINLESS STEEL w/19 bore dia 1/4 Tube OD	2
113	WATER LINE	PTFE CONVOLUTED	ø 3/16" (.120 I.D.)	2
114	WATER LINE INSERT (EXT.)	304 STAINLESS STEEL	.220 O.D. (.180 ID) x 7/8 Lg.	2
115	POWER CABLE	RG 142 (OR TO ORDER)		1
116	POWER CONNECTOR	TYPE "N" OR "HN"		1
117	GROUND CABLE	14 AWG (41/30) TC	.016 PVC INS MIL-W-76B TYPE MW 80° 1000V	1
118	GROUND EYE			1
119	CATHODE STOP	RULAND #SP-12-A	ALUMINUM for 3/4 Tube 2 Pc Clamp Type Collar	1

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NOTE: (*) DENOTES OPTIONAL PART

NO.	DATE	REVISION	BY	APD

TOLERANCES
(UNLESS OTHERWISE SPECIFIED)
LINEAR (IN.)
FRACTIONAL = ±1/64
2 PLACE DECIMAL = ±0.01
3 PLACE DECIMAL = ±0.005
4 PLACE DECIMAL = ±0.0005
ANGULAR
DEGREES = ±1°
DEGS, MINS = ±00',30'
DEGS, MINS, SECS = ±00',00', 30"

SCALE: N/A
DWN BY: C. WOLFE DATE: 07/11/00
CHD BY: DATE:
APD BY: DATE:
SHEET: 1 OF 1
PART NO:

ANGSTROM SCIENCES, INC.
TITLE: ONYX - 3 INDIRECT COOLED PARTS LIST
DRAWING NUMBER: 0N03-MAN2
REV: 0
SIZE: B

ANGSTROM SCIENCES
ONYX-813I™
MAGNETRON SPUTTERING CATHODE

PROCEDURES OF OPERATION

Effective Date: January, 2001

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40 South Linden Street, Duquesne, PA 15110 / Phone: (412) 469-8466 Fax: (412) 469-8511
www.angstromsciences.com

CERTIFICATE OF INSPECTION

-1-	Visual inspection for external damage.	✓
-2-	Internal inspection of parts for damage.	✓
-3-	Examination of parts for proper fit.	✓
-4-	Internal inspection of parts for cleanliness.	✓
-5-	Leak rate less than 10^{-8} cc/sec of atmospheric helium.	✓
-6-	Electrical isolation between anode and cathode.	✓
-7-	Minimal electrical resistance breakdown between anode and cathode of 1.5 Kv.	✓
-8-	Water pressure test. Forward 60 psi (24 hours). Back pressure 60 psi (24 hours). Spike 90 psi (10 seconds).	✓
-9-	Magnet map within ±10%	✓
-10-	Source packaged and shipped in a contamination free container including operations manual.	✓

Customer: T-M VACUUM PRODUCTS, INC.

Model #: ONYX™-813I

Serial #: ON813IDBCHVSSS0002

Quality Control Inspector: Richard A White

Date: JANUARY 19, 2001

REVISION DATE: 09-09-99

ATTENTION

Do not disassemble magnetron.

This will void all warranties.

Special procedures and/or tools are required to assemble and disassemble.

ANGSTROM SCIENCES is not responsible for misuse by customers.

Please consult ANGSTROM SCIENCES for any technical questions.

PRODUCT WARRANTY

Cooling Water Connection:

CAUTION: If the source is mounted in a sputter down configuration, then proceed to operation specifications. However, if the source is mounted in any other configuration (ie. side sputter or sputter up), the cathode will have to be purged of any trapped air inside the cathode body. To do this, first, place the source in a sputter down orientation and fill with water until all air is removed from the source. Any trapped air can be further removed by tilting the source from side to side. Next, proper fittings should be connected to ensure that source can be installed without air entering the cathode. If this procedure is not followed the source may run at high temperature and damage may occur to the source and/or target material. Failure to follow this procedure will void any or all warranties stated or implied.

Manufacturer's Declaration:

The manufacturer warrants that the accuracy of the data listed in this manual for the ONYX-813I™ is within the tolerances given. The manufacturer reserves the right to alter other data of the equipment. The customer will be informed about occasional alterations as may be appropriate. Any alteration by customer of the ONYX-813I™ may only be performed if the main parameters of the equipment will be kept or improved.

Warranted Data:

The following data are warranted:

-identification of the equipment and its manufacturer;
-main and characteristic dimensions and weights of the equipment;
-main and technical parameters of the equipment;
-characteristic dimensions, features and quantity of accessories;
-optional accessories according to delivery contract.

Statement of Warranty:

Angstrom Sciences warrants that all equipment manufactured by it shall be free from defects in materials and workmanship under normal use and service for a period of twenty-four (24) months from the date of shipment from the Angstrom Sciences production facility. This warranty is subject to the Angstrom Sciences equipment being installed, maintained and operated in accordance with the operating and maintenance instructions accompanying each item manufactured by Angstrom Sciences. Warranty shall be void if the Angstrom Sciences equipment is modified by customer or used in other than recommended manner or applications. Purchased equipment incorporated into any item supplied by Angstrom Sciences will be covered by manufacturer's warranty.

The liability of Angstrom Sciences for any claims of customer arising out of damages alleged to result from the use or failure of equipment manufactured by Angstrom Sciences shall be limited to the original invoice cost as adjusted by generally accepted accounting practices for useful life expectancy.

OPERATION SPECIFICATIONS ONYX-813I™

Maximum Sputtering Power	26 Kilowatts DC 8 Kilowatts RF
Cathode Voltage	100 to 1500 Volts
Discharge Current	0.1 to 40 Amps
Operating Pressure	1 to 50 milliTorr
Cooling Requirements	
Flow Rate	7 Gallons per Minute At Maximum Power
Maximum Input Temperature	20°C
Input Pressure (open drain)	60 psi
Target	
Form	Planar
Length	13" (± 0.005")
Width	8" (± 0.005")
Thickness	0.250"
Cooling	Direct/Indirect
Magnetic Enhancement	Permanent (NdFeB) Encapsulated
Source Dimensions	
Outside Width	10.50"
Length	15.50"
Height	3"
Weight	55 Pounds
Mounting	(2) 1.25" Dia Tubes
Maximum Temperature	100°C
Source-to-Substrate Distance	2 - 12"
Uniformity	±5% across center of target area with a 4" source-to-substrate distance
Construction	
Cathode Body	OFHC Copper
Anode	304 SS
Insulator	Teflon (PTFE)

INSTALLATION PROCEDURE

The ONYX-813I™ is supplied with an external flange that can be mounted in any vacuum system. All utilities are maintained at atmosphere and are accessed from the rear of the cathode assembly. All ONYX-813I™ cathodes are supplied with utilities (water and electric) properly fitted to the cathode which allow the customer to access these without disassembly of the source.

The ONYX-813I™ is supplied with 0.500" OD water lines (water in/water out). In order to function properly, the ONYX-813I™ requires a water flow rate of two gallons per minute of 30°C water with an open drain (input pressure should be 60 psi). Proper flow and water temperature must be maintained to allow effective use of the ONYX-813I™; and any deviation can constitute a loss of product warranty. All ONYX-813I™ cathodes should be fitted with a water flow inter-lock switch in the exit line which is wired to prevent operation of the power supply in the event that water flow falls below the minimum operation specifications. Operation of the ONYX-813I™ sputtering source without proper water flow will damage the magnet array and the target and void the product warranty.

The ONYX-813I™ operates with either Direct Current (DC) or Radio Frequency (RF) power supplies. Maximum power levels for the ONYX-3513I™:

Direct Current————— 26 Kilowatts
Radio Frequency———— 8 Kilowatts

The ONYX-813I™ is supplied standard with a power coupling which is fastened to the cathode body. A sufficient ground line should be attached to the cathode mounting plate. Please consult Angstrom Sciences if any questions arise. The anode is maintained at ground potential. BECAUSE THE ONYX-813I™ IS A HIGH VOLTAGE DEVICE, EXTREME CARE MUST ALWAYS BE TAKEN DURING OPERATION. To protect the operator, safety interlocks should be added to the vacuum system prior to powering of the ONYX-813I™. These interlocks should include and not be limited to the following:

-a vacuum interlock preventing operation of the power supply without a minimum vacuum level within the chamber working environment (preventing operation of the ONYX-813I™ with the chamber open and the source exposed to the operator).

-mechanical door interlocks on all system panels to prevent operation of the high voltage power supply with the doors open or removed, exposing the operator to the high voltage.

-a water flow switch must be installed in the drain line of the ONYX-813I™ and wired to prevent operation of the power supply in the event that the water flow drops below 1 gallon per minute.

Once all interlocks are installed, operation of the ONYX-813I™ may be initiated (see Operation Procedures).

NOTE:

The ONYX-813I™ is factory pretested for vacuum integrity, electrical circuit and water circuit integrity. There is no reason to disassemble the ONYX-813I™ prior to installation. In the event of failure of the source, please contact the factory prior to disassembly for proper procedure, or, if possible, return the source to the factory for repair.

OPERATION PROCEDURE

Target Installation:

The ONYX-813I™ utilizes a 8" x 13" x 0.250" thick target which can be fabricated of elemental metals, dielectrics (oxides, nitrides, carbides, etc.), precious metals, composite alloys, stoichiometric oxide superconductors, etc. Angstrom Sciences manufactures a complete range of sputtering targets for the ONYX line of Magnetrons and for most commercial sputtering and evaporation equipment. Please consult the sales department for a quotation. Actual fabrication tolerance on the target is:

8" wide x 13" long x 0.250" thick all (±.005")

Target is to be flat to within 0.005" to ensure the proper seating in the cathode.

Once a target has been fabricated to the above tolerances, remove the anode/dark space shield from the source, then remove the target clamp. Place target on the cathode body or bond to backing plate target and fasten with target clamp onto cathode. Target clamp should be tightened to rest on the target and secure the target to the cathode (do not overtighten - maximum torque should not exceed 3 foot-pounds). Tighten the anode/dark space shield onto the source.

Initial Operation:

Make certain all interlocks (as defined in Installation Procedure section of manual) are functional. The system chamber should be vacuum pumped down to a minimum of 5×10^{-6} Torr. Backfill the system chamber with a high purity working gas (typically Argon; Oxygen or Nitrogen for reactive sputtering applications) to a pressure between 2 and 20 microns. If available, place source shutter in front of the source to prevent deposition of the target material onto the substrate during target break-in. Turn on the power supply. Slowly increase the power to the source (voltage should increase with no increase in the current - an increase in current indicates a short circuit in the source and the power supply should immediately be turned off). The ONYX-813I™ should ignite a plasma at approximately 100 watts depending upon the target material (metals which readily oxidize, i.e. Ti, Al may require a higher voltage if operated by DC to penetrate the existing surface oxide layer).

Operate the source at 200-500 watts for approximately ten (10) minutes to "clean" the target surface (some plasma irregularity may exist during break-in, allow the plasma to stabilize prior to increasing the power. Slowly increase the power to a level consistent with the levels outlined for continuous operation in the Standard Specification Section of this manual. In the event that the plasma extinguishes, it may necessary to either ramp the power slower and/or increase the working pressure in the chamber and repeat the above procedure. Open the source shutter and deposition begins on the substrate (to obtain the maximum deposition rate and uniformity characteristics of the ONYX-813I™, the substrate should be positioned approximately 4" from the target surface). At the completion of the deposition process, reduce the power to zero, turn off the power supply, turn off the working gas flow, vent the chamber. Allow water to flow for approximately 15 minutes after power shutdown.

NOTES:

ALLOW WATER TO FLOW FOR A MINIMUM OF FIFTEEN MINUTES AFTER POWER HAS BEEN TURNED OFF TO SUFFICIENTLY COOL CATHODE BODY AND PREVENT MAGNET OVERHEATING.

PNEUMATIC HI-ROTOR
(Vane Type Rotary Actuator)

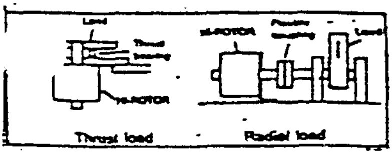
Installation and maintenance
instructions for Norgren Martonair
HI-ROTORS M/60280 - M/60288

- Care should always be taken during installation of pneumatic HI-ROTORS to ensure that they are fitted in such a manner that they are protected against dirt, water or other contamination as well as against mechanical damage. The environmental temperature for HI-ROTORS should not exceed 60°C.

- Maintenance:
As a rule Norgren Martonair HI-ROTORS require hardly any maintenance. However, the condition of the compressed air determines the life of the installation. For this reason the air user should be treated so that it is suitable for this purpose in the interests of long life. Clean air filtered to 50 my, free of water and lubricated with oil fog, will ensure a long service life for the equipment.

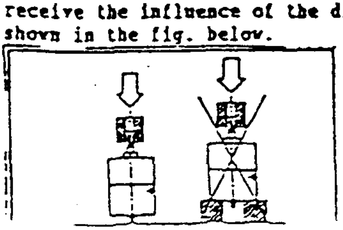
- Mounting load

Note that, if the thrust load and radial load applied to the HI-ROTOR's shaft exceed the allowable range, it may cause the HI-ROTOR to malfunction. When the thrust load or radial load unavoidably exceed the allowable range, use a bearing as shown below to prevent the load(s) being directly applied to the HI-ROTOR



Note that, when the mass of the load is large and working speed is high, great impact will be generated, which could damage the HI-ROTOR

When assembling a coupling etc. to the shaft, adopt a method where the body does not receive the influence of the direct force as shown in the fig. below.



Safety Instructions

The HI-ROTOR is a high-tech tool with a maximum of working safety. However, there might still be danger if:
- the HI-ROTOR is applied, mounted or maintained by unskilled personal.
- the HI-ROTOR is not used in the application it was designed for.
- advices of the instruction manual are disregarded.

The mounting of the HI-ROTOR and proximity switches as well as the connection and starting of the rotor has to be done by authorized and skilled personal.
Do not apply working methods that influence the security or function of the HI-ROTOR.

We recommend the HI-ROTOR is removed from the handling unit in order to do any modifications outside the danger zone.

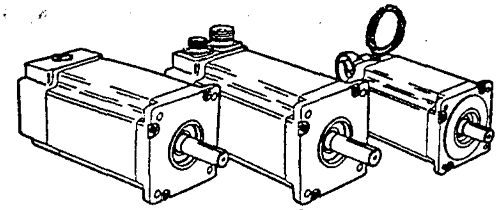
Make sure that an unintentional actuation of the HI-ROTOR by an erector or any other personal is impossible when you mount, connect, adjust or start the HI-ROTOR.

All safety regulations and all regulations for prevention of accidents in the operating range are equally valid.

- Lubrication
We recommend the following grades of oil for use in the oilers:

Shell Oil	Tellus C 32
Mobil Oil	D.T.E. Oil Light
Esso Oil	Terresso 32

INSTALLATION BULLETIN
POWERPAC™ NEMA 34 AND 42 HYBRID STEP MOTORS AND SYNCHRONOUS MOTORS



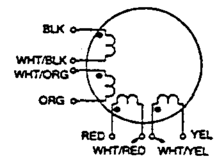
- Power Connections
- Phase Sequencing Tables
- Encoder Options
- Installation Guidelines
- Warranty/Return Authorization

POWER CONNECTIONS: 8 flying leads (NEMA 34 only) or 8 terminals (not available in systems construction - MS connector).

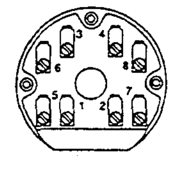
The 8 lead motor is the most versatile configuration. It may be connected by the user in choice of 8 lead, 4 lead (series or parallel) or 6 lead configuration.

CONNECTION	DRIVER CONNECTION	LEAD COLOR	TERMINAL #
4-LEAD BIPOLAR	A	BLACK (BLK)	1
SERIES	$\overline{A}$	ORANGE (ORG)	3
	B	RED	2
	$\overline{B}$	YELLOW (YEL)	4
	NONE	WHT/BLK & WHT/ORG	6 & 5
	NONE	WHT/RED & WHT/YEL	8 & 7
4-LEAD BIPOLAR	A	BLK & WHT/ORG	1 & 5
PARALLEL	$\overline{A}$	ORG & WHT/BLK	3 & 6
	B	RED & WHT/YEL	2 & 7
	$\overline{B}$	YEL & WHT/RED	4 & 8
6-LEAD UNIPOLAR	A	BLACK (BLK)	1
	B	ORANGE (ORG)	3
	C	RED	2
	D	YELLOW (YEL)	4
	+V	WHT/BLK & WHT/ORG	6 & 5
	+V	WHT/RED & WHT/YEL	8 & 7
GND		GREEN/YELLOW	

NOTE:
1. See phase sequencing tables.



8-Lead Configuration
NEMA 34 only



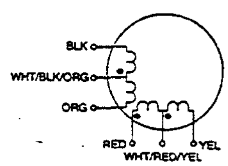
Terminal Board
NEMA 34 and 42

POWER CONNECTIONS: 6 flying leads (NEMA 34 only) or 6 terminals (not available in systems construction - MS connector).

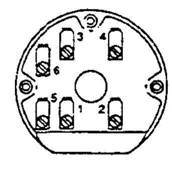
The 6 lead motor is normally used with unipolar drives. In some cases, the 6 lead motor can be used in a 4 lead series configuration for use with bipolar drives.

CONNECTION	DRIVER CONNECTION	LEAD COLOR	TERMINAL #
6-LEAD UNIPOLAR	A	BLACK (BLK)	1
	B	ORANGE (ORG)	3
	C	RED	2
	D	YELLOW (YEL)	4
	+V	WHT/BLK/ORG	5
	+V	WHT/RED/YEL	6
4-LEAD BIPOLAR	A	BLACK (BLK)	1
SERIES	$\overline{A}$	ORANGE (ORG)	3
	B	RED	2
	$\overline{B}$	YELLOW (YEL)	4
	NONE	WHT/BLK/ORG	5
	NONE	WHT/RED/YEL	6
GND		GREEN/YELLOW	

NOTE:
1. Terminals 7 and 8 are not used. 2. See phase sequencing tables.



6-Lead Configuration
NEMA 34 only



Terminal Board
NEMA 34 and 42

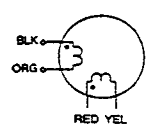
POWER CONNECTIONS: 4 flying leads, 4 terminals or MS connector.

The 4 lead motor is for use with bipolar drives.

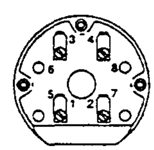
CONNECTION	DRIVER CONNECTION	LEAD COLOR	TERMINAL #	MS PIN OUT
4-LEAD BIPOLAR	A	BLACK	1	A
	$\overline{A}$	ORANGE	3	B
	B	RED	2	C
	$\overline{B}$	YELLOW	4	D
GND		GREEN/YELLOW		E

MOTOR POWER CONNECTOR
NEMA 34 & 42
MS3102R14S-5P

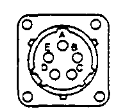
SUGGESTED MATING CONNECTOR	
NEMA 34 & 42	PAC SCI P.N.
MS3106F14S-5S	SZ00019



4-Lead Configuration



Terminal Board



MS Connector
NEMA 34 and 42

NOTE:
1. Terminals 5, 6, 7 and 8 are not used.
2. See phase sequencing tables.

PHASE SEQUENCING TABLES:

NOTE: Direction of rotation as viewed from mounting end of motor.

DRIVER CONNECTION

STEP	A	$\overline{A}$	B	$\overline{B}$
1	+	-	0	0
2	+	-	+	-
3	0	0	+	-
4	-	+	+	-
5	-	+	0	0
6	-	+	-	+
7	0	0	-	+
8	+	-	-	+

CCW ↓ ↑ CW

BIPOLAR HALF STEP PHASE SEQUENCING

DRIVER CONNECTION

STEP	A	$\overline{A}$	B	$\overline{B}$
1	+	-	-	+
2	-	+	-	+
3	-	+	+	-
4	+	-	+	-
1	+	-	-	+

CCW ↓ ↑ CW

BIPOLAR FULL STEP PHASE SEQUENCING

STEP	A	B	C	D
1	GND	0	GND	0
2	0	GND	GND	0
3	0	GND	0	GND
4	GND	0	0	GND
1	GND	0	GND	0

CCW ↓ ↑ CW

UNIPOLAR FULL STEP PHASE SEQUENCING

NOTES:
1 0 = OFF OR OPEN.
2 + = POSITIVE CURRENT FLOW.
3 − = NEGATIVE CURRENT FLOW.

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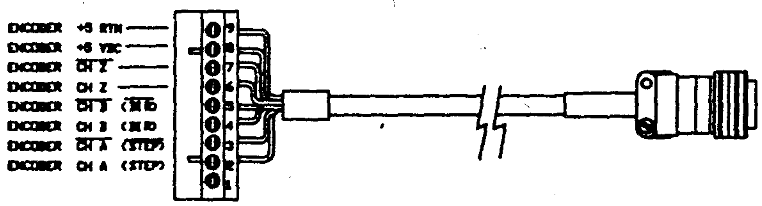
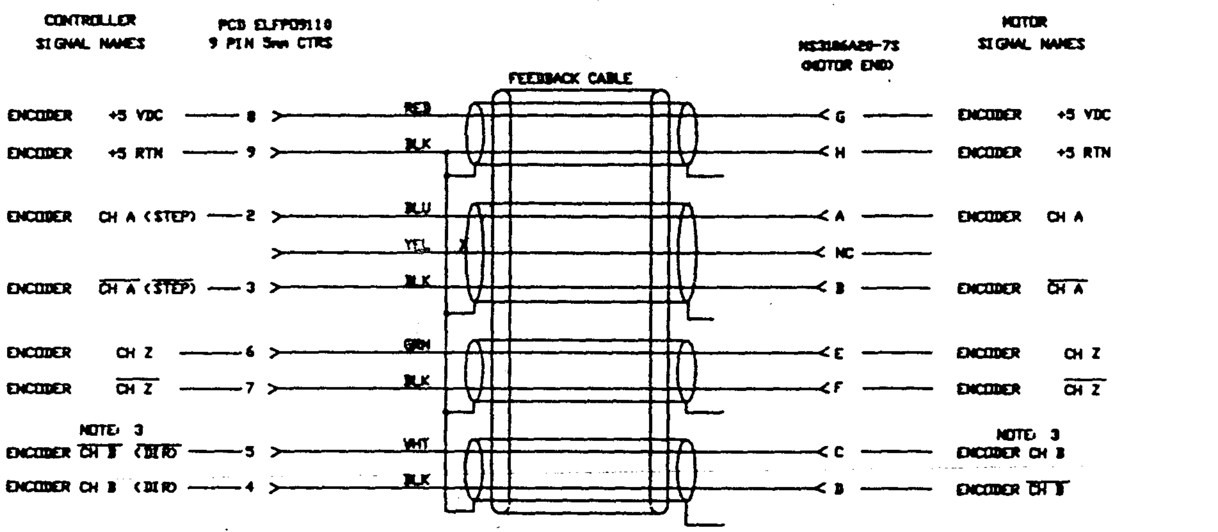
DATE	SYM	REVISION RECORD	AUTH	DWN	CHK
	A	ORIGINATE PER R.Q		RMQ	
	B	REV PER ECN1812		VP	





SEC-XXX-KN
STEPPER ENCODER CABLE
USE WITH 5445, 5645, 6445
FOR MOTORS WITH ENCODER

NOTE:
1. INDIVIDUALLY INSULATE SHIELD DRAIN AT MOTOR END.
2. INDIVIDUALLY INSULATE UNUSED WIRE AT BOTH ENDS
3. CH B TO CH B̄ IS REQUIRED FOR CONTROLLER AND MOTOR COMPATIBILITY

FILE NO: SECXXXKN
NETWORK DIR: Q:\CABLES\ACAD

PACIFIC SCIENTIFIC
MOTION TECHNOLOGY DIVISION
BOSTON OPERATION
110 FORDHAM ROAD
WILMINGTON, MA 01887

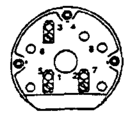
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.(mm)
TOLERANCES ON
DECI: XX±.01 XXX±.005 FRAC ±1/64 ANGLES ±1°
ALL SHARP EDGES .015 MAX.
ALL MACHINED SURFACES 125
DO NOT SCALE THIS DRAWING

VERSION DESIGNATIONS
PART NO.: SEC-XXX-KN
BILL OF MAT'L NO.: 107-560002-02

CABLES
SCALE 1x1
DWN: RMQ
APPR: RMQ
TITLE: CABLE, STEPPER ENCODER
DATE: 4-24-97
SIZE A
DRAWING NO: 107-560002-02
REV B
SHT 1 OF 1

■ SYNCHRONOUS MOTOR POWER CONNECTIONS

Splashproof Construction = **L or M**
Terminal Board



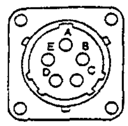
TERMINAL NUMBER	LEAD COLOR
1	RED
2	WHITE
3	BLACK

Regular Construction = R
Flying Leads

MOTOR LEADS
#22 AWG.

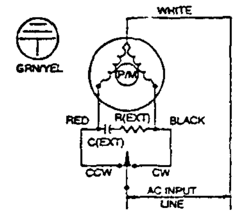
SEE SCHEMATIC
FOR HOOKUP

System Construction = C
MS Connector



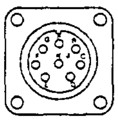
PIN	LEAD COLOR
A	BLK
B	WHT
C	RED
D	—
E	GRN/YEL

Schematic Diagram
All Constructions



NOTE:
MIL Spec Standard Circular Connector MS3102R14S-5P.
Suggested Mating Connector MS3106F14S-5S

■ NEMA 34 AND NEMA 42 ENCODER OPTIONS



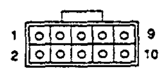
Encoder factory installed (inside).

ENCODER CONNECTOR ⚠1

PIN	FUNCTION
A	CHANNEL A
B	CHANNEL $\bar{A}$
C	CHANNEL B
D	CHANNEL $\bar{B}$
E	CHANNEL Z
F	CHANNEL $\bar{Z}$
G	+ 5 VDC
H	5 VDC RTN

MOTOR FEEDBACK CONNECTOR
MS3102E20-7P

SUGGESTED MATING CONNECTOR	
SCI P.N.	MS P.N.
Z00008	MS3106F20-7S



Encoder factory installed (outside on rear end bell).

ENCODER CONNECTOR ⚠2

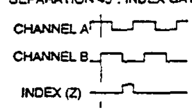
PIN	FUNCTION
1	N/C
2	+5V
3	GROUND
4	N/C
5	$\bar{A}$
6	A
7	$\bar{B}$
8	B
9	$\bar{Z}$
10	Z

MODELS PX

MATING CONNECTOR NOT OFFERED SUGGESTED MFR. P/N NUMBERS
BERG 65692-001

ENCODER OUTPUT

ENCODER OUTPUT
FOR CW DIRECTION OF ROTATION WHEN VIEWED FROM MOTOR DRIVE SHAFT END. (COMPLEMENTS NOT SHOWN) MIN. EDGE SEPARATION 45°. INDEX GATED TO A AND B.

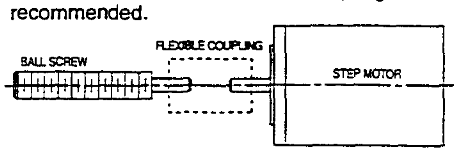


NOTE:
⚠1 NEMA 34, NEMA 42 SYSTEM CONSTRUCTION

⚠2 NEMA 34, REGULAR CONSTRUCTION ONLY.

■ INSTALLING THE MOTOR

1. Mounting.
   — Mount the motor tightly against a metal surface with good thermal conductivity such as steel or aluminum, making sure that adequate clearance is provided for mounting pilot in mounting plate.
   — Secure the motor firmly using hexagonal socket screws and nuts or an equivalent method.
2. Alignment of the load.
   — When connecting the load to the shaft, assure that the load and shaft axes are in line. A flexible coupling or similar device is recommended.



   — When connecting the motor shaft to a pulley or other device, do not subject the shaft to a thrust load, overhung load or shock, in excess of those specified in the product catalog.

■ CAUTION

1. Do *not* disassemble the motor, drop it or subject it to shock.
   — Disassembly results in a considerable reduction in motor performance. Dropping it or subjecting it to shock may cause internal damage. Any of the above conditions may void the warranty.
2. Do *not* subject the motor to these conditions.
   – Locations where strong vibrations or shock occur.
   Dusty locations. (Unless rated IP65).
   — Locations where water, oil or other liquids are likely to contact the motor. (Unless rated IP65).
   — Locations where flammable or corrosive gases are present.
   — Locations where the ambient temperature is outside the permissible temperature range of -20°C (-4°F) to +40°C (+104°F).
3. Thermal limitation.
   — The temperature rise of the motors' winding should not exceed +130°C (+266°F). This corresponds to a temperature on the housing of ≈ 115°C in an ambient of 40°C. Note that operating the motor with a constant-current driver can lead to a sharp temperature rise under certain drive conditions. Employ forced air cooling if the temperature exceeds ≈ 115°C (+239°F) on the outer surface.

■ WARRANTY POLICY/RETURN AUTHORIZATION

1. Pacific Scientific warrants motors to be free of material and workmanship defects for **two years** from the date of manufacture as determined by the date code on the product label. The warranty does not include damage resulting from misapplication or damage resulting from abuse, overload or overheat conditions, or failure to provide adequate maintenance.
2. Prior to returning any products for repair, authorization must first be received from Pacific Scientific Customer Service (Phone 815-226-3044 or FAX 815-226-3148). Customer Service issues a Return Material Authorization Number which *must* be included on the packing slip and on the outside of the shipping container of the returned products. Returns without a valid Authorization Number will not be accepted.

PACIFIC SCIENTIFIC

MOTOR PRODUCTS DIVISION
4301 Kishwaukee Street, P.O. Box 106, Rockford, Illinois 61105-0106
(815) 226-3100 Fax (815) 226-3148

A528-40-880
Issue P

Instruction Manual

QDP Drystar® Vacuum Pumps

Description	*Item Number*
QDP40 Drystar Pump	*A528-40-905*
QDP80 Drystar Pump (4 kW)	*A528-79-905*
QDP80 Drystar Pump (8 kW)	*A528-80-905*

Drystar is a registered Trademark of the BOC group of companies

BOC EDWARDS

Manor Royal, Crawley, West Sussex, RH10 9LW, UK
Telephone: +44 (0) 1293 528844 Fax: +44 (0) 1293 533453
http://www.bocedwards.com

Declaration of Conformity

We, BOC Edwards,
Manor Royal,
Crawley,
West Sussex RH10 2LW, UK

declare under our sole responsibility that the product(s)

Standard pumping system configured using the Q-matrix modular build structure, as shown below

Q _ _ _ _ _ _ _ _

Pump(s)
1. QDP40
2. QDP80
3. QDP40/QMB250
4. QDP40/QMB500
5. QDP80/QMB250
6. QDP80/QMB500
7. QDP80/QMB1200

Gas Control
0. None
1. Gas Module
2. Gas Module & Exhaust Pressure Module
3. Shaft Seal Purge Module
4. Gas Module and Nitrogen Flow Switch
5. Gas Module, Exhaust Pressure Module and Nitrogen Flow Switch

Mechanical Booster Frame
0. No Booster pump fitted
1. Direct mount (not available with QMB1200)
2. Booster Frame

Enclosures
0. None
1. Standard Enclosures
2. Extractable Enclosure

Electrical control
0. None
B. Motor Control Module (End User version)
C. Motor Control Module (OEM 24 V d.c.)
D. Motor Control Module (OEM 24 V a.c.)
E. Q Series Controller with N_2 Flow/OLM alarms

Oil Level Monitor(s)
0. None
1. Oil Level Monitor

Cables
0. None
1. 5 metres (wall mounted controller)
2. 1 metre (frame mounted controller)
3. 7 metres cable only
4. 7 metres armoured cable only

Electrical supply
1. 200-208 V, 50 Hz, 3-ph
2. 200-208 V, 60 Hz, 3-ph
3. 230 V 60 Hz, 3-ph
4. 380-415 V, 50 Hz, 3-ph
5. 460 V, 60 Hz, 3-ph

and the following standard accessories, not configured via the Q-matrix:

Water Cooled Exhaust Trap	A531-14-000
Enclosure Extraction Fan Kit	A223-01-006
Dual Enclosure Extraction Fans Kit	A528-60-000

to which this declaration relates is in conformity with the following standard(s) or other normative document(s)

EN 60204-1	Electrical Safety: Machines.
EN13463-1	Non Electrical Equipment for Potentially Explosive Atmospheres*.

following the provisions of

73/023/EEC	Low Voltage Directive.
89/336/EEC	Electromagnetic Compatibility Directive.
94/9/EC	Equipment for use in Potentially Explosive Atmospheres (ATEX Directive) (Category 3GD) Internal Atmospheres Only*.
98/37/EC	Machinery Safety Directive.

* Only applies to systems fitted with a Q Series 3 Exhaust Pressure Module.

JDWatson 10 June 2007 Shoreham

Dr J. D. Watson, Senior Technical Manager *Date and Place*

Vacuum Equipment and Exhaust Management and Product Divisions

BOC EDWARDS

DJD A528-40-880 A 22/05/03

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Associated publications

Publication title	Publication Number
Vacuum Pump and Vacuum System Safety	P300-20-000
QMB Mechanical booster Pumps	A301-85-880
Q Controller	A380-00-880
CDP Accessories - Flap Valve	A504-51-880
QDP Acoustic Enclosure	A528-01-880
QDP Gas Module	A528-05-880
Q Series 3 Exhaust Pressure Module	A528-50-880
QDP Shaft-Seals Purge Module	A528-55-880
Leak-testing CDP installations	P500-10-000

1 INTRODUCTION

1.1 Scope and definitions

This manual provides installation, operation and maintenance instructions for the BOC Edwards QDP Drystar Vacuum Pumps, abbreviated to QDP pumps in the remainder of this manual. You must use the pumps as specified in this manual.

Read this manual before you install and operate the pump. Important safety information is highlighted as WARNING and CAUTION instructions; you must obey these instructions. The use of WARNINGS and CAUTIONS is defined below.

> WARNING
>
> Warnings are given where failure to observe the instruction could result in injury or death to people.

> CAUTION
>
> Cautions are given where failure to observe the instruction could result in damage to the equipment, associated equipment or process.

1.2 ATEX directive implications

Note: The following information only applies to a QDP pump with an Exhaust Pressure Module fitted. QDP pumps without an Exhaust Pressure Module fitted are not ATEX compliant.

Ex II 3 GD T3 X

INTERNAL ATMOSPHERES ONLY
Tech File Ref. MPTR0263

- This equipment is designed to meet the requirements of Group II Category 3 equipment in accordance with Directive 94/9/EC of the European Parliament and the Council of 23rd March 1994 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres. (The ATEX Directive)

  The ATEX Category 3 applies in respect of potential ignition sources internal to the equipment. An ATEX Category has not been assigned in respect of potential ignition sources on the outside of the equipment as the equipment has not been designed for use where there is an external potentially explosive atmosphere.

  There is no potential source of ignition within the pump during normal operation but there may be potential sources of ignition under conditions of predictable and rare malfunction as defined in the Directive. Accordingly, although the pump is designed to pump flammable materials and mixtures, operating procedures should ensure that under all normal and reasonably predictable conditions, these materials and mixtures are not within explosive limits. Category 3 is considered appropriate for the avoidance of ignition in the case of a rare malfunction which allows flammable materials or mixtures to pass through the pump while within their explosive limits.

- When flammable or pyrophoric materials are present within the equipment you must:
  - Not allow air to enter the equipment.
  - Ensure that the system is leak tight.
  - Use an inert gas purge (for example, a nitrogen purge) to dilute any flammable gases or vapours entering the pump inlet, and/or use an inert gas purge to reduce the concentration of flammable gases or vapours in the pump and in the exhaust pipeline to less than one quarter of the gases' published lower explosive limits (LEL).

- For further information, please contact BOC Edwards: refer to the Addresses page at the end of this manual for details of your nearest BOC Edwards company.

1.3 Description

1.3.1 Overview

The QDP pumps operate at pressures between atmospheric and ultimate vacuum with no lubricating or sealing fluid in the pumping chamber. This ensures a clean pumping system without back-migration of oil into the system being evacuated.

QDP pumps have enclosed, water-cooled motors and are therefore suitable for applications in clean environments where fan cooling is unacceptable.

The QDP pumps are each fitted with a gas system, exhaust-silencer and check-valve. The pump is fixed to the framework by vibration isolators. The framework has castors and levelling feet.

1.3.2 The QDP pump

The QDP pumps are four-stage, positive displacement rotary pumps in which pairs of intermeshing rotors (of different profiles mounted on common shafts) are held in correct phase relation by a pair of timing-gears. The timing-gears and the adjacent double-row angular contact ball-bearings, are oil lubricated.

The pump shafts and rotors are made from cast-iron. The internal and external shaft-seals on the motor drive-shaft are made of polytetrafluoroethylene (PTFE). Bearings are located on the high vacuum end of the shaft, near to the pump-inlet. These bearings are packed with perfluoropolyether (PFPE) grease.

1.3.3 Gas system

QDP pumps have a gas system of stainless steel pipelines (see Figure 1) which allows nitrogen to be delivered to the following points :

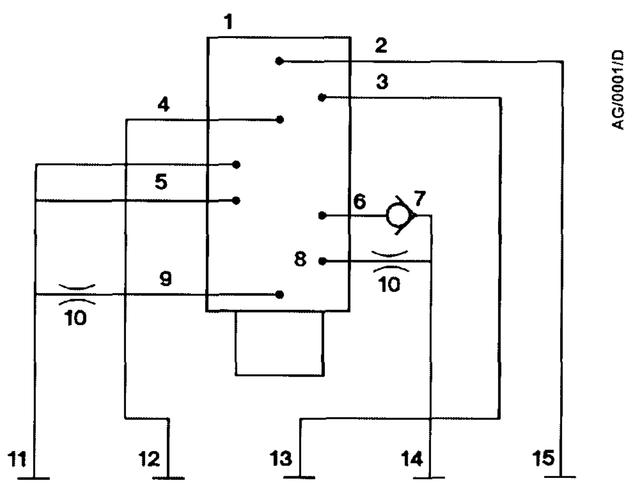
- Inlet-purge
- Shaft-seal purge
- 2/3-interstage purge
- Exhaust-purge
- 3/4-interstage purge.

You will connect your nitrogen supplies to this gas system through connectors on the gas services panel (see Figure 2).

1.3.4 Temperature control system

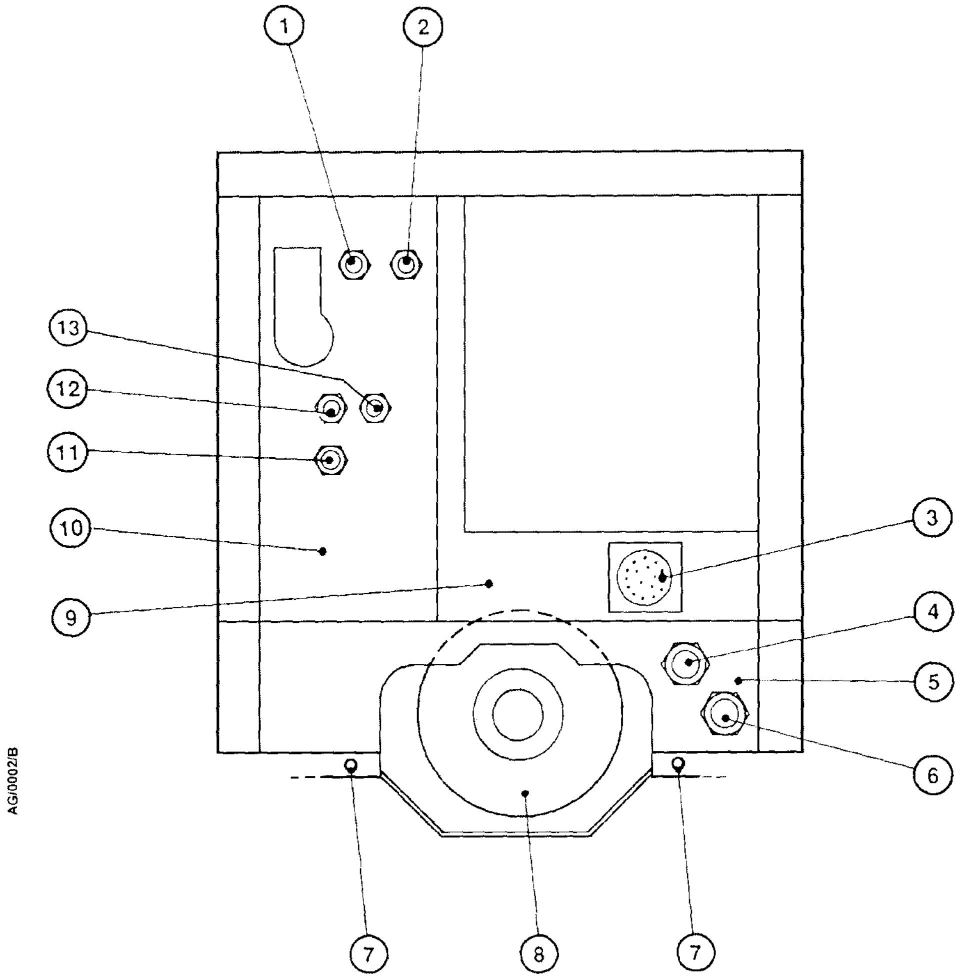
The low vacuum stage of the pump has an indirect cooling system, all other stages are air-cooled by natural convection and radiation. In the secondary circuit of the indirect cooling system, coolant circulates around the pump-body by natural convection. In the primary circuit, cooling-water is circulated through copper coils to extract heat from the coolant. In operation, the pump is maintained at a constant temperature by a thermostatic control-valve (TCV) which controls the supply of cooling-water to the primary circuit in the pump.

(Continued on page 6)



1.	QDP pump	8.	Gearbox vent
2.	Inlet-purge pipeline	9.	Motor shaft-seals purge pipeline
3.	2/3-interstage purge pipeline	10.	Restrictor
4.	3/4-interstage purge pipeline	11.	Shaft-seals purge inlet connector
5.	Pump shaft-seals purge pipeline	12.	3/4-interstage purge inlet connector
6.	Exhaust-purge pipeline	13.	2/3-interstage purge inlet connector
7.	Check-valve	14.	Exhaust-purge inlet connector
		15.	Inlet-purge inlet connector

Figure 1 - Schematic diagram of the gas system



1. Exhaust-purge inlet connector
2. Inlet-purge inlet connector
3. 17-way electrical connector
4. Water return connector
5. Water services panel
6. Water supply connector
7. Exhaust support-plate retaining screw
8. Exhaust silencer
9. Electrical services panel
10. Gas services panel
11. 3/4-interstage purge inlet connector
12. Shaft-seals purge inlet connector
13. 2/3-interstage purge inlet connector

Figure 2 - Services panels

The pump-motor is cooled by water flowing through a cooling jacket which surrounds the motor. The pump-motor cooling circuit is separate from the pump cooling circuit. The cooling-water supply and return pipelines are connected to the pump by connectors on the water services panel at one end of the pump (see Figure 2).

The cooling-water manifold on the pump distributes the cooling-water to the pump cooling circuit and to the pump-motor cooling circuit (and to the QMB pump-motor cooling circuit, if a QMB pump is fitted). When a QMB pump is not fitted, the flow of cooling-water to the QDP pump-motor is greater than the minimum required flow. When a QMB pump is fitted, the cooling-water flow is distributed equally between the two pump-motors and the overall flow requirement for the pumping combination increases (see Section 2.3).

Two thermal snap-switches are fitted to the pump-body. One of these snap-switches (the warning switch) opens at 88 ^{o}C and the other snap-switch (the shut-down switch) opens at 95 ^{o}C. Use the warning switch to provide a warning that the pump is too hot. Use the shut-down switch to shut down the pump.

Three motor-protection thermistors are fitted to the pump-motor (one on each winding). These thermistors are solid-state devices which have an electrical resistance of 100 to 500 Ω at normal pump-motor operational temperature. When the pump-motor is too hot, the electrical resistance rises quickly to 3000 Ω. The thermistors are connected in series and you can use the output of the thermistors to shut down the pump because the motor is too hot.

1.3.5 Electrical system

The QDP pumps have universal voltage and frequency motors. These motors are supplied configured for 'low voltage' operation (200-208 V at 50 Hz or 200-230 V at 60 Hz). To change the motor to 'high voltage' operation, refer to Section 3.8.2.

You will connect your electrical supply cable to the pump through a cable-gland on the terminal-box on the end of the pump-motor (see Figure 11). You must use a suitably rated contactor (see Section 2.4). The electrical services panel has a connector to connect the outputs of the thermal snap-switches and the motor-protection thermistors to your control equipment.

1.3.6 Exhaust system

The pump outlet is connected to an exhaust-silencer, which is below the pump. The outlet also has a port which allows gearbox vent gases to join the main exhaust stream (see Figure 1). The exhaust-silencer attenuates the pulses in the exhaust pressure and reduces pump-induced resonance in your exhaust-extraction system. The outlet of the silencer has a check-valve which prevents the suck-back of exhaust vapours after the pump is shut down. The valve also provides additional attenuation of the pulses in the exhaust pressure.

1.4 Accessories

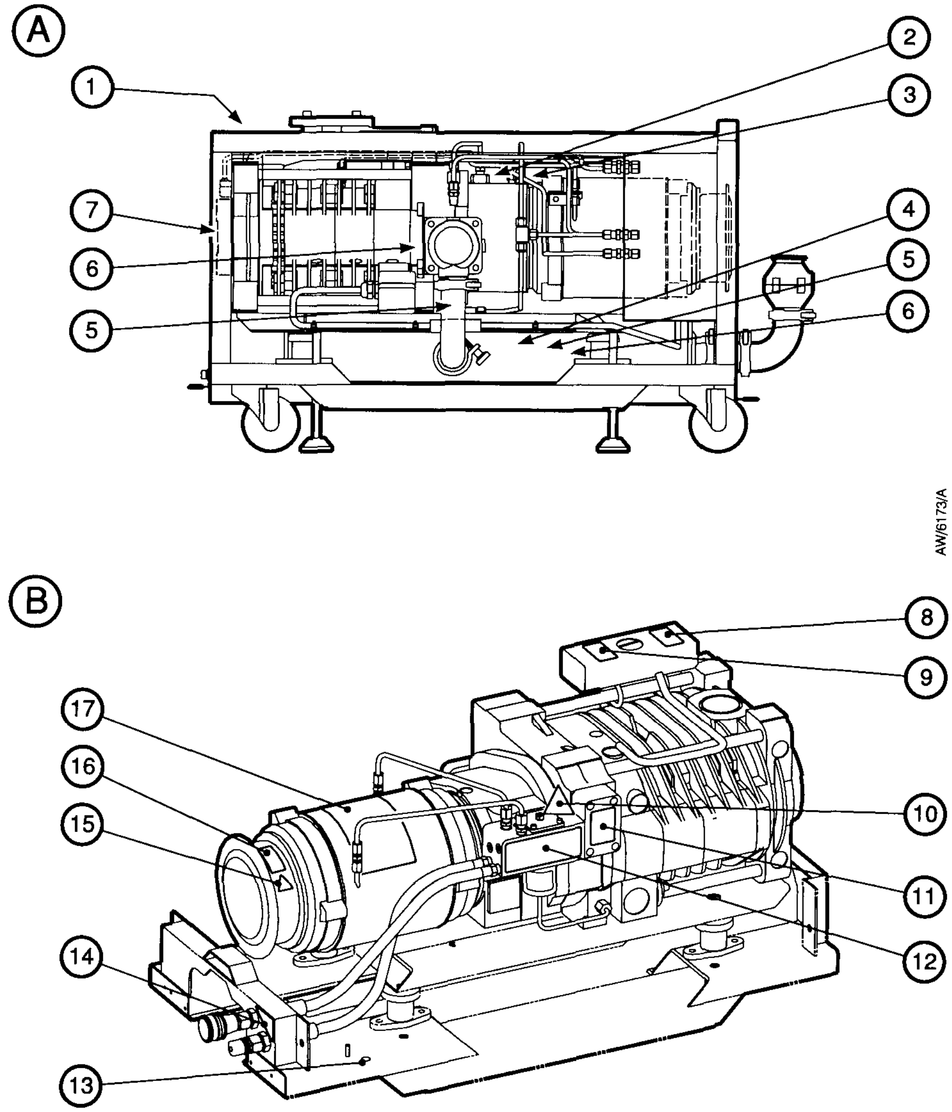
A number of accessories are available for the QDP pump; use these to configure the pumps for specific applications. These accessories are listed in Section 7.

1.5 Labels

Labels are fitted to the QDP pump in order to:

- Identify components.
- Define required installation/operating/maintenance procedures.
- Identify safety hazards.

Refer to Figure 3 which shows the positions of the labels on the QDP pump.



A General view of the QDP pump
B Detail view of the QDP pump

1. 'Warning - Maximum lifting angle 60°' label
2. 'Caution - Do not overfill with oil' label
3. 'Use only Fomblin Y25 or Krytox 1525 oil' label
4. Direction of gas flow arrow label
5. Caution symbol label
6. 'Warning - Risk of high temperature' label
7. QDP information/'Warning - Risk of high temperature' label
8. 'Caution - For safe operation, this equipment must be installed, operated and maintained in accordance with the instruction manual' label
9. 'Caution - Do not overfill with coolant' label
10. 'Caution - Valve is factory preset' label
11. 'Caution - Read instruction manual before adjusting valve' label
12. 'Supply In/Out / Bleed air: lift' label
13. Protective earth (ground) symbol label
14. Water In/Out label
15. 'Warning - Risk of electric shock' label
16. Direction of rotation arrow label
17. QDP motor rating information label

Figure 3 - Positions of the labels on the QDP pump

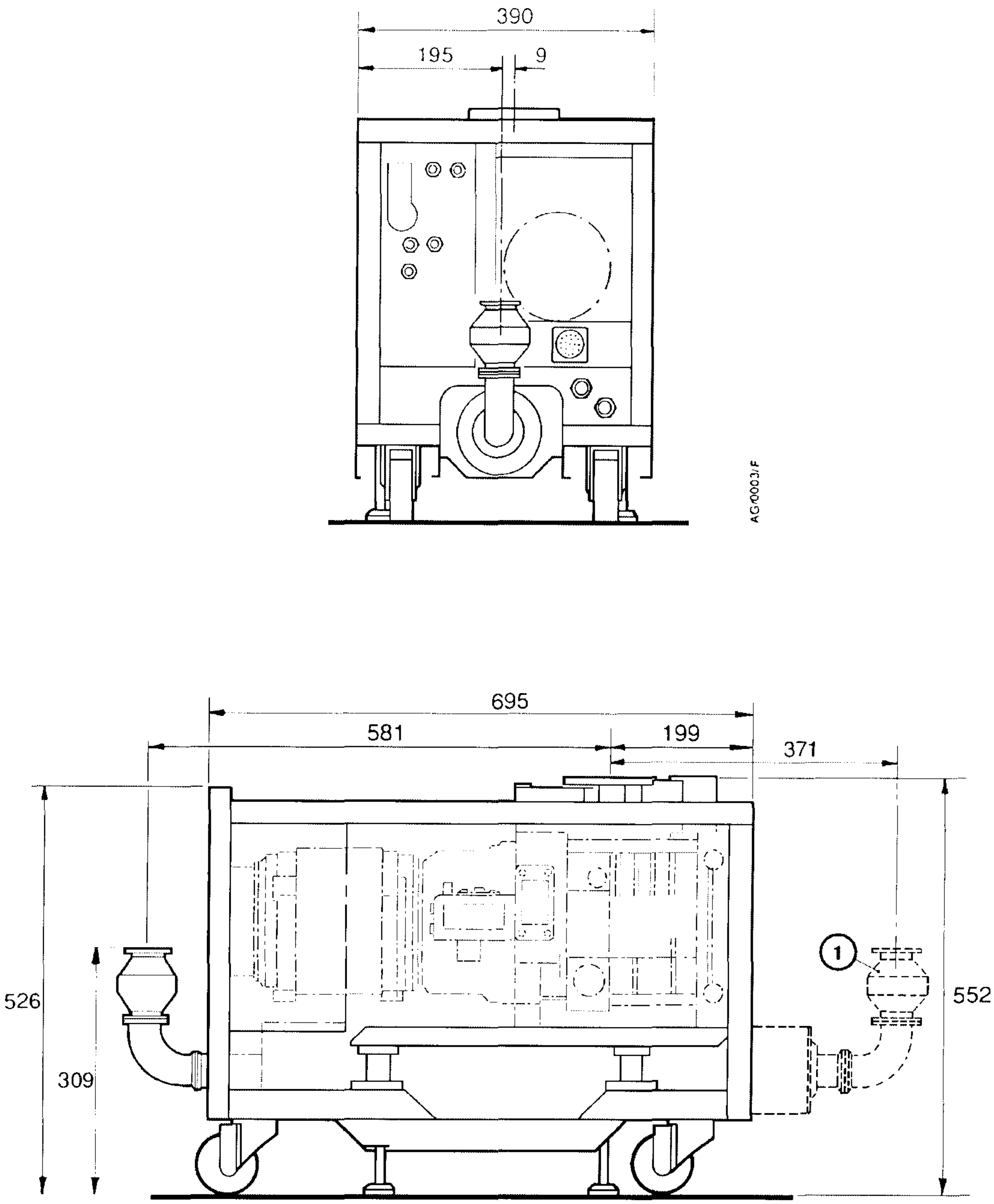
2 TECHNICAL DATA

2.1 General

	QDP40	QDP80 (4 kW and 6 kW)
Overall dimensions	See Figure 4	See Figure 5
Mass	172 kg	202 kg
Motor rating	2.2 kW	4 kW/6 kW
Warm-up time to nominal performance	15 min	15 min
Inlet connections	ISO40	ISO63
Outlet connections	NW40	NW40
Vacuum system maximum leak-rate	1×10^{-5} mbar l s^{-1} (1×10^{-3} Pa l s^{-1})	1×10^{-5} mbar l s^{-1} (1×10^{-3} Pa l s^{-1})
Exhaust system maximum leak-rate	1×10^{-5} mbar l s^{-1} (1×10^{-3} Pa l s^{-1})	1×10^{-5} mbar l s^{-1} (1×10^{-3} Pa l s^{-1})
Ambient operating temperature range	5 to 40 °C	5 to 40 °C
Maximum ambient operating humidity	90% RH	90% RH
Protection degree (as defined by IEC 529)	IP44	IP44
Continuous A-weighted sound pressure level (at 1 meter)	< 70 dB(A)	< 70 dB(A)

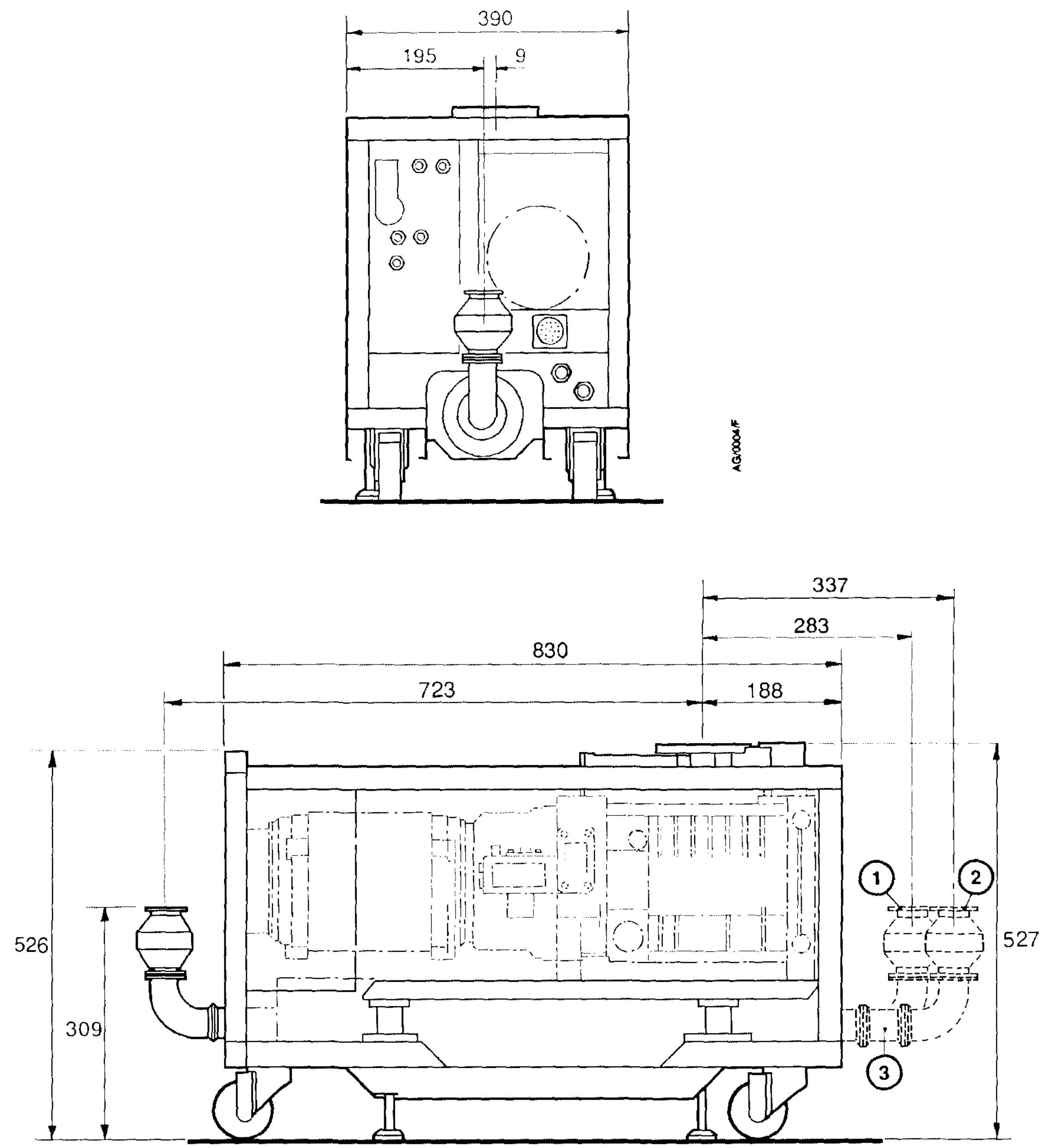
2.2 Performance data

	QDP40	QDP80 (4 kW and 6 kW)
Pumping speed range	See Figure 6	See Figure 7
Power curves	See Figure 8	See Figure 9
Typical peak pumping speed		
50 Hz	44 $m^3 h^{-1}$	80 $m^3 h^{-1}$
60 Hz	55 $m^3 h^{-1}$	96 $m^3 h^{-1}$
Displacement (swept volume)		
50 Hz	52 $m^3 h^{-1}$	91.5 $m^3 h^{-1}$
60 Hz	62.4 $m^3 h^{-1}$	109.8 $m^3 h^{-1}$
Typical ultimate vacuum without gas-ballast		
50 Hz	5×10^{-2} mbar (5×10^{0} Pa)	3×10^{-2} mbar (3×10^{0} Pa)
60 Hz	3×10^{-2} mbar (3×10^{0} Pa)	3×10^{-2} mbar (3×10^{0} Pa)



1. Alternative outlet position

Figure 4 - QDP40 Pump dimensions without enclosures (mm)



1. Alternative outlet position (without adaptor fitted)
2. Alternative outlet position (with adaptor fitted)
3. Adaptor

Figure 5 - QDP80 Pump dimensions without enclosures (mm)

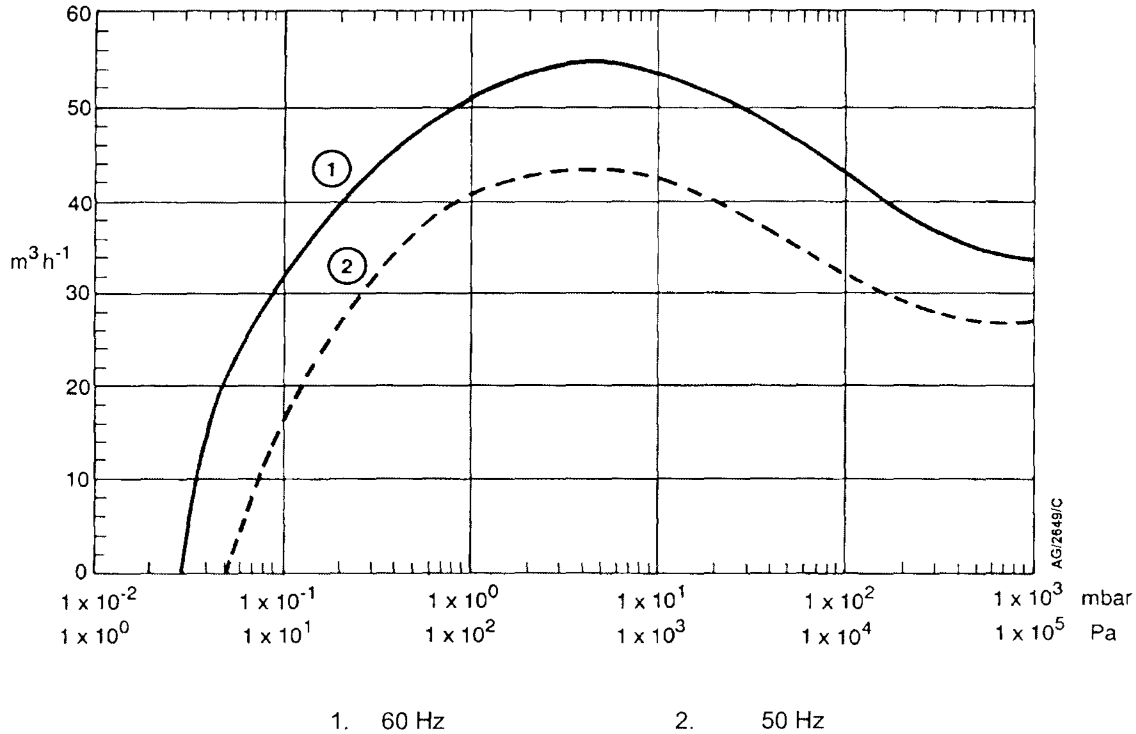


Figure 6 - Typical pumping speeds for QDP40: pumping speed against pressure

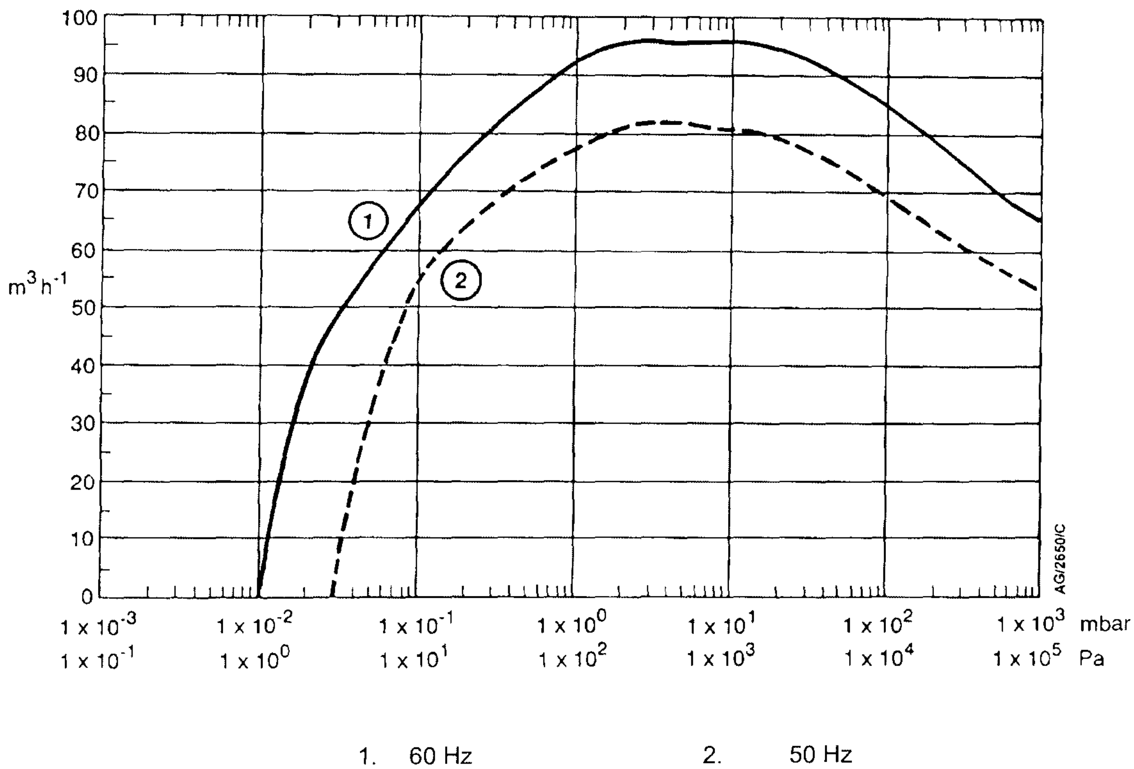
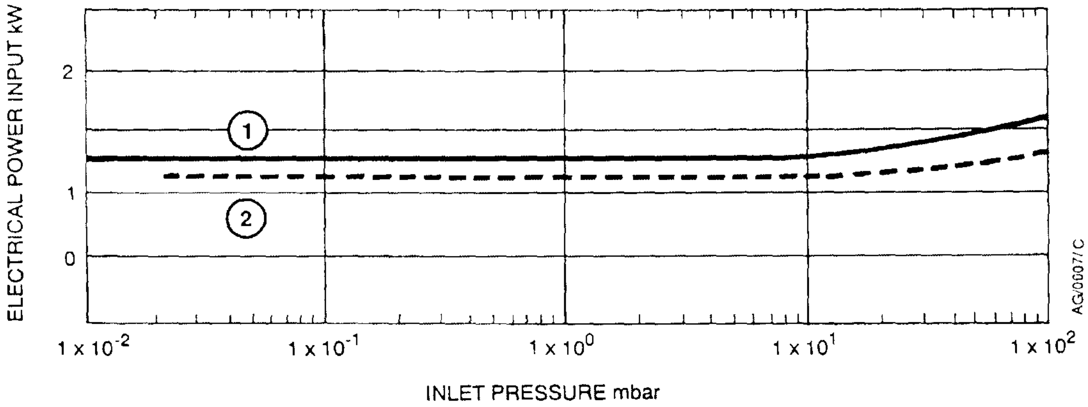
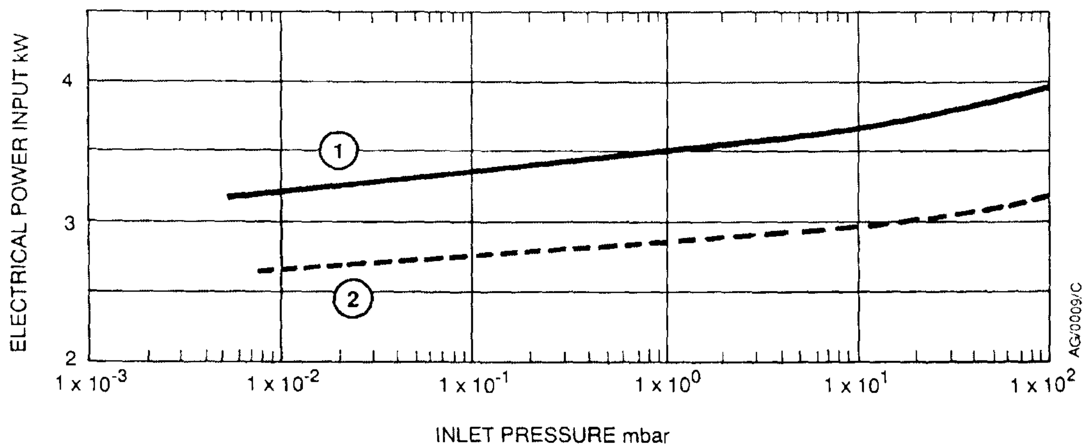


Figure 7 - Typical pumping speeds for QDP80: pumping speed against pressure



1. 60 Hz power curve 2. 50 Hz power curve

Figure 8 - QDP40 Power curves



1. 60 Hz power curve 2. 50 Hz power curve

Figure 9 - QDP80 Power curves

2.3 Services

Note: The motors are supplied configured for low voltage operation (200-208 V at 50 Hz or 200-230 V at 60 Hz). To change the motor to high voltage operation (380-415 V at 50 Hz or 460 V at 60 Hz), refer to Section 3.8.2.

Electrical supply	
Supply voltage	200-208/380-415 V at 50 Hz, 3-phase 200-230/460 V at 60 Hz, 3-phase
Voltage tolerance	±10% (except for 208 V and 415 V at 50 Hz which are +6% and -10%)
Cooling-water	
Maximum supply pressure	100 psi (6.9 bar absolute, 6.9×10^5 Pa)
Minimum required pressure differential across supply and return	30 psi (2.1×10^5 Pa)
Typical heat removed from pump	1.75 kW (QDP40), 2.75 kW (QDP80)
Maximum water consumption	See Table 1
Maximum particle size in supply	0.03 mm^2
Nitrogen supply	
Supply pressures and flow rates	For recommendations, see Table 2
Fittings type	$^1/_4$ inch compression

Pump operating temperature (measured at the thermal snap-switch position)	Maximum water consumption at ultimate vacuum with 50 Hz electrical supply, cooling-water supply temperature of 20 °C and a pressure differential across the supply and return of 30 psi (2.1×10^5 Pa)	
	QDP40	QDP80
55 °C	300 l h^{-1}	324 l h^{-1}
70 °C	150 l h^{-1}	165 l h^{-1}
90 °C *	135 l h^{-1}	126 l h^{-1}

* The 88° thermal snap-switch must be configured to provide warning only, or you must fit the high temperature thermal snap-switch kit: see Section 7.4.

Table 1 - Maximum cooling-water consumption

		Shaft-seals purge	3/4-inter-stage purge	2/3-inter-stage purge	Inlet-purge	Exhaust-purge
Supply pressure (min)		8 psig (1.55×10^5 Pa)	-	-	-	-
Supply pressure (max)		10 psig (1.69×10^5 Pa)	-	-	-	-
Flow rate (l min^{-1})	QDP40	25 (max)	20 (max)	5 (max)	25 (max)	5 (typical)
	QDP80	25 (max)	25 (max)	10 (max)	25 (max)	5 (typical)

Table 2 - Recommended nitrogen supply pressures and flow rates

2.4 Full load current ratings

Supply voltage and frequency		200-208 V 50 Hz	200-208 V 60 Hz	230 V 60 Hz	380-415 V 50 Hz	460 V 60 Hz
QDP40 Pump	Full load (A)	8.7	8.8	7.8	5.0	4.4
	Rating (kW)	2.2	2.2	2.2	2.2	2.2
QDP80 Pump (4 kW)	Full load (A)	16.0	16.0	14.2	8.0	8.0
	Rating (kW)	4.0	4.0	4.0	4.0	4.0
QDP80 Pump (6 kW)	Full load (A)	18.9	22.2	19.7	9.5	9.9
	Rating (kW)	5.0	6.0	6.0	5.0	6.0

Table 3 - Full load current ratings

2.5 Temperature control system

Note: A BOC Edwards Material Safety Data Sheet for the coolant used in the QDP pump is available on request.

Water-cooling system	
Type	Indirect water-to-coolant heat exchanger
Coolant capacity	1.7 litres
Thermostatic control-valve	
Manufacturer	Danfoss
Model	AVTA DN15
Part number	003N2110
Working temperature range	50 to 90 °C
Maximum sensor temperature	130 °C
Thermal snap-switches	
Manufacturer	Fenwal Inc
Model	08-02
Opening temperatures	88 °C (warning switch) 95 °C (shut-down switch)
Closing temperatures	78 °C (warning switch) 85 °C (shut-down switch)
Contact rating	
Maximum voltage	240 V
Maximum current (inductive load)	6.3 A
Maximum current (resistive load)	12 A
Motor-protection thermistors	
Type	Positive temperature coefficient
Reference temperature	160 °C
Compliant with	IEC 34-11 (BS4999 part 111)
Recommended control-unit	To comply with IEC 34-11 (BS4999 part 111)
Relay contact rating	Suitable for use with your contactor

2.6 Electrical connectors

17-way connector	
Pump half	MS type, CA3100E20-29P/F80
Cable half	MS type, CA3106E20-29S

2.7 Lubrication system

Note: BOC Edwards Material Safety Data Sheets for the oils and greases referenced below are available on request.

2.7.1 Gearbox

Oil capacity	0.4 litres
Grade of oil	SAE 40
ISO viscosity grade	150
Recommended perfluoropolyether oils	Fomblin Y25, Krytox 1525

2.7.2 High vacuum bearings

Grease type	Perfluoropolyether
Recommended grease	Fomblin RT15

2.8 Exhaust system

2.8.1 Exhaust-silencer

Gas temperature	5 to 150 ^{o}C
Exhaust pulsation attenuation	30 dB(A)
Mass	5.5 kg

2.8.2 Exhaust check-valve

Gas temperature	5 to 130 ^{o}C
Reverse flow leak tightness when clean (minimum)	0.4 mbar l s^{-1} (4 x 10^{1} Pa l s^{-1})
Mass	0.95 kg

3 INSTALLATION

3.1 Safety

> WARNING
>
> Obey the safety instructions given below and take note of appropriate precautions. If you do not, you can cause injury to people and damage to equipment

- A suitably trained and supervised technician must install the QDP pump.
- Ensure that the installation technician is familiar with the safety procedures which relate to the products pumped. Wear the appropriate safety-clothing when you come into contact with contaminated components. Dismantle and clean contaminated components inside a fume-cupboard.
- Vent and purge the process system (if the QDP Pump is replace an existing pump) with nitrogen for 15 minutes before you start installation work.
- Disconnect the other components in the pumping system from the electrical supply so that they cannot be operated accidentally.
- Do not reuse any 'O' ring or 'O' ring assembly, and do not allow debris to get into the QDP pump during installation.
- Wipe up any water or oil spilt during installation, so that people cannot slip over any spillages.
- Safely route and secure cables, hoses and pipes during installation, so that people cannot trip over them.
- Do not remove the temporary cover or the blanking-plate from the pump inlet-flange until you are ready to connect the pump to your vacuum system. Do not operate the pump unless the inlet blanking-plate is fitted, or the pump is connected to your vacuum system.
- Do not remove the temporary cover or the blanking-plate from the exhaust-silencer outlet until you are ready to connect the pump to your exhaust system. Do not operate the pump unless the pump is connected to your exhaust system.
- Obey all local and national rules and safety regulations when you install the pump.
- Consult BOC Edwards publication P300-20-000 (Vacuum Pump and Vacuum System Safety) before you pump hazardous materials. This publication is available on request: contact your supplier or BOC Edwards.

3.2 Unpack and inspect

> WARNING
>
> Ensure that the maximum angle between paired slings used to lift the pump is 60°.

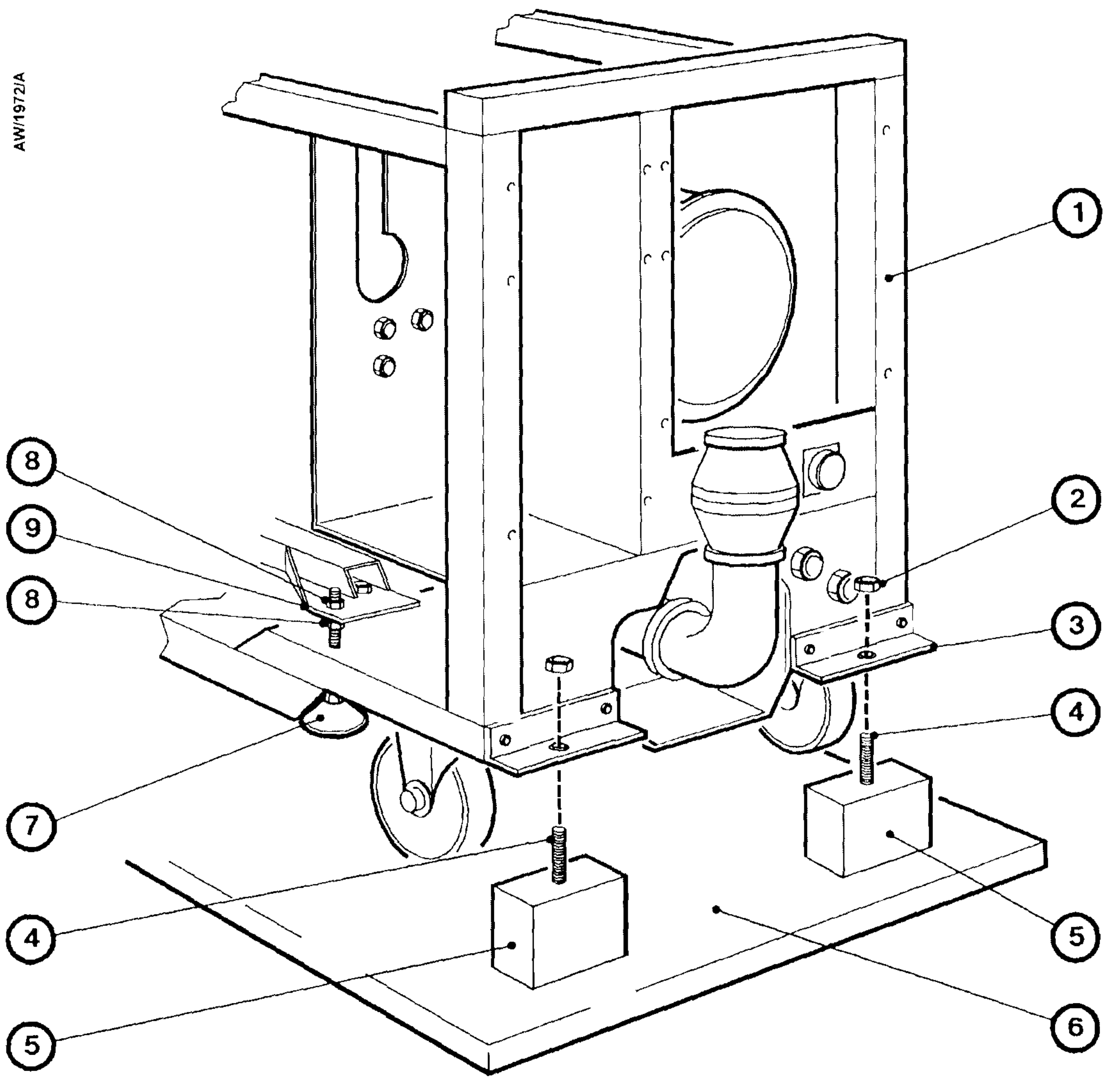
1. Place the pallet in a convenient position with a fork-lift truck or a pallet truck.
2. Remove the staples which secure the cardboard box to the pallet then remove the cardboard box; alternatively, open the top of the cardboard box. Tear open the foil bag around the pump.
3. Refer to Figure 10. Remove the two nuts and washers (2) which secure the front of the pump to the pallet. Dispose of the nuts and washers. Remove the two nuts and washers (2) which secure the rear of the pump to the pallet.
4. Use suitable lifting-equipment to remove the pump from its pallet. Do not try to lift the pump by hand (see Section 2 for the mass of the pump).
5. Inspect the pump. If the pump or any other item is damaged, notify your supplier and the carrier in writing within three days; state the Item Number of the pump together with your order number and your supplier's invoice number. Retain all packing materials for inspection. Do not use the pump if it is damaged.
6. Check that the pallet contains the items listed in Table 4. If any of these items is missing, notify your supplier in writing within three days.
7. If the pump is not to be used immediately, replace the packing materials. Store the pump in suitable conditions as described in Section 6.

Qty	Description	Check (✓)
1	QDP Pump	❑
1	General fitting-kit	❑

Table 4 - Checklist of components

3.3 Height adjustment

The height of the pump-inlet from the ground can be lowered by 6 mm. To lower the pump-inlet, remove each of the castors and then remove the spacer plate between each castor and the pump frame. Refit the castors with 16 mm long M8 cap-head bolts.



1. QDP pump frame
2. Nut and washer
3. Bracket
4. Stud
5. Block
6. Pallet
7. Levelling foot
8. Nut and washer
9. Bracket

Figure 10 - Remove the pump from the pallet

3.4 Check the coolant-level

1. Refer to Figure 11. Unscrew and remove the combined filler-plug/level indicator (5). Use a clean lint-free cloth to wipe the shaft of the indicator, then replace the combined filler-plug/level indicator in the coolant header-tank.
2. Remove the combined filler-plug/level indicator again and check the coolant-level: the coolant-level must be visible on the shaft of the indicator, but must not be above the notch mark on the indicator shaft.
3. If necessary, add more coolant: refer to Section 5.4.
4. Check that the bonded seal on the combined filler-plug/level indicator (5) is in place. Refit and tighten the combined filler-plug/level indicator.

3.5 Check the gearbox oil-level

Check that the gearbox oil-level is correct; the oil-level must be between the MIN and MAX marks on the bezel of the oil-level sight-glass (see Figure 11). If necessary, drain excess oil from the pump or fill the pump with oil: refer to Section 5.3.

3.6 Locate the pump

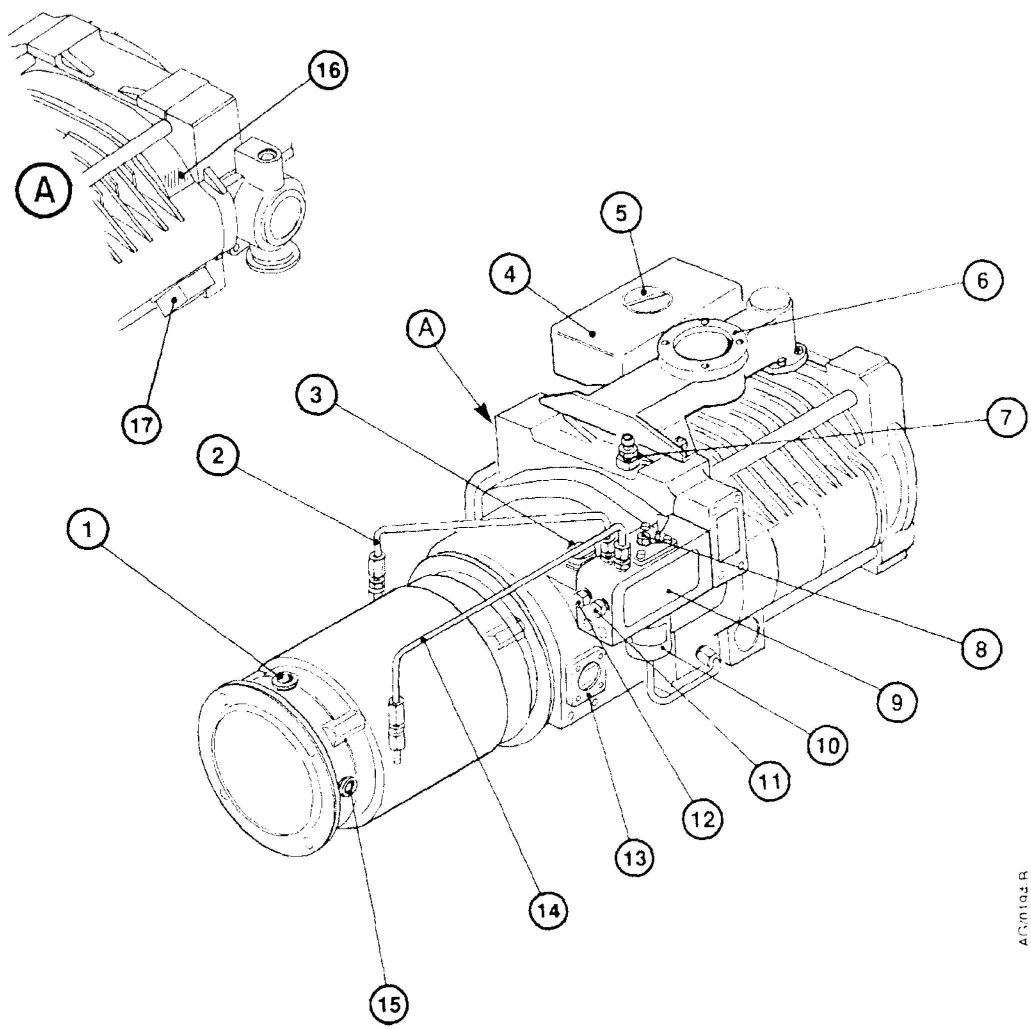
1. Refer to Figure 10. Remove the nuts and washers (8) fitted to the top of the four levelling feet (7), then retract the levelling feet.
2. Wheel the pump on its castors to move the pump into its operating position. The QDP pump must be located on a firm, level surface.
3. Once located in its final operating position, adjust the levelling feet to make sure that the QDP pump is level and is not supported by the castors.

3.7 Connect to your emergency stop system

The QDP pump must be connected to an emergency stop facility. The operation of the emergency stop function should immediately disconnect power from the pump when the emergency stop control is operated. Returning the emergency stop control to its normal position should not result in power being re-applied to the QDP pump; a separate start or reset control should be used for this.

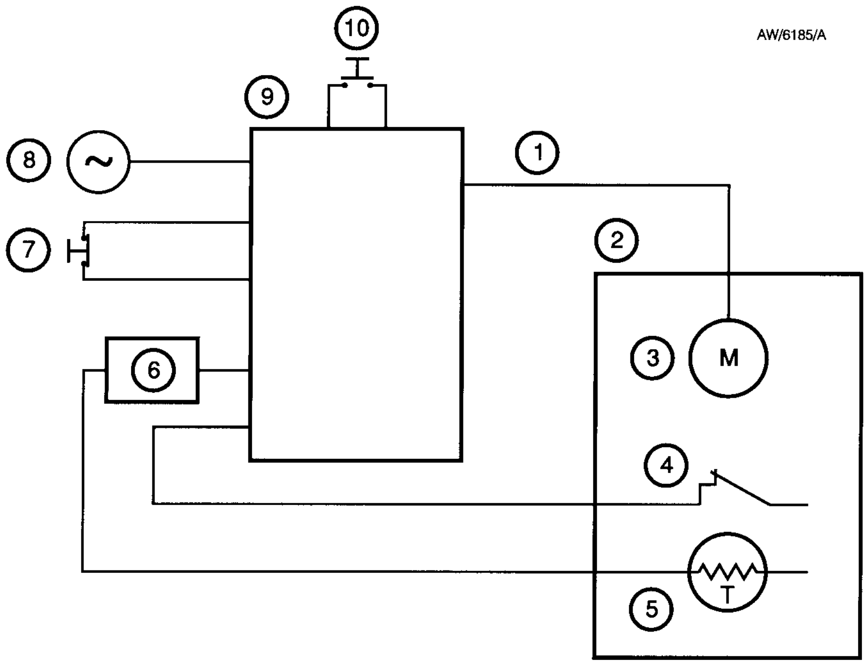
The shut-down thermal snap-switch and excess temperature detected by the motor winding thermistors should also be connected to an emergency stop facility to cause the QDP pump to stop immediately, in the same way as the emergency stop function.

Refer to Figure 12 and to Section 3.8 for more information about the electrical connections.



1.	Electrical supply cable-gland	9.	Cooling-water manifold
2.	Pump-motor cooling-water pipe	10.	Thermostatic control-valve (TCV)
3.	Oil filler-plug	11.	Cap (over QMB water return connection)
4.	Coolant header-tank	12.	Cap (over QMB water supply connection)
5.	Combiner filler-plug/ level indicator	13.	Oil-level sight-glass
		14.	Pump-motor cooling-water pipe
6.	Inlet	15.	Thermistors cable-gland
7.	Air bleed-valve	16.	Temperature measurement point
8.	TCV adjuster spindle	17.	Thermal snap-switch box

Figure 11 - Cooling system and lubrication system components



1. Electrical supply to QDP pump-motor
2. QDP pump
3. QDP pump-motor
4. Thermal snap-switch
5. Motor-protection thermistors
6. Thermistor interface
7. Emergency stop control
8. External electrical supply
9. Emergency stop system
10. Reset/start controls

Figure 12 - Schematic diagram of the emergency stop system

3.8 Electrical connections

WARNING

If you use gas dilution as a safety feature of your system, you must fit a suitable alarm and interlock system to prevent operation of the QDP pump when the gas dilution system does not work. If you do not, the concentration of dangerous process gases in the exhaust of the pump may (without warning) exceed safe limits and may cause an explosion or injury to people.

WARNING

Use a suitable cable-gland so that the seal of the electrical cable entry into the motor terminal-box meets the requirements of IP44 in IEC 529. If you do not, condensation may form inside the terminal-box and there may be a risk of electric shock.

WARNING

Do not turn on the cooling-water supply until after you complete the electrical installation of the pump. If you do, condensation may form inside the motor terminal-box and there may be a risk of electric shock.

3.8.1 17-way connector

There is a 17-way connector (Figure 2, item 3) on the electrical services panel for the outputs from the thermal snap-switches and the motor-protection thermistors. The connector may also be used to carry electrical supplies and signals to pump accessories (refer to the instruction manual supplied with your accessory). A wiring diagram for the connector is shown in Figure 13; all of the wiring shown in this figure is inside the QDP frame.

Note also that:

- A mating-half for the 17-way connector is not supplied with the pump: refer to Section 7.3 for the Item Number of the connector mating-half.
- A 3-way mating-half for the flow-switch link (3) is supplied fitted to the connector on the flying leads in the pump. You must remove this link if you fit a flow-switch.
- A 2-way mating-half for the QMB thermistors electrical connector (4) is supplied fitted to the connector on the flying leads in the pump. If you fit a QMB mechanical booster pump, you must remove the link from the mating-half and connect the QMB thermistors through the mating-half of this 2-way connector.

We recommend that you use the pins of the 17-way connector as shown in Table 5 (see page 19).

Pins	Wire colour	Use
A and B	Red	Enclosure interlock and/or emergency off
C	Green/Yellow	Thermal snap-switch earth (ground)
D and N	D: brown, N: Blue	Oil-level monitor control (if required)
E and F	Black	Warning (88 °C) thermal snap-switch
G and H	Black	Shut-down (95 °C) thermal snap-switch
J and K	Black	Not assigned to a specific accessory
L and M	Black	Oil-level monitor outputs
P and R	White	QMB motor-protection thermistor outputs
S and T	S: Blue, T: Brown	QDP motor-protection thermistor outputs

Table 5 - 17-way connector pins

3.8.2 High and low voltage operation

The universal voltage and frequency motors are supplied configured for 'low voltage' operation (200-208 V at 50 Hz or 200-230 V at 60 Hz). Figures 14 and 16 show the low voltage configurations for the QDP40 and QDP80 Pumps.

To change the QDP40 Pump-motor to 'high voltage' operation (380-415 V at 50 Hz or 460 V at 60 Hz), remove the pump-motor terminal-box cover, then remove the three links from the U, V and W terminals. Link the U1, V1 and W1 terminals as shown in Figure 15.

To change the QDP80 Pump-motor to 'high voltage' operation, remove the pump-motor terminal-box cover, then remove the wires from the U1, V1 and W1 terminals. Reconnect the wires to the W2, U2 and V2 terminals as shown in Figure 17.

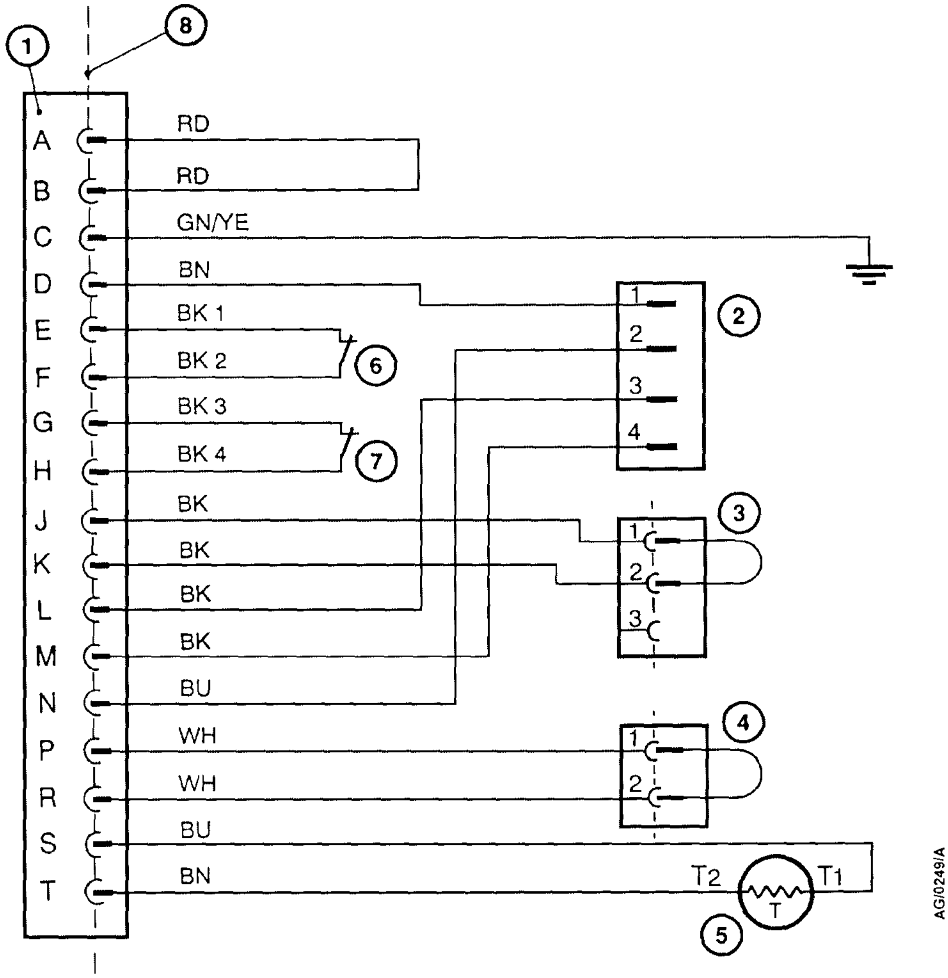
3.8.3 Connect the electrical supply

> CAUTION
>
> The motor must be correctly configured and you must make the correct electrical connections for your electrical supply. If you do not, you can damage the motor.

Connect the motor to the electrical supply as described below. Connect the supply through a contactor which has overload-protection, or use a controller which incorporates a contactor. You must use a contactor which has a manual reset control. If you do not, the pump could automatically restart after an electrical overload or an electrical supply failure.

1. Remove the motor terminal-box cover.
2. Check your electrical supply voltage and frequency. If necessary, configure the motor to operate with your supply voltage (see Section 3.8.2).
3. Remove the plug from the cable entry-hole.

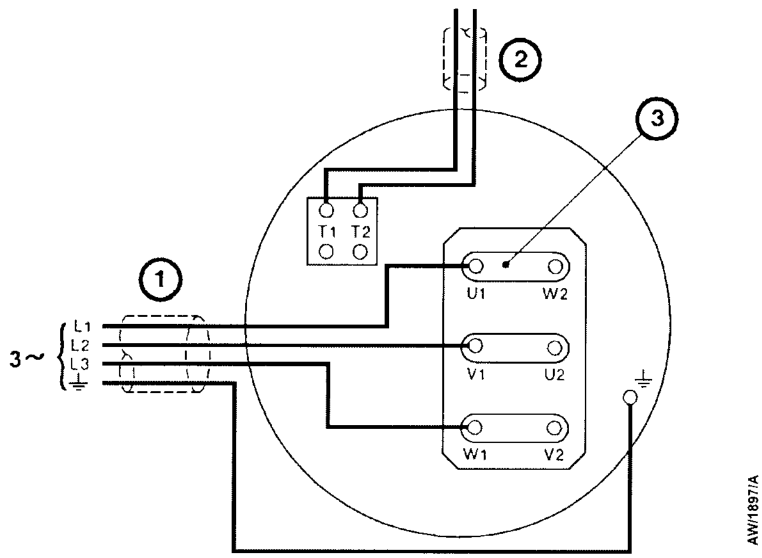
(Continued on page 28)



1. 17-way connector
2. Electrical connector (oil-level monitor)
3. Electrical connector (flow-switch)
4. Electrical connector (QMB thermistors)
5. QDP thermistors
6. Warning thermal snap-switch
7. Shut-down thermal snap-switch
8. QDP electrical services panel

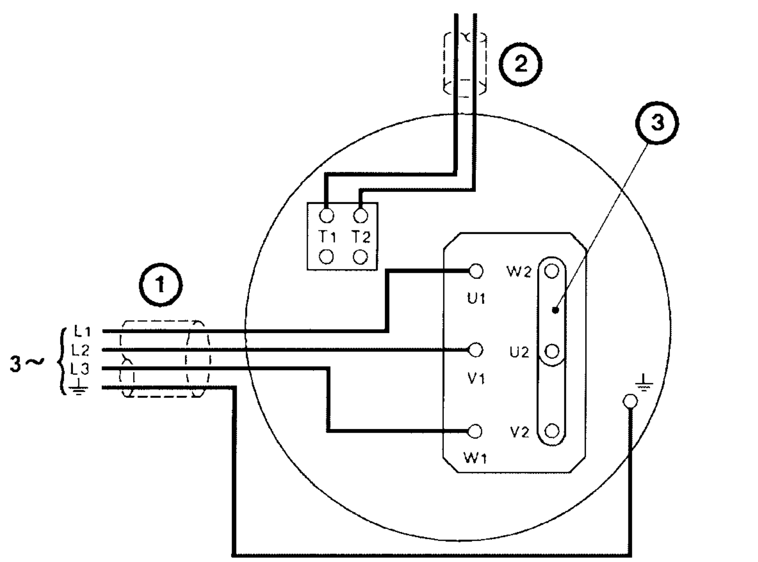
Wire colour codes:
BK Black
BN Brown
BU Blue
GN Green
RD Red
WH White
YE Yellow

Figure 13 - 17-way connector wiring



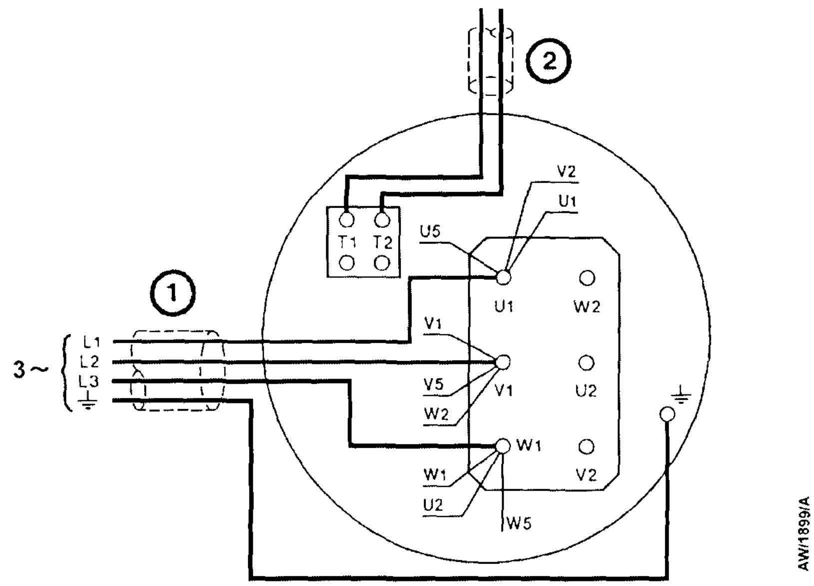
1. To electrical supply
2. To 17-way connector on electrical services panel
3. Links

Figure 14 - QDP40 low voltage configuration



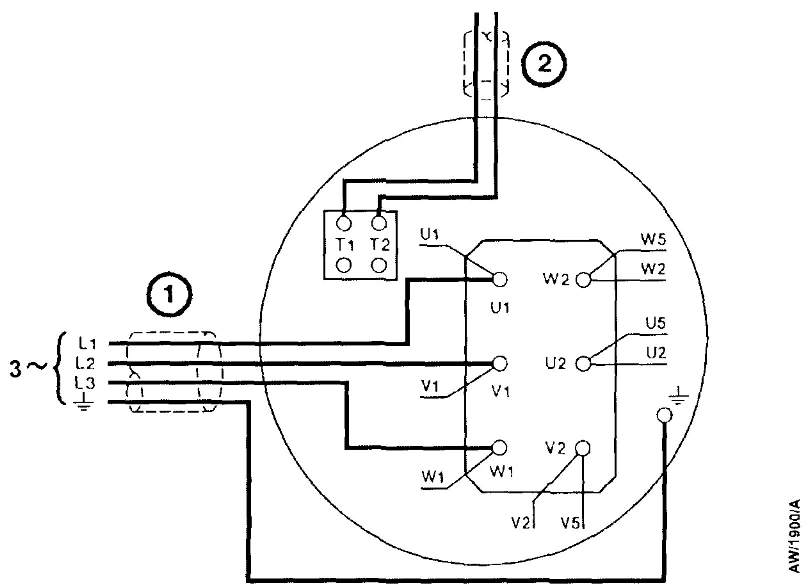
1. To electrical supply
2. To 17-way connector on electrical services panel
3. Links

Figure 15 - QDP40 high voltage configuration



1. To electrical supply
2. To 17-way connector on electrical services panel

Figure 16 - QDP80 low voltage configuration



1. To electrical supply
2. To 17-way connector on electrical services panel

Figure 17 - QDP80 high voltage configuration

4. Fit a suitable 20 mm cable-gland to the hole. If your cable is too large to pass through a 20 mm cable-gland, fit a 20 mm to 25 mm female thread-adaptor to the cable entry-hole, and fit a 25 mm cable-gland to the adaptor. The cable-gland (and adaptor, if fitted) must provide a protective seal to IP44 (or higher), as defined by IEC 529.

5. Pass the supply cable through the cable-gland and connect the wires of the electrical supply cable to the appropriate terminals (see Figures 14 to 17).

6. Tighten the cable-gland and refit the terminal-box cover.

3.8.4 Connect the thermal snap-switches

> WARNING
>
> Incorporate a manual reset device in your control equipment. If you do not (and a fault which causes the shut-down thermal snap-switch to open is not corrected), the pump will switch on again when it cools down.

You can connect the warning thermal snap-switch to your control equipment to provide an indication that the pump is too hot. Connect the shut-down thermal snap-switch to your control equipment to shut down the pump. Alternatively, you can connect the shut-down thermal snap-switch to the electrical-overload control-loop of your contactor. If you do this, the contactor will automatically switch off if the pump is too hot.

The thermal snap-switches will reset (that is, close again) when the pump cools down to a preset temperature (see Section 2). We therefore recommend that your control equipment incorporates a manual reset device to prevent the pump switching on again automatically when it cools down.

You can use a 17-way connector mating-half (not supplied: refer to Section 7.4) to connect the thermal snap-switches to your control equipment; Table 5 defines the functions of the pins.

3.8.5 Connect the motor-protection thermistors

Connect the output of the motor-protection thermistors to your control equipment to switch off the pump if the motor is too hot. Refer to Section 2 for the specification of a suitable control-unit. You can use a 17-way connector mating-half (not supplied: refer to Section 7.4) to connect the thermistors outputs to your control equipment; Table 5 defines the functions of the pins.

If you have a QMB mechanical booster pump in your pumping system, then :

- If you connect the QDP and QMB thermistors to a single control-unit (for example, a BOC Edwards Q Controller), you must connect the outputs in series not in parallel. The outputs must not be short-circuited by any links or jumpers.
- If you connect the QMB thermistor outputs directly to a BOC Edwards Q Controller (that is, you do not use the 17-way connector on the QDP), either make sure that pins P and R on the electrical connector on the QDP are not connected to the auxiliary socket of the Q Controller, or make sure that the mating-half of the 2-way QMB thermistors electrical connector is removed (refer to Section 3.8.1).

3.8.6 Check the pump rotation

Check the direction of pump rotation as described below.

1. Loosen the bolts which secure the blanking-plate to the pump-inlet.
2. Watch the pump-inlet blanking-plate and switch on the pump for one or two seconds, then switch the pump off. If the blanking-plate lifts from the inlet, the direction of rotation is incorrect. If the direction of rotation is incorrect, isolate the electrical supply and reverse any two of the electrical supply phase-wires in the pump-motor terminal-box.
3. Repeat the check to ensure that the direction of rotation is correct.

3.9 Fit a mechanical booster pump

If you want to use a mechanical booster pump, fit it now. Details of the connection kits available from BOC Edwards are given in Section 7. Refer to the installation procedures in the instruction manual supplied with the connection kit.

3.10 Connect the cooling-water supply

WARNING
Do not turn on the cooling-water supply until after you complete the electrical installation of the pump. If you do, condensation may form inside the motor terminal-box and there may be a risk of electric shock.

CAUTION
Drain the cooling-water from the pumping system, if you will transport or store it in conditions where the cooling-water could freeze. If you do not, cooling-water may freeze in the QDP pump and damage the pump.

Note: *If you will transport or store the pumping system in conditions where the cooling-water could freeze, you must ensure that all cooling-water is drained from the pumping system : refer to Section 6.1*

Connect the cooling-water supply as described below. If a QMB mechanical booster pump is fitted, you must connect the QMB cooling-water supply and return to the cooling-water manifold on the QDP as described in the instruction manual supplied with the QMB Connection Kit. When you connect the hoses between the QDP cooling-water manifold and the QMB pump, remove only the $^3/_8$ BSP caps on the manifold (Figure 11, items 11 and 12). Do not remove the $^3/_8$ to $^1/_4$ inch reducer fittings on the manifold.

If you need to connect more than one QDP pump to the water supply, you must connect them in parallel and not in series.

(Continued on page 30)

1. Take out the male and female type quick-release connectors from the general fitting-kit.
2. Fit these connectors to your cooling-water supply and return hoses with $^{3}/_{8}$ inch BSP male pipe fittings (which you must supply). Fit the female quick-release connector to the water supply hose and fit the male quick-release connector to the water return hose.
3. Remove the dust-caps from the cooling-water connectors on the water services panel (Figure 2, items 4 and 6).
4. Connect your water return pipe to the water return connector on the water services panel, then connect your water supply pipe to the water supply connector on the water services panel.
5. Turn on the cooling-water supply.
6. To bleed air out of the water cooling system, use a screwdriver to lift up the spindle on the top of the TCV (Figure 11, item 8) and hold it up for 15 to 30 seconds to allow a steady flow of water to establish. Do not turn the spindle against the locking-wire.
7. Check the water hoses, pipelines and connections to ensure that there are no leaks.
8. Turn off the water supply while you complete the remainder of the installation procedures.

3.11 Connect the nitrogen supply

WARNING

If your vacuum system is not suitable for pressures above atmospheric, you must install a suitable control-valve system. If you do not, your system could be pressurised up to the nitrogen supply pressure.

Connect nitrogen supplies to the pump through the five connectors on the gas services panel (see Figure 2). You must connect a nitrogen supply to the shaft-seals purge connector (Figure 2, item 12) for all QDP pump applications. Use the other gas pipelines according to your application.

The gas pipeline connections are $^{1}/_{4}$ inch compression fittings. Use rigid metal supply pipelines (such as stainless steel) with an outside diameter of $^{1}/_{4}$ inch. If you have an acoustic enclosure to fit, ensure that the pipelines will not obstruct the enclosure. Use the connectors in the general fitting-kit to connect your pipelines to the pump. If you have a gas module accessory, the necessary pipelines and connectors are supplied with the accessory.

Use a suitable regulator in the nitrogen supply pipeline to the shaft-seals purge to maintain a constant supply pressure of 8 psig (0.55 bar gauge, 3.8×10^{3} Pa) minimum and 10 psig (0.69 bar gauge, 6.9×10^{4} Pa) maximum.

If your vacuum system is not suitable for positive pressures, install an inlet-valve or nitrogen supply solenoid-valve, interlocked to the pump-motor electrical supply, to prevent over-pressurisation. To prevent over-pressurisation of the exhaust-line, install a facility to monitor the exhaust pressure and to cut off the nitrogen supply automatically if this pressure reaches 6 psi (4.1×10^{4} Pa).

3.12 Connect the pump to your vacuum system

When you connect your pump to the vacuum system, take note of the following:

- To get the best pumping speed, ensure that the pipeline which connects the vacuum system to the pump is the minimum length possible and has an internal diameter not less than the pump-inlet port. Use a flexible connection in the pipeline to reduce vibration and stress in the system pipelines.
- On very dusty applications, use an inlet-filter to minimise damage to the pump.
- You must be able to isolate the pump-inlet from the atmosphere and from your vacuum system if you have pumped or produced corrosive chemicals.
- Vacuum pipelines must be adequately supported to stop the transmission of stress to pipeline joints.

The QDP40 inlet-flange is ISO40 and the QDP80 inlet-flange is ISO63. Use the following procedure to connect the QDP pump to your vacuum system. This procedure assumes that a mechanical booster pump has not been fitted. If a mechanical booster pump has been fitted, use the instructions given in the appropriate instruction manual supplied with the mechanical booster pump.

1. Remove the four M8 x 45 mm cap-head bolts, nuts and washers. Remove the inlet blanking-plate.
2. Retain the nuts, bolts and washers for future use. Retain the blanking-plate for future use as a temporary cover, for uncontaminated pumps only.
3. Use the trapped 'O' ring supplied to connect the pump inlet-flange to your vacuum system. Secure with the bolts provided in the general fitting-kit or the bolts removed in Step 1.

3.13 Exhaust system connection

3.13.1 Use of the alternative outlet position

Figures 4 and 5 show the positions of the outlet on the QDP pump; as supplied, the outlet is at the motor end of the pump. If required, the outlet can be moved to the opposite end of the pump. Use the following procedure to use the alternative outlet position.

1. Remove the two screws (Figure 2, item 7) which secure the exhaust-silencer support-plate to the pump and remove the support-plate.
2. Undo and remove the NW40 clamp which secures the inlet of the exhaust-silencer to the outlet of the pump.
3. Remove the exhaust-silencer and turn it through 180°, so that the outlet is at the other end of the pump (as in Figures 4 and 5).

(Continued on page 32)

4. If required, you can remove the adaptor (Figure 5, item 3) from the exhaust-silencer on the QDP80 pump. To remove the adaptor:
   - Remove the two NW40 clamps which secure the adaptor to the outlet of the exhaust-silencer and the elbow and remove the adaptor.
   - Use one of the clamps to secure the elbow to the outlet of the exhaust-silencer.
5. Use the clamp removed in Step 2 to secure the inlet of the exhaust-silencer to the outlet of the pump.
6. Refit the exhaust-silencer support-plate and secure with the two screws removed in Step 1.

3.13.2 Connect the pump to your exhaust system

> WARNING
>
> Pipe the exhaust to a suitable treatment plant to prevent the discharge of dangerous gases or vapours to the surrounding atmosphere.

> WARNING
>
> Do not operate the QDP pump with the exhaust pipeline blocked. If the exhaust pipeline is blocked, the QDP pumps can generate exhaust pipeline pressures up to 7 bar (7×10^5 Pa).

> CAUTION
>
> Use a catchpot to prevent condensate draining back into the pump. Condensate which drains back into the pump could damage the pump.

When you connect the pump to the exhaust system, take note of the following:

- Ensure that all components in the exhaust pipeline have a pressure rating which is greater than the highest pressure that can be generated in your system.
- Incorporate flexible pipelines in the exhaust pipeline to reduce the transmission of vibration and to prevent loading of coupling-joints. We recommend that you use BOC Edwards flexible pipelines.
- You must be able to isolate the exhaust-silencer outlet from the atmosphere if you have pumped or produced corrosive chemicals.
- Exhaust pipelines must be adequately supported to stop the transmission of stress to pipeline joints.

1. Remove the plastic cover from the NW40 flange on the exhaust-silencer outlet. Retain the cover for future use as a temporary cover, for uncontaminated pumps only.
2. Connect the exhaust-silencer outlet to your exhaust system. The outlet has an NW40 flange.

3.14 Leak-test the installation

> WARNING
>
> Leak-test the system after installation and maintenance and seal any leaks found to prevent leakage of dangerous substances out of the system and leakage of air into the system.

Leak-test the system after installation and seal any leaks found. Dangerous substances which leak from the system will be dangerous to people and there will be a danger of explosion if air leaks into the system. We recommend that the leak rate is 1×10^{-5} mbar l s^{-1} (1×10^{-3} Pa l s^{-1}) helium or less.

3.15 Commission the pump

3.15.1 Adjust the thermostatic control-valve (TCV)

> WARNING
>
> Do not adjust the TCV to a lower setting (that is, turn the adjuster spindle anticlockwise) when the pump is hot. This will increase the flow of cooling-water which may damage the pump because of the differential contraction of the pump rotor and case.

Note: The QDP pump can only be operated at pump temperatures above 88 ^{o}C if you configure the pump so that the 88 ^{o}C thermal snap-switch gives a warning only, (that is, does not automatically shut down the QDP pump), or if you fit the high temperature thermal snap-switch kit, which contains a warning thermal snap-switch which opens at 95 ^{o}C and a shut-down thermal snap-switch which opens at 115 ^{o}C.

The TCV regulates the flow of water through the water cooling system to maintain the pump at the required operating temperature.

A pump operating temperature of 70 ^{o}C is suitable for most processes and, as supplied, the TCV is factory set to maintain this temperature (measured at the thermal snap-switch position). The adjuster spindle on the TCV is held at this setting by a locking-wire.

You can adjust the TCV to vary the operating temperature of the pump (measured at the temperature measurement point - Figure 11, item 16) between approximately 55 ^{o}C (minimum) and approximately 90 ^{o}C (maximum). If you need to adjust the TCV to suit your operating conditions, refer to Figure 11 and use the following procedure. Note that it takes approximately 30 minutes for the pump to stabilise at its final operating temperature.

1. Cut and remove the locking-wire on the spindle on the top of the TCV (8).

(Continued on page 34)

2. Use a suitable screwdriver to turn the spindle (8) the necessary number of turns from the factory set position to select the required operating temperature (refer to Table 6 for the QDP40 and Table 7 for the QDP80). If you are not sure whether the adjuster spindle is at the factory set position, turn the spindle fully clockwise until it will turn no further, then adjust the spindle from this position.

Required pump operating temperature °C	Required number of turns of TCV adjuster spindle	
	From factory set position	From fully clockwise position
Valve shut/pump off	10 Clockwise	-
90 #	9 Clockwise	1 Anti-clockwise
70 *	-	10 Anti-clockwise
55	6 Anticlockwise	16 Anti-clockwise

88 °C thermal snap-switch must be configured to provide warning only, or you must fit the high temperature thermal snap-switch kit.
* Factory set position

Table 6 - Adjust the TCV on the QDP40

Required pump operating temperature °C	Required number of turns of TCV adjuster spindle	
	From factory set position	From fully clockwise position
Valve shut/pump off	13 Clockwise	-
90 #	9 Clockwise	4 Anti-clockwise
70 *	-	13 Anti-clockwise
55	8 Anticlockwise	21 Anti-clockwise

88 °C thermal snap-switch must be configured to provide warning only, or you must fit the high temperature thermal snap-switch kit.
* Factory set position

Table 7 - Adjust the TCV on the QDP80

3.15.2 Commissioning procedure

1. Isolate the pump from your vacuum system.
2. Turn on the cooling-water supply, the nitrogen supply and your exhaust-extraction system (if fitted).
3. Check all of the water, nitrogen system, exhaust-extraction system and vacuum system connections.
4. Switch on the pump (and the mechanical booster pump, if fitted).
5. Allow the pump temperature to stabilise (approximately 30 minutes).
6. Turn off the pump and the services.

4 OPERATION

4.1 ATEX directive implications

Note: *The information in this section only applies to a QDP pump with an Exhaust Pressure Module fitted. QDP pumps without an Exhaust Pressure Module fitted are not ATEX compliant.*

4.1.1 Introduction

This equipment is designed to meet the requirements of Group II Category 3 equipment in accordance with Directive 94/9/EC of the European Parliament and the Council of 23rd March 1994 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres. (The ATEX Directive)

The ATEX Category 3 applies in respect of potential ignition sources internal to the equipment. An ATEX Category has not been assigned in respect of potential ignition sources on the outside of the equipment as the equipment has not been designed for use where there is an external potentially explosive atmosphere.

There is no potential source of ignition within the pump during normal operation but there may be potential sources of ignition under conditions of predictable and rare malfunction as defined in the Directive. Accordingly, although the pump is designed to pump flammable materials and mixtures, operating procedures should ensure that under all normal and reasonably predictable conditions, these materials and mixtures are not within explosive limits. Category 3 is considered appropriate for the avoidance of ignition in the case of a rare malfunction which allows flammable materials or mixtures to pass through the pump whilst within their explosive limits.

4.1.2 Flammable/pyrophoric materials

WARNING

You must obey the instructions and take note of the precautions given below, to ensure that pumped gases do not enter their flammable ranges.

When flammable or pyrophoric materials are present within the equipment you must:

- Not allow air to enter the equipment.
- Ensure that the system is leak tight.
- Use an inert gas purge (for example, a nitrogen purge) to dilute any flammable gases or vapours entering the pump inlet, and/or use an inert gas purge to reduce the concentration of flammable gases or vapours in the pump and in the exhaust pipeline to less than one quarter of the gases' published lower explosive limits (LEL).
- Use an inert gas purge in to the pump gas ballast connection to prevent the condensation of flammable vapours within the pump mechanism and exhaust pipeline.

4.1.3 Gas purges

WARNING

If you use inert gas purges to dilute dangerous gases to a safe level, ensure that the QDP pump is shut down if an inert gas supply fails.

WARNING

You must obey the instructions and take note of the precautions given below, to ensure that pumped gases do not enter their flammable ranges.

Switch on the inert gas purge to remove air from the pump and the exhaust pipeline before the process starts. Switch off the purge flow at the end of the process only after any remaining flammable gases or vapours have been purged from the pump and exhaust pipeline.

If liquids that produce flammable vapours could be present in the pump foreline, then the inert gas purge to the QDP pump should be left on all the time this liquid is present. Flammable liquids could be present in the foreline as a result of condensation, or may be carried over from the process.

When you calculate the flow rate of inert gas required for dilution, consider the maximum flow rate for the flammable gases/vapours that could occur. For example, if a mass flow controller is used to supply flammable gases to the process, you should assume a flow rate for flammable gases that could arise if the mass flow controller is fully open.

Continually measure the inert gas purge flow rate: if the flow rate falls below that required, you must stop the flow of flammable gases or vapours into the pump.

Note: *We recommend that you obtain and read the Vacuum Pump and Vacuum System Safety manual (publication number P300-20-000), available from BOC Edwards or your supplier.*

4.2 Start-up procedure

1. Check the gearbox oil-level in the sight-glass on the side of the pump (see Figure 11).
2. Check the coolant level with the filler-cap/level indicator.
3. Turn on the cooling-water supply, the nitrogen supply and the exhaust-extraction system (if fitted).
4. Check all of the water, nitrogen system, exhaust-extraction system (if any) and vacuum system connections.
5. Switch on the pump (and the mechanical booster pump, if fitted).
6. Refer to Section 2.3 and Section 4.3 for operation of the gas system to suit your process conditions.

4.3 Gas flow rates and pressures

Table 2 (see Section 2) shows the maximum flow rates for the shaft-seals purge, 3/4-interstage purge and 2/3-interstage purge gas flows.

During operation, you must set the flow rates of the 3/4-interstage purge and the 2/3-interstage purge pipelines to the required values. These values are dependent on the process in which the pump is used and you should adjust the flow rates according to your experience. If you exceed the flow rates specified in Table 2, the performance of the pump may be reduced.

You must set the pressure of the shaft-seals purge as specified in Table 2 and Section 3.11. You must not attempt to adjust the flow rate of the shaft-seals purge (which is determined by the pump itself). The nominal flow rate of the shaft-seals purge is 12 l min^{-1} . If the flow rate is higher than the nominal value, you may reduce the flow rate of the 3/4-interstage purge by [F-12] l min^{-1} (where F is the actual shaft-seals flow rate). This will reduce the amount of nitrogen exhausted from the pump.

4.4 Pump shutdown

Shut down the pump as described below.

1. Isolate the pump-inlet from your vacuum system and operate it for 15 minutes with the nitrogen supply switched on.
2. Turn off the nitrogen supply.
3. Switch off the QDP pump (and the mechanical booster pump if fitted).
4. Turn off the cooling-water supply.

5 MAINTENANCE

5.1 Safety

> WARNING
>
> Obey the safety instructions given below and take note of appropriate precautions. If you do not, you can cause injury to people and damage to equipment.

- A suitably trained and supervised technician must maintain the QDP pump.
- Ensure that the maintenance technician is familiar with the safety procedures which relate to the products handled by the pumping-system. Wear the appropriate safety-clothing when you come into contact with contaminated components. Dismantle and clean contaminated components inside a fume-cupboard.
- Allow the pump to cool to a safe temperature before you start maintenance work.
- Vent and purge the pumping system with nitrogen before you start any maintenance work.
- Isolate the pump and other components in the pumping system from the electrical supply so that they can not be operated accidentally.
- Fit a suitable blanking-plate to the pump inlet-flange and to your vacuum system as soon as you have disconnected the pump from your vacuum system. Do not operate the pump unless the inlet blanking-plate is fitted, or the pump is connected to your vacuum system.
- Fit a suitable blanking-plate to the exhaust-silencer outlet-flange and to your exhaust system as soon as you have disconnected the pump from your exhaust system. Do not operate the pump unless the exhaust-silencer outlet is connected to your exhaust system.
- Recheck the pump rotation direction if the electrical supply has been disconnected.
- 'O' ring replacement intervals will vary depending on your application: contact BOC Edwards for advice.
- Do not reuse 'O' rings or 'O' ring assemblies.
- Dispose of components, grease and oil safely (see Section 6.2).
- Take care to protect sealing-faces from damage.
- Do not touch or inhale the thermal breakdown products of fluorinated materials which may be present if the pump has been overheated to 260 °C and above. These breakdown products are very dangerous. Fluorinated materials in the pump may include oils, greases and seals. The pump may have overheated if it was misused, if it malfunctioned or if it was in a fire. BOC Edwards Material Safety Data Sheets for fluorinated materials used in the pump are available on request: contact your supplier or BOC Edwards.
- Leak-test the system after maintenance work is complete if you have connected or disconnected any vacuum or exhaust joints. Seal any leaks found to prevent leakage of dangerous substances out of the system and leakage of air into the system.
- Wipe up any water, Drystar coolant or oil spilt during maintenance, so that people cannot slip over any spillages.
- Safely route and secure all cables, hoses and pipes during maintenance, so that people cannot trip over them.

5.2 Maintenance plan

The plan in Table 8 details the maintenance operations we recommend to maintain the pump in normal operation. Instructions for each operation are given in the section shown.

When you maintain the pump, use BOC Edwards maintenance and service kits. These contain all of the necessary seals, lubricating grease and other components necessary to complete maintenance operations successfully. The Item Numbers of the service kits are given in Section 7.3.

In practice, the frequency of maintenance is dependent on your process. In clean processes, you may be able to decrease the frequency of maintenance operations; in harsh processes you may have to increase the frequency of maintenance operations. Adjust the maintenance plan according to your experience.

Operation	Frequency	Refer to Section
Check the gearbox oil-level	6 Monthly	5.3
Check the coolant-level	6 Monthly	5.4
Inspect and clean the exhaust-silencer	3 Monthly	5.5
Inspect the pipelines and connections	6 Monthly	5.6
Inspect the exhaust check-valve	6 Monthly	5.7
Change the gearbox oil	Yearly or when contaminated, whichever occurs first*	5.8
Relubricate the rotor bearings	Yearly	5.9

* If the gearbox oil is not contaminated, you may only need to change the gearbox oil once a year. If there is contamination (indicated by a change in colour of the oil; for example, water contamination will turn the oil a white colour), you must change the oil. You may be able to remove the contaminants from the oil by filtration.

Table 8 - Maintenance plan

5.3 Check the gearbox oil-level

WARNING

Do not remove the oil filler-plug when the pump is operating. If you do, hot oil may be ejected from the pump gearbox

Refer to Figure 11 and check that the pump gearbox oil-level is between the MIN and MAX marks on the bezel of the oil-level sight-glass. If the oil-level is above the MAX mark, drain excess oil from the pump as described in Section 5.7 until the oil-level is correct. If the oil-level is below the MAX mark:

1. Unscrew and remove the oil filler-plug (3).
2. Pour oil into the gearbox until the oil-level is at the MAX mark on the bezel of the oil-level sight-glass.

(Continued on page 40)

3. Make sure that the bonded seal is in place on the oil filler-plug. Screw the filler-plug back in and tighten to finger tight. Use a spanner to tighten a further $^{1}/_{16}$th of a turn.

The gearbox is vented and the loss of a small amount of oil during operation is normal. If you need to pour oil into the gearbox frequently, or if there is a sudden loss of a large amount of oil, this may indicate that the pump has a fault. In these circumstances, we recommend that you shut down the pump as soon as possible and contact your supplier or BOC Edwards for advice.

5.4 Check the coolant-level

WARNING

Do not remove the combined filler-plug/level indicator when the QDP pump is hot. If you do, hot coolant may be ejected from the header-tank and could cause injury.

CAUTION

Fill the QDP pump with the correct type and amount of coolant. If you do not, the pump may overheat and it may not work correctly.

In addition to cooling the pump, the coolant acts as a corrosion inhibitor and anti-scaling agent. Check the coolant-level and fill the pump with coolant as described below; new coolant is available as a spare: refer to Section 7. The locations of the components of the cooling-water system are shown in Figure 11.

1. Isolate the pump from the electrical supply and ensure that the cooling-water supply is off.
2. Unscrew and remove the combined filler-plug/level indicator (5). Use a clean lint-free cloth to wipe the shaft of the indicator, then replace the combined filler-plug/level indicator in the coolant header-tank.
3. Remove the combined filler-plug/level indicator again and check the coolant-level: the coolant-level must be visible on the shaft of the indicator, but must not be above the notch mark on the indicator shaft. If the coolant-level is acceptable, continue at Step 12, otherwise continue at Step 4.
4. Remove the cap from a container of pump coolant and pour in de-ionised water until the 2.1 litre fill line on the container is reached.
5. Refit the cap firmly on the container. Shake the container gently to fully mix the fluids.
6. Check that the coolant drain-plug on the underside of the pump is securely fitted.
7. Fit a length of transparent flexible hose to the air bleed-valve, then unscrew the air bleed-valve (7).
8. Use a clean funnel to slowly fill the pump with the coolant mixture until the coolant fluid starts to flow through the hose fitted to the air bleed-valve.
9. Tighten the air bleed-valve (7), then remove the flexible hose.

10. Continue to fill the system slowly until you see the fluid in the bottom of the coolant header-tank (4).
11. Refit the combined filler-plug/level indicator (5) and then remove it to check the fluid-level on the shaft of the indicator: refer to Step 3.
12. Check that the bonded seal on the combined filler-plug/level indicator (5) is in place. Refit and tighten the combined filler-plug/level indicator.

5.5 Inspect and clean the exhaust-silencer

> WARNING
>
> Substances which accumulate in the exhaust-silencer may be dangerous. Do not allow these substances to come into contact with your skin or eyes. Do not inhale vapours from these substances. Fit blanking caps to the inlet and outlet flanges when you move the silencer around your workplace.

Refer to Figure 18 and dismantle, inspect and clean the silencer as described below.

1. Release the NW40 clamps at the silencer inlet and outlet flanges to disconnect the silencer from the check-valve and the pump.
2. Slide the silencer out towards the high-vacuum end of the pump to remove the silencer from the pump. Alternatively, undo the two support-plate retaining screws (see Figure 2) and slide the silencer complete with the support-plate towards the motor end of the pump.
3. Weigh the silencer. If the mass of the silencer is greater than 7.5 kg, dismantle, clean and reassemble the silencer as in Steps 4 to 9 below. If you do not need to clean the silencer, refit the silencer as in Step 12.
4. Remove and retain the six bolts and washers which secure each end-cover plate to the silencer body. Pull the end-cover plates squarely from the outlet pipe to remove them.
5. Remove the three 'O' rings from the silencer and discard.
6. Empty all loose deposits from the silencer body; take care not to damage the end-cover plate sealing surfaces.
7. Use a suitable tool to dislodge remaining deposits, then wash the silencer body with steam or water. Finally, glass-bead blast the silencer body. If required, use a cleaning solution suitable for the nature of the deposits.
8. Inspect the silencer for internal corrosion and check that the wall of the silencer body is not excessively eroded. Inspect the end-cover plate and inlet and outlet flange sealing-faces for damage and refinish if necessary. If silencer damage is excessive, it should be replaced.
9. Check that the 'O' ring grooves are clean. Apply a light wipe of vacuum grease and place the new 'O' rings in position.

(Continued on page 42)

10. Refit the end-cover plates and secure with the bolts and washers removed in Step 3. Tighten the bolts progressively; alternate between bolts on opposite sides of the end-cover plate. Tighten to a torque of 10 Nm.

11. Leak-test the silencer.

12. Slide the silencer in from the high-vacuum end of the pump. Alternatively, slide the silencer complete with the support-plate in from the motor end of the pump and tighten the support-plate retaining screws (see Figure 2).

13. Reconnect the silencer to the pump and the check-valve with the new NW40 clamps and trapped 'O' rings supplied in the servicing kit.

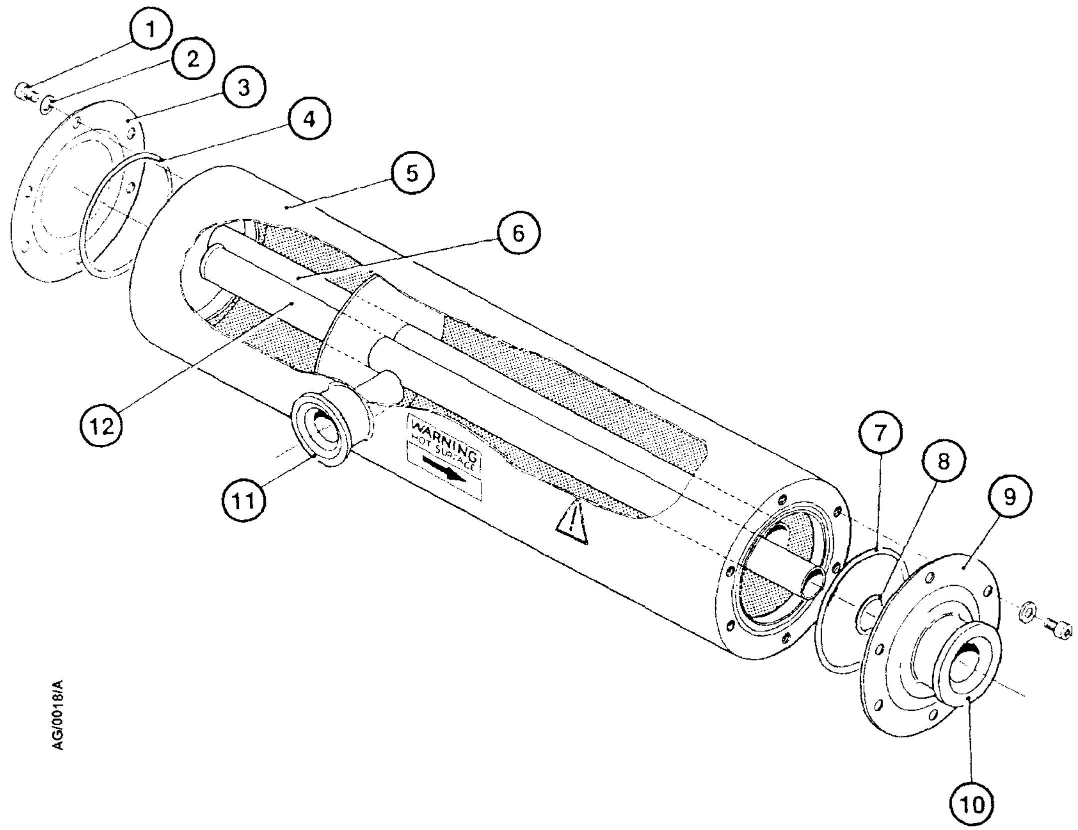
5.6 Inspect the pipelines and connections

1. Inspect all cooling-water connections and check that they are secure; tighten any loose connection. Inspect all cooling-water pipelines and connections for corrosion, leaks and damage. Repair or replace any corroded or damaged components and seal any leaks found.

2. Inspect all nitrogen supply connections and check that they are secure; tighten any loose connection. Inspect all nitrogen supply pipelines and connections for leaks and damage. Repair or replace any corroded or damaged components and seal any leaks found.

3. Inspect all electrical connections and check that they are secure; tighten any loose connection. Inspect all electrical cables and check thay they are not damaged and have not overheated. Repair or replace any cable that is damaged or has overheated.

4. Inspect all vacuum connections and check that they are secure; tighten any loose connection. Inspect all vacuum pipelines for corrosion and damage and check that they do not leak. Repair or replace any corroded or damaged components and seal any leaks found.



1. Cap-head bolt
2. Washer
3. End-cover plate
4. 'O' ring
5. Silencer body
6. Transfer tube
7. 'O' ring
8. 'O' ring
9. End-cover plate
10. Outlet flange
11. Inlet flange
12. Outlet tube

Figure 18 - Exhaust silencer

5.7 Inspect the exhaust check-valve

> WARNING
>
> Substances which accumulate in the check-valve may be dangerous. Do not allow these substances to come into contact with your skin or eyes. Do not inhale vapours from these substances. Fit blanking caps to the inlet and outlet flanges when you move the check-valve around your workplace.

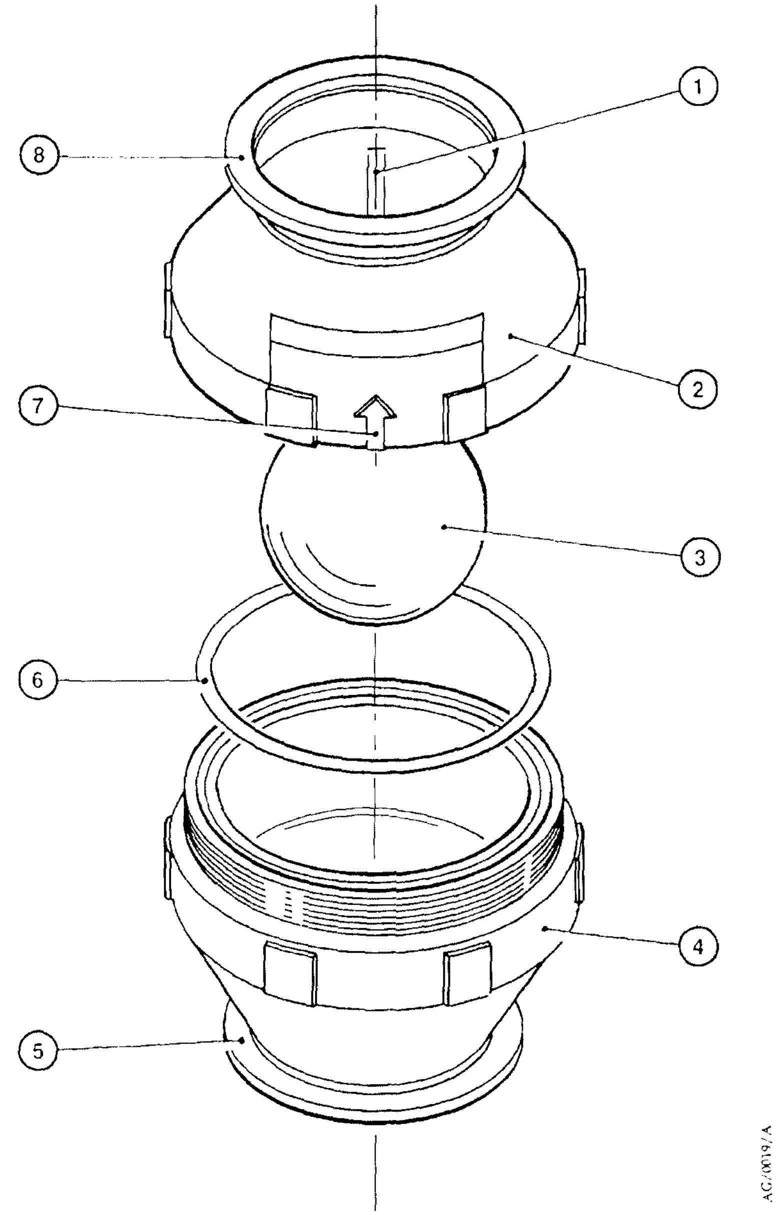
You must remove the exhaust check-valve from the silencer and your exhaust-extraction system before you can inspect it. It is convenient, therefore, to inspect the exhaust check-valve at the same time as you inspect the exhaust-silencer (see Section 5.5).

Use the procedure below to remove and inspect the valve. This procedure assumes that the exhaust-silencer has already been disconnected from the pump and the exhaust check-valve has been removed. Figure 19 shows the component parts of the exhaust check-valve.

1. Release the NW40 clamp at the exhaust check-valve outlet flange and remove the check-valve from the system pipeline.
2. Unscrew the two halves of the check-valve body; use a strap wrench if necessary.
3. Remove the fluoroelastomer ball and the 'O' ring.
4. Use a cleaning solution suitable for the process products pumped to clean the valve body and the fluoroelastomer ball. If necessary, replace the fluoroelastomer ball with a new one.
5. Inspect the 'O' ring groove and the KF40 flange sealing-faces for damage and refinish if necessary.
6. Apply a light wipe of vacuum grease and position the 'O' ring in its groove in the valve body.
7. Ensure that the fluoroelastomer ball is positioned correctly and screw the two halves of the valve body together.
8. Refit the valve to the system pipeline with the NW40 clamp and trapped 'O' ring. Ensure that the flow direction arrow points away from the silencer (towards your exhaust-extraction system).

5.8 Change the gearbox oil

1. Remove the oil filler-plug (see Figure 11).
2. Use a suitable pump or syringe to suck the oil out of the gearbox.
3. Discard the old bonded seal on the oil filler-plug and replace with a new one from the pump maintenance kit.
4. Fill the gearbox through the filler hole, with the correct grade and quantity of oil. Allow the oil to drain into the gearbox and then check the level on the oil sight-glass (refer to Section 3.5).
5. Ensure that the new bonded seal is positioned correctly and refit the oil filler-plug.



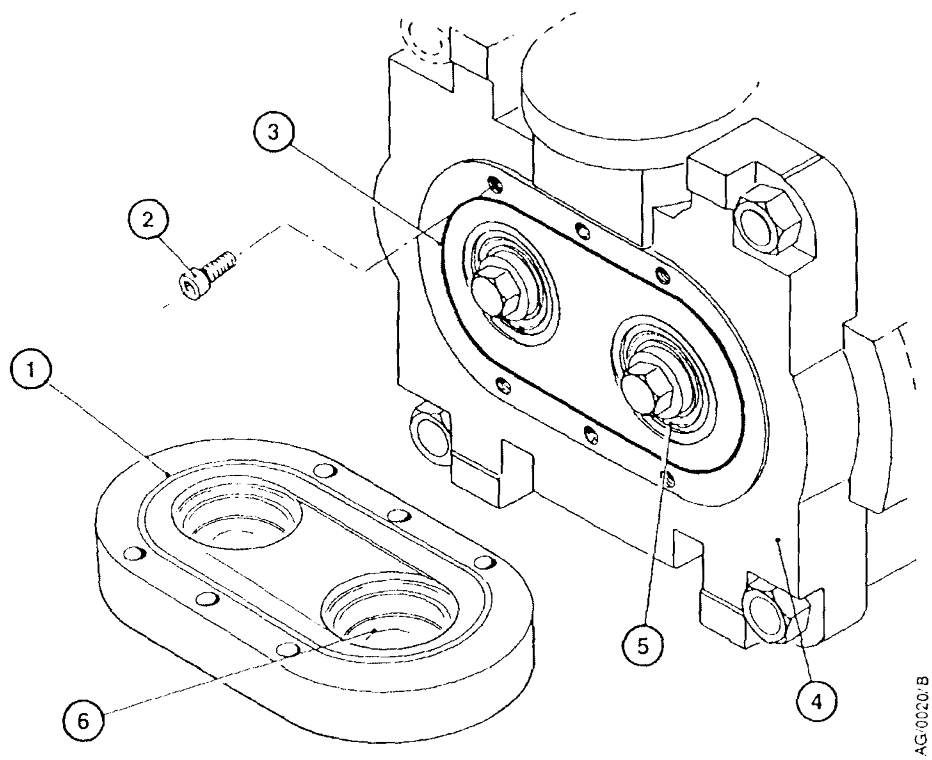
1.	Spider leg	5.	Inlet-flange
2.	Valve body (female)	6.	'O' ring
3.	Fluoroelastomer ball	7.	Mounting direction arrow
4.	Valve body (male)	8.	Outlet-flange

Figure 19 - Exhaust check-valve

5.9 Relubricate the rotor bearings

Relubricate the rotor bearings as described below. Figure 20 shows the location of the rotor bearings components.

1. Remove the six screws (2) which secure the bearing end-cover (1) to the high vacuum head-plate (4).
2. Lift away the end-cover and remove the sealing 'O' ring (3). Dispose of the 'O' ring (see Section 6.2).
3. Use a clean lint-free cloth or a plastic or wooden spatula to remove as much old grease as possible from the end-cover and bearings. Do not use your fingers for this operation.
4. Inspect the bearings for obvious signs of wear or the presence of debris. If the bearings are worn, return the pump to a BOC Edwards Service Centre for repair.
5. If the bearings are in a satisfactory condition, force new PFPE grease (supplied in the maintenance kit) into the bearings so that a smooth layer of grease covers the case and bearings. Do not over-pack the bearings or the pump will run hot.
6. Apply a light wipe of PFPE grease to the new 'O' ring seal and position it in its groove in the head-plate. Refit the end-cover to the high vacuum head-plate.



1.	Bearing end-cover	4.	High vacuum head-plate
2.	End-cover securing screw	5.	Bearing
3.	'O' ring	6.	End-cover cavity

Figure 20 - Rotor bearing relubrication

6 STORAGE AND DISPOSAL

6.1 Storage

> CAUTION
>
> Drain the cooling-water from the pumping system, if you will transport or store it in conditions where the cooling-water could freeze. If you do not, cooling-water may freeze in the QDP pump and damage the pump.

If you will transport or store the pumping system in conditions where the cooling-water could freeze (for example, if you transport the pump as air freight), you must ensure that all cooling-water is drained from the pumping system.

Use the following procedure :

1. Remove the cooling-water connectors from the pump, or attach an open pair of quick-connector halves to the connectors on the pump.
2. Blow compressed air through the cooling-water inlet, to force any water out of the cooling system.

Store the pump as follows :

1. If applicable, ensure that the pump has been shut down as described in Section 4.4 and disconnect all services, process and exhaust connections.
2. Fit blanking-plates to all vacuum inlets and outlets. Place protective covers over the pump services connection points.
3. Store the pump in clean dry conditions until required.
4. When required for use, prepare and install the pump as described in Section 3 of this manual.

6.2 Disposal

Dispose of the QDP pump and any components safely in accordance with all local and national safety and environmental requirements.

Take particular care with the following:

- Fluoroelastomers which may have decomposed as the result of being subjected to high temperatures
- Components which have been contaminated with dangerous process substances.

7 SERVICE, SPARES AND ACCESSORIES

7.1 Introduction

BOC Edwards products, spares and accessories are available from BOC Edwards companies in Belgium, Brazil, China, France, Germany, Israel, Italy, Japan, Korea, Singapore, United Kingdom, U.S.A and a world-wide network of distributors. The majority of these centres employ Service Engineers who have undergone comprehensive BOC Edwards training courses.

Order spare parts and accessories from your nearest BOC Edwards company or distributor. When you order, please state for each part required:

- Model and Item Number of your equipment
- Serial number (if any)
- Item Number and description of the part.

7.2 Service

BOC Edwards products are supported by a world-wide network of BOC Edwards Service Centres. Each Service centre offers a wide range of options including: equipment decontamination; service exchange; repair; rebuild and testing to factory specifications. Equipment which has been serviced, repaired or rebuilt is returned with a full warranty.

Your local Service Centre can also provide BOC Edwards engineers to support on-site maintenance, service or repair of your equipment.

For more information about service options, contact your nearest Service Centre or other BOC Edwards company.

7.3 Spares

The spare parts listed below are available for the QDP pumps :

Product	Item Number
Pump routine maintenance kit	A526-40-820
Exhaust-silencer servicing kit	A386-11-820
Exhaust check-valve servicing kit	A440-03-820
Coolant	H128-10-002
Krytox 1525 oil (1 kg)	H113-09-018
Fomblin RT15 grease (100 g)	H113-50-003
Exhaust-silencer	A528-19-000
Exhaust check-valve	A440-03-000

7.4 Accessories

The accessories listed below are available for the QDP pumps. Each accessory contains all the necessary components for assembly and installation of the accessory. Full functional descriptions and installation details are included in the instruction manual supplied.

Accessory	**Item Number**
QDP High Temperature Thermal Snap-Switch Kit	A505-27-000
QDP Gas Module	A528-05-000
QDP Acoustic Enclosure for QDP40 with inlet manifold	A528-01-000
QDP Acoustic Enclosure for QDP80 with inlet manifold	A528-03-000
Q Series 3 Exhaust Pressure Module	A528-50-000
QMB Booster Connection Kit for QDP40/QMB250F	A528-31-000
QMB Booster Connection Kit for QDP40/QMB500F	A528-32-000
QMB Booster Connection Kit for QDP80/QMB250F	A528-33-000
QMB Booster Connection Kit for QDP80/QMB500F	A528-34-000
QDP Shaft-Seals Purge Module	A528-55-000
CDP Flap Valve	A504-51-000
17-way connector mating-half	A528-40-067

BOC EDWARDS

Form HS1

Return of BOC Edwards Equipment - Procedure

INTRODUCTION

Before returning your equipment, you must warn BOC Edwards if substances you used (and produced) in the equipment can be hazardous. This information is fundamental to the safety of our Service Centre employees and will determine the procedures employed to service your equipment.

Complete the Declaration (HS2) and send it to BOC Edwards before you dispatch the equipment. It is important to note that this declaration is for BOC Edwards internal use only, and has no relationship to local, national or international transportation safety or environmental requirements. As the person offering the equipment for shipment, it is your responsibility to ensure compliance with applicable laws.

GUIDELINES

- Equipment is '**uncontaminated**' if it has not been used, or if it has only been used with substances that are not hazardous. Your equipment is '**contaminated**' if it has been used with any substances classified as hazardous under EU Directive 67/548/EEC (as amended) or OSHA Occupational Safety (29 CFR 1910).
- If your equipment has been used with radioactive substances, biological or infectious agents, mercury, polychlorinated biphenyls (PCB's), dioxins or sodium azide, you must decontaminate it before you return it to BOC Edwards. You must send independent proof of decontamination (for example a certificate of analysis) to BOC Edwards with the Declaration (HS2). Phone BOC Edwards for advice.
- If your equipment is contaminated, you must either:
  - Remove all traces of contamination (to the satisfaction of laws governing the transportation of dangerous/hazardous substances).
  - Or, properly classify the hazard, mark, manifest and ship the equipment in accordance with applicable laws governing the shipment of hazardous materials.

Note: Some contaminated equipment may not be suitable for airfreight.

PROCEDURE

1. Contact BOC Edwards and obtain a Return Authorisation Number for your equipment.
2. Complete the Return of BOC Edwards Equipment - Declaration (HS2).
3. If the equipment is contaminated, you must contact your transporter to ensure that you properly classify the hazard, mark, manifest and ship the equipment, in accordance with applicable laws governing the shipment of contaminated/hazardous materials. As the person offering the equipment for shipment, it is your responsibility to ensure compliance with applicable law. **Note: Equipment contaminated with some hazardous materials, such as semiconductor by-products, may not be suitable for airfreight - contact your transporter for advice.**
4. Remove all traces of hazardous gases: pass an inert gas through the equipment and any accessories that will be returned to BOC Edwards. Where possible, drain all fluids and lubricants from the equipment and its accessories.
5. Seal up all of the equipment's inlets and outlets (including those where accessories were attached) with blanking flanges or, for uncontaminated product, with heavy gauge tape.
6. Seal equipment in a thick polythene/polyethylene bag or sheet.
7. If the equipment is large, strap the equipment and its accessories to a wooden pallet. If the equipment is too small to be strapped to a pallet, pack it in a suitable strong box.
8. Fax or post a copy of the Declaration (HS2) to BOC Edwards. The Declaration must arrive before the equipment.
9. Give a copy of the Declaration (HS2) to the transporter. You must tell your transporter if the equipment is contaminated.
10. Seal the original Declaration in a suitable envelope: attach the envelope securely to the outside of the equipment package, in a clear weatherproof bag.
    WRITE YOUR RETURN AUTHORISATION NUMBER CLEARLY ON THE OUTSIDE OF THE ENVELOPE OR ON THE OUTSIDE OF THE EQUIPMENT PACKAGE.

P900-70-000 Issue K

BOC EDWARDS

Form HS2

Return of BOC Edwards Equipment - Declaration

Return Authorisation Number:

You must:

- Know about all of the substances which have been used and produced in the equipment before you complete this Declaration
- Read the Return of BOC Edwards Equipment - Procedure (HS1) before you complete this Declaration
- Contact BOC Edwards to obtain a Return Authorisation Number and to obtain advice if you have any questions
- Send this form to BOC Edwards before you return your equipment

SECTION 1: EQUIPMENT

Equipment/System Name____________________

Part Number ____________________

Serial Number____________________

Has the equipment been used, tested or operated ?

YES ☐ Go to Section 2   NO ☐ Go to Section 4

IF APPLICABLE:

Tool Reference Number________________

Process ________________

Failure Date________________

Serial Number of Replacement Equipment________________

SECTION 2: SUBSTANCES IN CONTACT WITH THE EQUIPMENT

Are any substances used or produced in the equipment:

- Radioactive, biological or infectious agents, mercury, poly chlorinated biphenyls (PCBs), dioxins or sodium azide? (if YES, see Note 1) YES ☐ NO ☐
- Hazardous to human health and safety? YES ☐ NO ☐

Note 1 : BOC Edwards will not accept delivery of any equipment that is contaminated with radioactive substances, biological/infectious agents, mercury, PCB's, dioxins or sodium azide, unless you:

- Decontaminate the equipment
- Provide proof of decontamination

YOU MUST CONTACT BOC EDWARDS FOR ADVICE BEFORE YOU RETURN SUCH EQUIPMENT

SECTION 3: LIST OF SUBSTANCES IN CONTACT WITH THE EQUIPMENT

Substance name	Chemical Symbol	Precautions required (for example, use protective gloves, etc.)	Action required after a spill, leak or exposure

SECTION 4: RETURN INFORMATION

Reason for return and symptoms of malfunction ____________________

____

If you have a warranty claim:

- who did you buy the equipment from ? ________________
- give the supplier's invoice number________________

SECTION 5: DECLARATION

Print your name:________________Print your job title:________________

Print your organisation:________________

Print your address:________________

____

Telephone number: ________________Date of equipment delivery: __________

I have made reasonable enquiry and I have supplied accurate information in this Declaration. I have not withheld any information, and I have followed the Return of BOC Edwards Equipment - Procedure (HS1).

Note: Please print out this form, sign it and return the signed form as hard copy.

Signed: ________________Date__________

P900-71-000 Issue K

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BOC EDWARDS

A301-85-880
Issue M

Instruction Manual

QMB Mechanical Booster Pumps

Description	*Item Number*
QMB250F Mechanical Booster Pump, 50 Hz	*A301-85-905*
QMB250F Mechanical Booster Pump, 60 Hz	*A301-86-905*
QMB500F Mechanical Booster Pump, 50 Hz	*A302-85-905*
QMB500F Mechanical Booster Pump, 60 Hz	*A302-86-905*
QMB1200F Mechanical Booster Pump, 50 Hz	*A305-85-905*
QMB1200F Mechanical Booster Pump, 60 Hz	*A305-86-905*

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QMB Booster Frames	A528-37-880
QMB Booster Frame Connection Kits	A528-65-880
QMB Booster Frame Acoustic Enclosure	A528-70-880

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1 INTRODUCTION

1.1 Scope and definitions

This manual provides installation, operation and maintenance instructions for the BOC Edwards QMB250F, QMB500F and QMB1200F Mechanical Booster Pumps. You must use the pumps as specified in this manual.

Read this manual before you install and operate the pump. Important safety information is highlighted as WARNING and CAUTION instructions; you must obey these instructions. The use of WARNINGS and CAUTIONS is defined below.

> WARNING
>
> Warnings are given where failure to observe the instruction could result in injury or death to people.

> CAUTION
>
> Cautions are given where failure to observe the instruction could result in damage to the equipment, associated equipment and process.

The units used throughout this manual conform to the SI international system of units of measurement.

1.2 Description

1.2.1 General

BOC Edwards QMB Mechanical Booster Pumps are compact and have high pumping speeds. Low system pressures can be achieved by using two or more mechanical booster pumps in series. You must use the QMB Mechanical Booster Pump with a suitable backing pump. The maximum continuous inlet pressure is 20 mbar for the QMB250F and QMB500F Mechanical Booster Pumps and 1 mbar for the QMB1200F Mechanical Booster Pumps.

The QMB250F and QMB500F pumps are air-cooled and the QMB1200F pump is water-cooled. All the QMB pumps have enclosed, water-cooled motors and are therefore suitable for applications in clean environments where fan cooling is unacceptable.

The pump coupling-cover is connected to the pump outlet and forms an integral part of the vacuum system. The connecting pipelines have a filter which removes debris and so prevents contamination of the lubricating oil and bearings. For an even cleaner system, the coupling-cover and bearings can be evacuated by connection to the pump-inlet or to an external vacuum pump.

Three motor-protection thermistors (one on each winding) are fitted to the motor of the QMB pump. These thermistors are solid-state devices which have an electrical resistance of 100 to 500 Ω at normal pump-motor operational temperature. When the pump-motor is too hot, the electrical resistance rises quickly to 3000 Ω.

The thermistors are connected in series and you can connect the thermistors to control equipment to automatically shut down the system if a pump-motor is too hot.

1.2.2 Construction

The QMB pumps are positive displacement Roots vacuum pumps. The pump mechanism is driven by a three-phase electric motor through a hydrokinetic fluid-coupling. The motor is enclosed and is cooled by integral cooling-water coils.

The pump shafts and rotors are made of high-grade, corrosion-resistant, cast-iron. The internal and external shaft-seals are made of polytetrafluoroethylene (PTFE) or fluoroelastomer.

The pump-bearings, gears and seals are lubricated by oil fed from reservoirs in the coupling-cover. A series of seals stops the oil from reaching the vacuum side of the pump. The coupling-cover is evacuated. You can inspect the oil-levels through sight-glasses which are fitted to the coupling-cover. Oil-filler, oil-drain and external evacuation connections are provided on the cover.

The QMB250F and QMB500F pumps have rear bearings which are lubricated by perfluoropolyether (PFPE) grease. The QMB1200F pump gears are lubricated by oil in the gear-cover. The gear-cover of the QMB1200F has oil-filler and oil-drain plugs and an oil-level sight-glass. The QMB pumps are suitable for use only with PFPE oils.

1.2.3 Principle of operation

The QMB Mechanical Booster Pump is shown in Figure 1. The motor-shaft drives one of the rotors through the fluid-coupling. The 1:1 gears inside the coupling-cover drive the second rotor in the opposite direction inside the stator housing. A small, accurately gauged, clearance is maintained between the rotors and between each rotor and the stator wall. This clearance allows the pump to operate at high speed without mechanical wear and without the need for lubrication inside the swept volume.

1.2.4 Hydrokinetic fluid-coupling

The hydrokinetic fluid-coupling connects the electric-motor shaft to the rotor. This system is configured so that when the gas-load is high the rotational speed of the rotors is reduced. As the gas-load decreases, the rotors accelerate to full speed. This allows continuous operation of the pump over the vacuum range without the risk of overloading the motor and removes the need for bypass-valves and associated pipelines.

1. Cooling-water bracket (QMB250F/QMB500F pumps)
2. Cooling-water bracket (QMB1200F pump)
3. Shaft-seal reservoir vented oil filler-plug
4. Coupling-cover oil filler-plug
5. Inlet-flange
6. End-cover (QMB250F/QMB500F)
7. External evacuation port
8. Rotors
9. Stator housing
10. Coupling-cover oil drain-plug (under the pump)
11. Direction of rotation sight-glass
12. Oil-level sight-glasses
13. Electrical supply cable entry
14. Motor terminal-box cover
15. Gear-cover (QMB1200F)
16. Oil filler-plug (QMB1200F)
17. Oil drain-plug (under the gear-cover, QMB1200F)
18. Oil-level sight-glass (QMB1200F)

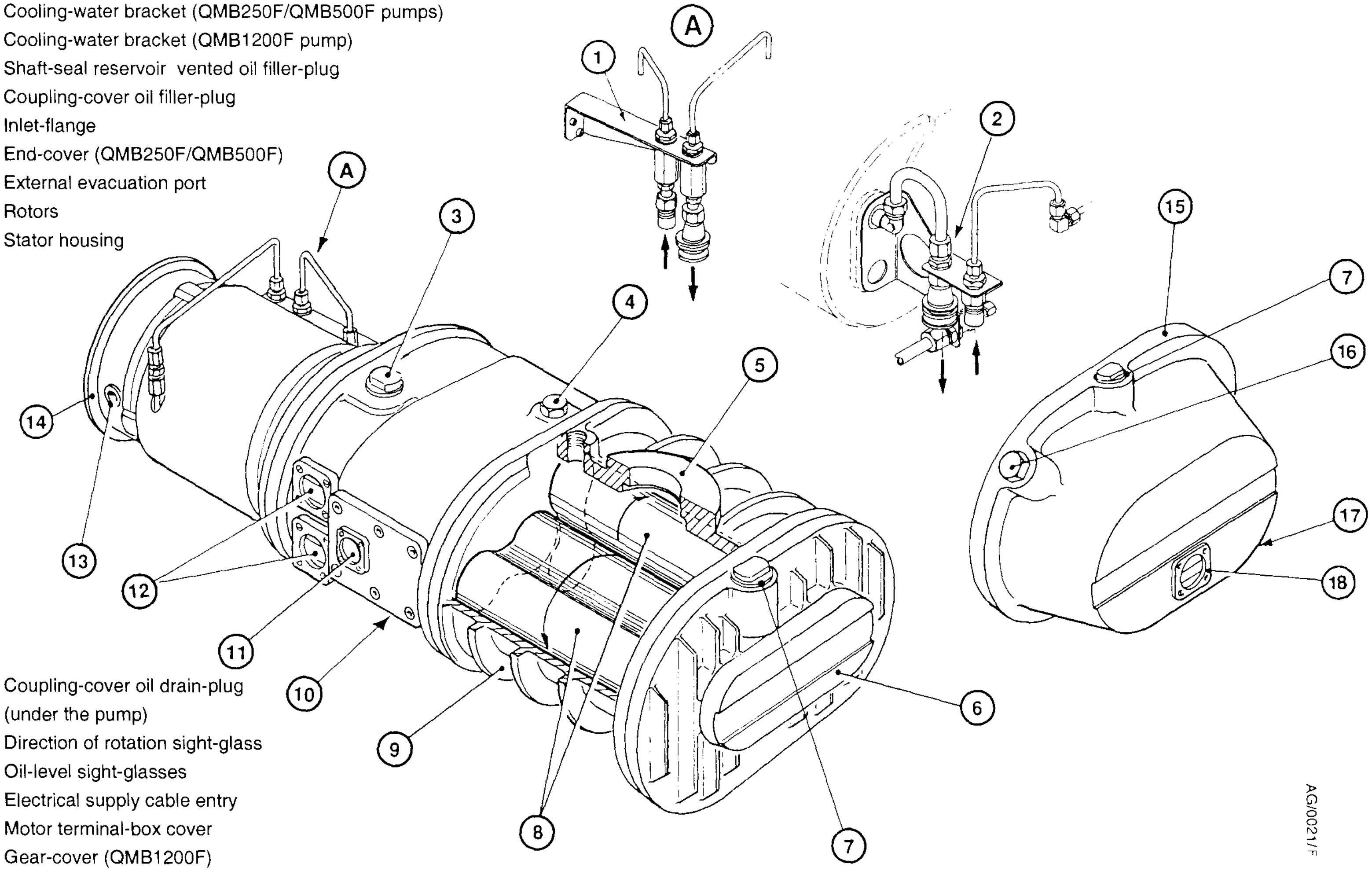


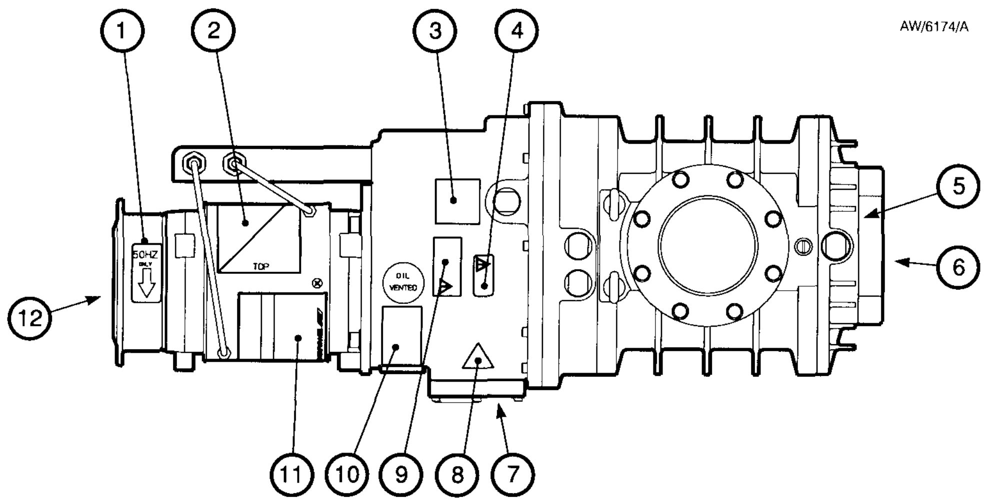
Figure 1 - QMB Mechanical booster pump (part cut-away)

1.3 Labels

Labels are fitted to the QMB pump in order to:

- Identify components.
- Define required installation/operation/maintenance procedures.
- Identify safety hazards.

Refer to Figure 2 which shows the positions of the labels fitted to the QMB pump.



1. Direction of rotation arrow/frequency label
2. 'Do not step on/motor damage' label
3. Coupling cover filler plug/Oil level lower sight glass
4. 'Use only Fomblin Y16/6 or Krytox 1514 oil' label
5. 'Regrease bearing in accordance with instruction manual' label
6. QMB information/'Warning - Risk of high temperature' label
7. Caution symbol
8. 'Warning - Risk of high temperature' label
9. 'Caution - Do not not overfill with oil' label
10. 'Use vented plug only/Shaft seal reservoir' label
11. QMB motor rating information label
12. 'Warning - Risk of electric shock' label

Figure 2 - Labels on the QMB pump

2 TECHNICAL DATA

2.1 General

Overall dimensions	See Figures 3 to 5
Performance	
Backed by QDP dry pump	See Figures 6 to 9
Backed by 1 or 2-stage rotary pump	See Table 2
Mass	See Table 2
Continuous inlet pressure	
QMB250F and QMB500F	0 to 20 mbar, 0 to 2 x 10^3 Pa
QMB1200F	0 to 1 mbar, 0 to 100 Pa
Maximum outlet pressure (see Section 1.2.4)	1000 mbar, 1 x 10^5 Pa
Ambient operating temperature range	5 to 40 °C
Maximum operating humidity	90% RH
Protection degree (as defined by IEC 529)	IP44
Oil capacity	See Table 2
Recommended oil type	Fomblin YVAC 16/6 or Krytox 1514
Recommended grease (for QMB250F and QMB500F rear bearing)	Fomblin RT15

Note: A BOC Edwards Material Safety Data Sheet for the above oil is available on request.

2.2 Electrical data

Note: The motor is supplied configured for low-voltage operation (200-208 V at 50 Hz or 200-230 V at 60 Hz). To change the motor to high-voltage operation (380-415 V at 50 Hz or 460 V at 60 Hz) refer to Section 3.7.1.

Number of phases	3
Supply voltage	200-208 V/380-415 V at 50 Hz 200-230 V/460 V at 60 Hz
Voltage tolerance	±10%, except 208 and 415 V at 50 Hz which are +6% and -10%
Full load current rating	See Table 1

Supply voltage and frequency		200-208 V 50 Hz	200-208 V 60 Hz	230 V 60 Hz	380-415 V 50 Hz	460 V 60 Hz
QMB250F and QMB500F	Full load (A)	8.7	8.8	7.8	5.0	4.4
	Rating (kW)	2.2	2.2	2.2	2.2	2.2
QMB1200F	Full load (A)	16	16	14.2	8	8
	Rating (kW)	4	4	4	4	4

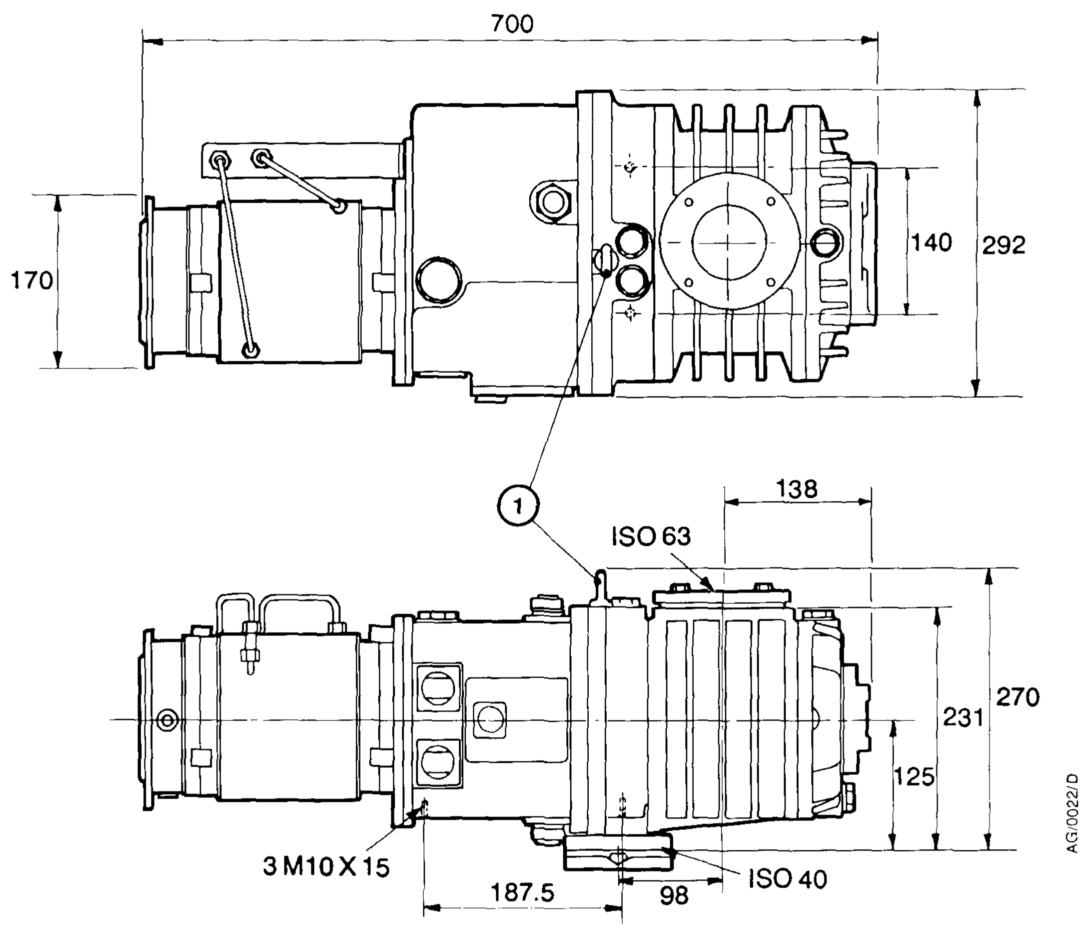
Table 1 - Full load current ratings

Motor protection thermistors

Type	Positive temperature coefficient
Reference temperature	160 °C
Compliant with	IEC 34-11 (BS4999 part 111)
Recommended control-unit	To comply with IEC 34-11 (BS4999 part 111)
Relay contact rating	Suitable for use with your contactor

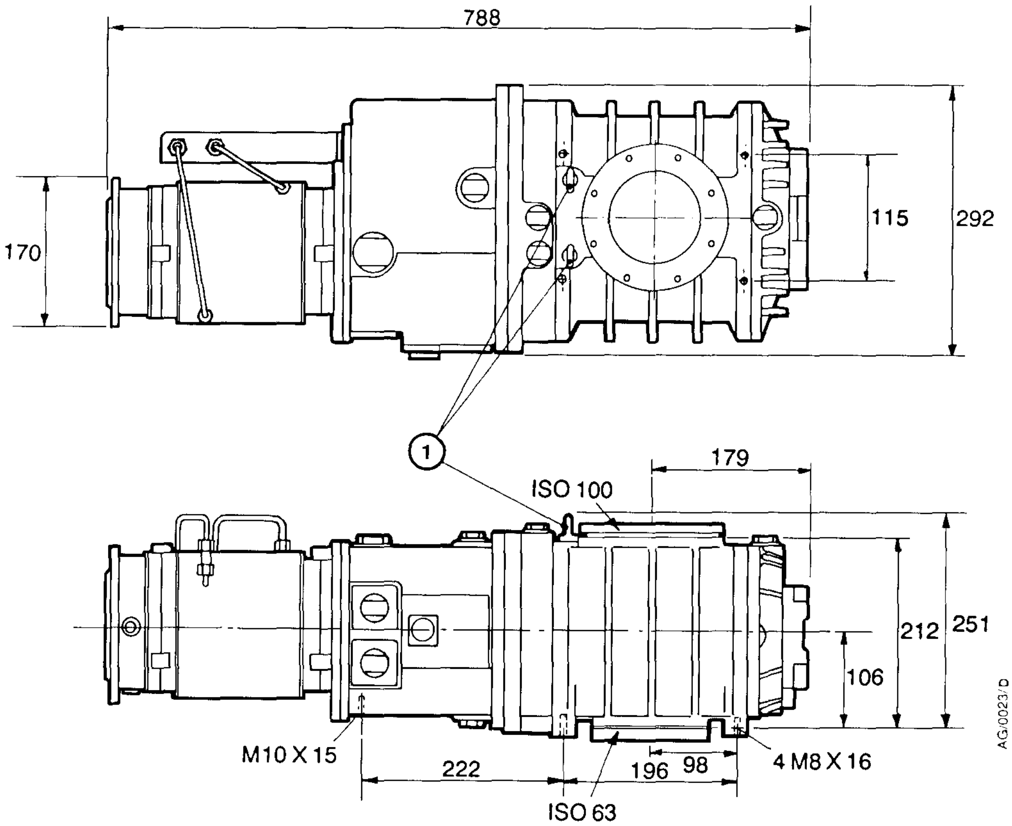
Parameter	QMB250F	QMB500F	QMB1200F
Mass (kg)	65	78	157
Minimum cooling-water flow ($l.h^{-1}$)	75	75	75
Oil capacity (l)			
Coupling-cover	1.5	1.5	2.4
Shaft-seal reservoir	0.125	0.125	0.125
Gear-case	-	-	1.25
Rotational speed ($r.min^{-1}$)			
50 Hz supply	0 to 2900	0 to 2900	0 to 2900
60 Hz supply	0 to 3500	0 to 3500	0 to 3500
Ultimate pressure without gas-ballast, permanent gases	8×10^{-4} mbar 8×10^{-2} Pa	8×10^{-4} mbar 8×10^{-2} Pa	8×10^{-4} mbar 8×10^{-2} Pa
Pressure differential across pump determined by the hydrokinetic drive	0 to 180 mbar 0 to 1.8×10^4 Pa	0 to 110 mbar 0 to 1.1×10^4 Pa	0 to 90 mbar 0 to 9×10^3 Pa
Recommended backing-pump	QDP40 or QDP80	QDP40 or QDP80	QDP80 or DP180
Vacuum connections			
Inlet connection	ISO63 bolted	ISO100 bolted	ISO160 bolted
Outlet connection	ISO40 bolted	ISO63 bolted	ISO100 bolted
Cooling-water connections			
Inlet connection (BSP)	Hansen quick connect $^3/_8$ inch male		
Outlet connection (BSP)	Hansen quick connect $^3/_8$ inchfemale		
Noise data			
Continuous A-weighted sound pressure level (dB(A))	66	66	70

Table 2 - Technical data



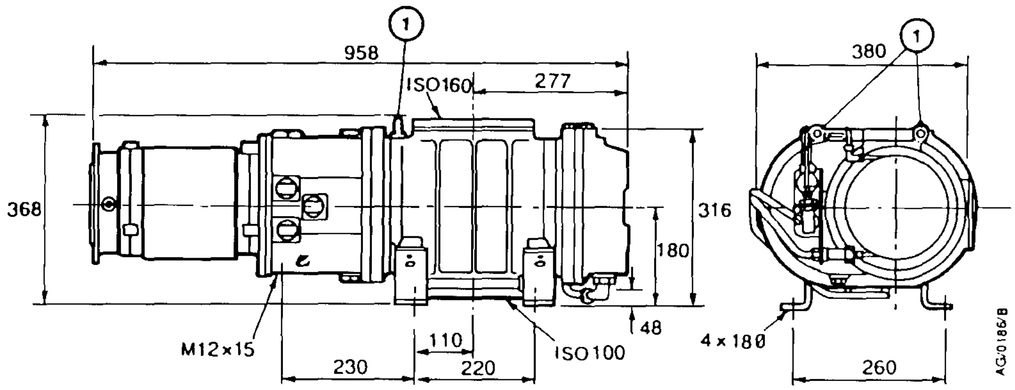
1. Lifting point

Figure 3 - QMB250F dimensions



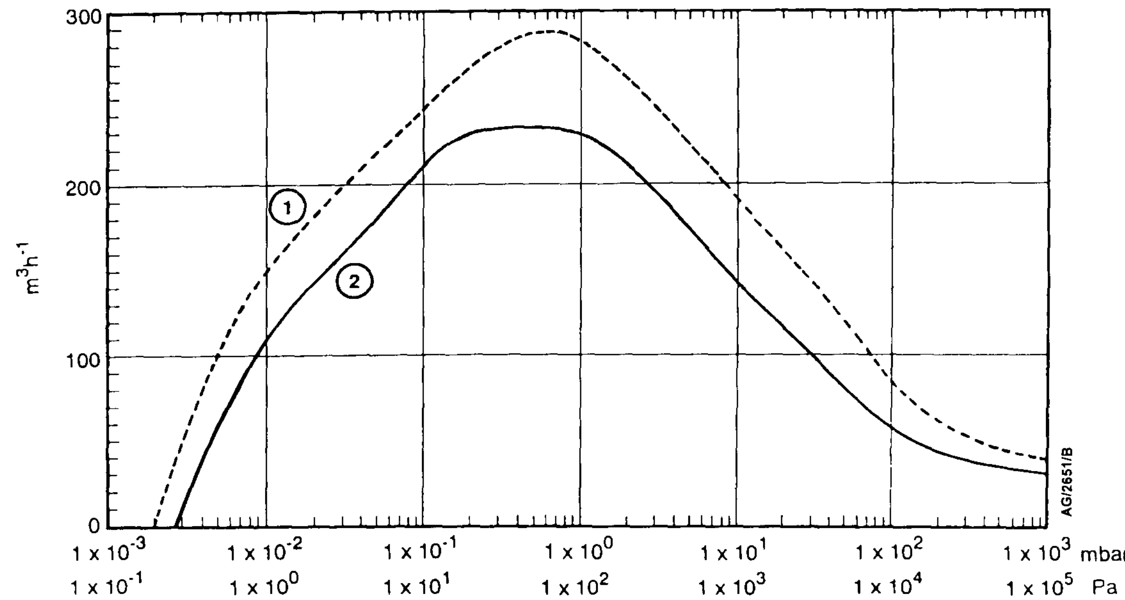
1. Lifting point

Figure 4 - QMB500F dimensions



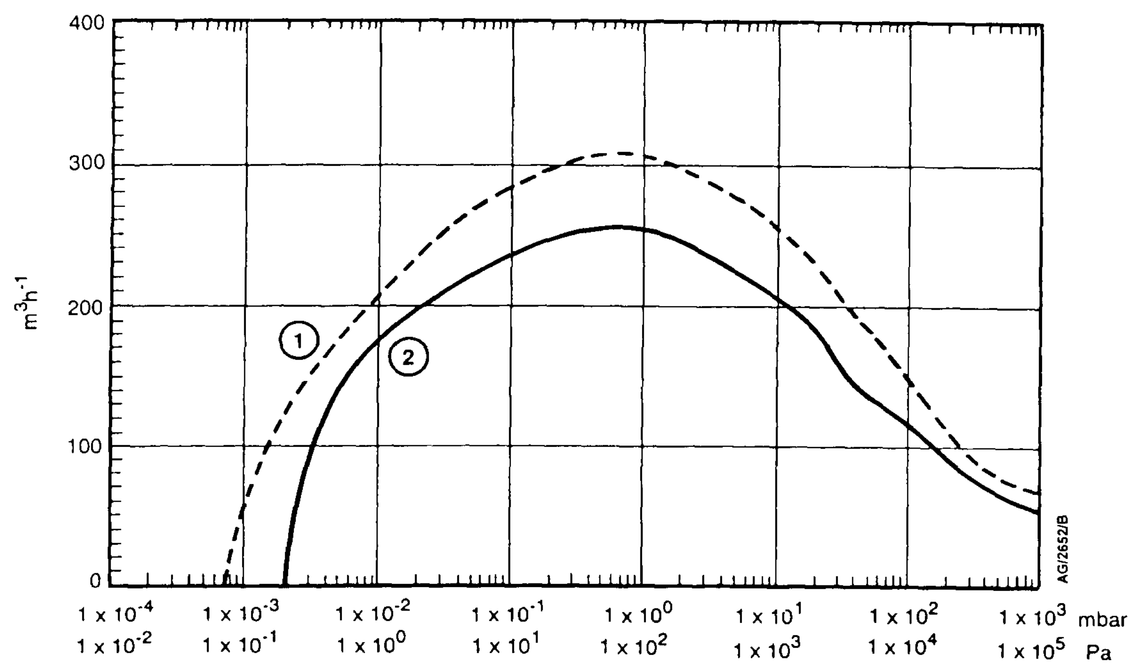
1. Lifting point

Figure 5 - QMB1200F dimensions



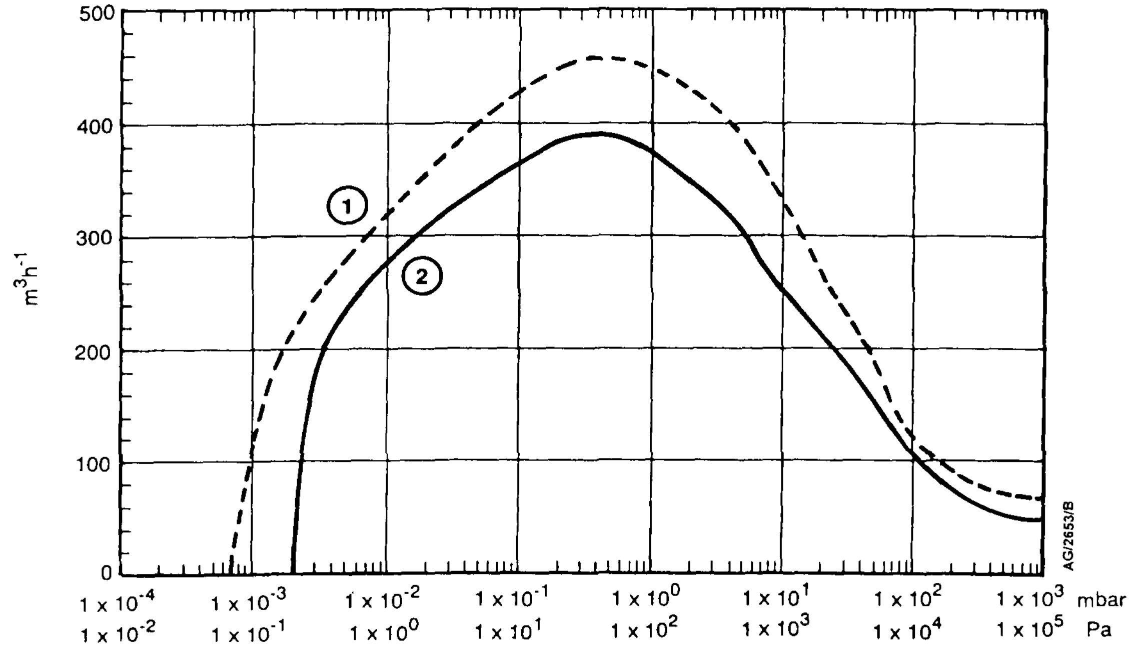
1. QDP40 and QMB250F at 60Hz 2. QDP40 and QMB250F at 50Hz

Figure 6 - Typical pumping speed for QDP40 and QMB250F pumping combinations



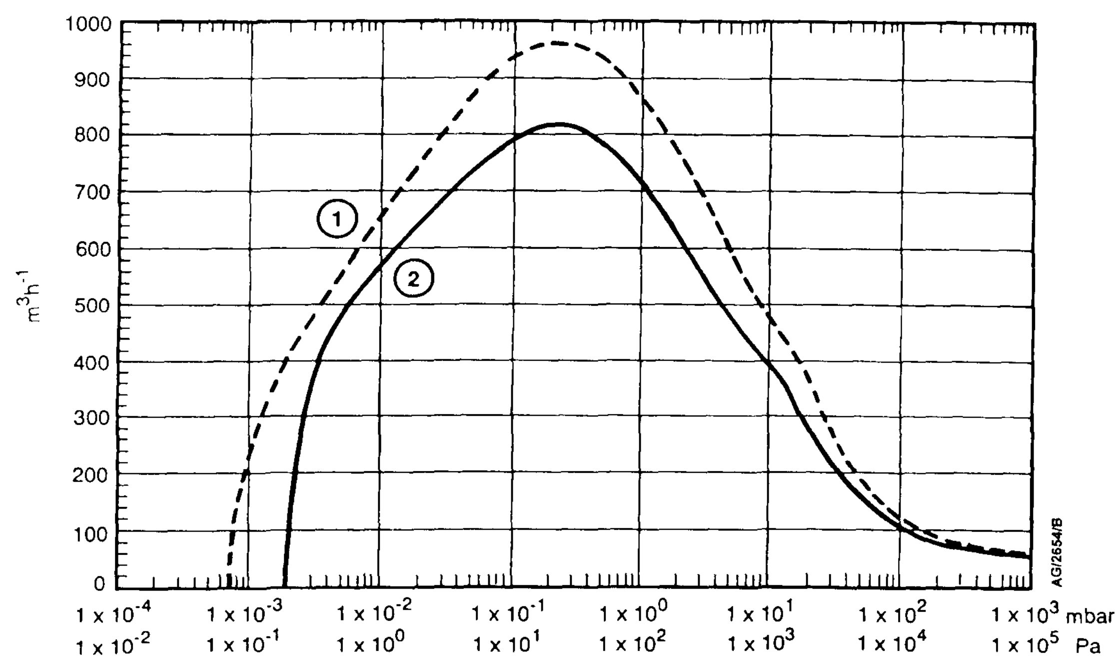
1. QDP80 and QMB250F at 60Hz 2. QDP80 and QMB250F at 50Hz

Figure 7 - Typical pumping speed for QDP80 and QMB250F pumping combinations



1. QDP80 and QMB500F at 60Hz 2. QDP80 and QMB500F at 50Hz

Figure 8 - Typical pumping speed for QDP80 and QMB500F pumping combinations



1. QDP80 and QMB1200F at 60Hz 2. QDP80 and QMB1200F at 50Hz

Figure 9 - Typical pumping speed for QDP80 and QMB1200F pumping combinations

3 INSTALLATION

3.1 Safety

> WARNING
>
> Obey the safety instructions given below and take note of appropriate precautions. If you do not, you can cause injury to people and damage to equipment.

- A suitably trained and supervised technician must install the pump.
- Ensure that the installation technician is familiar with the safety procedures which relate to the products handled by the pumping system. Wear the appropriate safety-clothing when you come into contact with contaminated components. Dismantle and clean contaminated components inside a fume-cupboard.
- If the QMB pump is to replace an existing pump, vent and purge the process system with nitrogen for 15 minutes before you start installation work.
- Check that all the required components are available and of the correct type before you start work.
- Disconnect the other components in the pumping system from the electrical supply so that they cannot be operated accidentally.
- Do not reuse any 'O' ring or 'O' ring assembly, and do not allow debris to get into the QMB pump during installation.
- Leak-test the system after installation work is complete to prevent leakage of hazardous substances out of the system and leakage of air into the system. Seal any leaks found to prevent leakage of dangerous substances out of the system, and leakage of air into the system.
- Do not remove the temporary cover or the blanking-plate from the QMB pump-inlet and pump-outlet until you are ready to connect the QMB pump to your vacuum system. Do not operate the QMB pump unless the inlet blanking-plate is fitted, or the QMB pump is connected to your vacuum system.
- Do not operate the QMB pump without a suitable backing pump: refer to Section 2.
- Wipe up any water or oil spilt during installation, so that people cannot slip over any spillages.
- Safely route and secure cables, hoses and pipes during installation, so that people cannot trip over them.
- Obey all local and national rules and safety regulations when you install the QMB pump.
- Consult BOC Edwards publication P300-20-000 (Vacuum Pump and Vacuum System Safety) before you pump hazardous materials. This publication is available on request: contact your supplier or BOC Edwards.

3.2 Unpack and inspect

> WARNING
>
> Use suitable lifting equipment to move the pump. Refer to Section 2 for the mass of the pump.

1. Place the pallet in a convenient position with a fork-lift truck or a pallet truck.
2. Remove all packing materials.
3. Use suitable lifting-gear to remove the pump from its pallet. Do not try to lift the pump by hand. Refer to Section 2 for the mass of the pump.
4. Remove all protective covers and inspect the pump. If the pump is damaged, notify your supplier and the carrier in writing within three days; state the Item Number of the pump together with your order number and your supplier's invoice number. Retain all packing materials for inspection. Do not use the pump if it is damaged.
5. If the pump is not to be used immediately, replace the protective covers. Store the pump in suitable conditions as described in Section 6.1.

3.3 Locate the pump

> WARNING
>
> Use suitable lifting equipment to move the pump. Refer to Section 2 for the mass of the pump.

Attach suitable lifting equipment to the lifting points on the pump (see Figures 3 to 5) to move the pump into its operating position. The pump must be mounted on a firm, level surface.

3.4 Fill the pump with oil

> CAUTION
>
> Ensure that the oil-levels in the pump are correct. If an oil-level is incorrect, pump performance may be affected and the pump may be damaged.

3.4.1 Coupling-cover

We recommend that the coupling-cover oil-level is maintained at the recommended oil-level shown in Figure 10, item 5; if the oil-level is above or below the recommended oil-level, the performance of the pump may be affected. Do not allow the coupling-cover oil-level to fall below the bottom of the reflector plate (Figure 10, item 4) or the pump may be damaged.

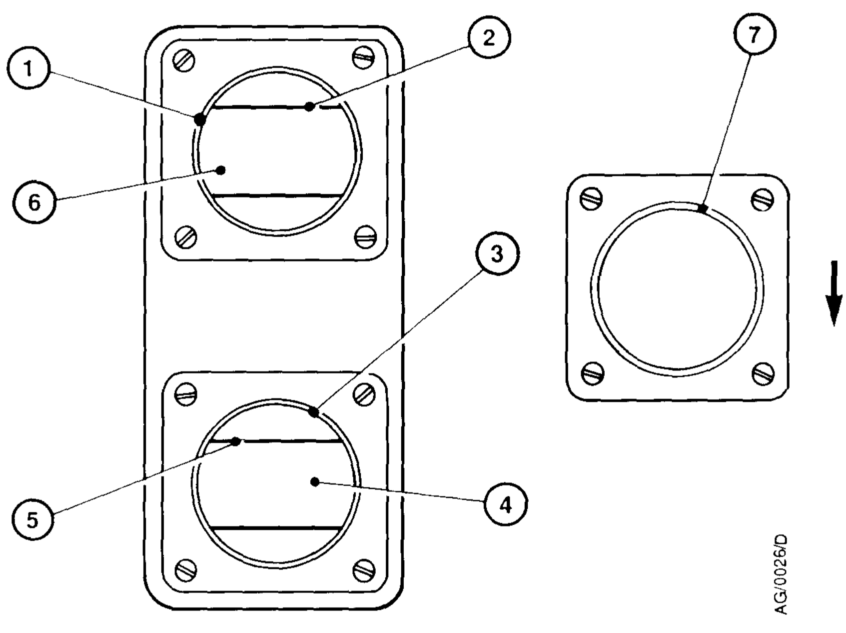
1. Remove the coupling-cover oil filler-plug (Figure 1, item 4).
2. Refer to Figure 10. Fill the coupling-cover with PFPE oil until the oil-level reaches the recommended oil-level (5) at the top of the reflector plate (4) in the coupling-cover sight-glass (3).
3. Refit the coupling-cover oil filler-plug.

3.4.2 Shaft-seal reservoir

> WARNING
>
> Ensure that the correct vented filler-plug is replaced in the shaft-seal reservoir. If you use a non-vented plug, the reservoir will be pressurised and the oil sight-glass may fracture.

We recommend that you fill the shaft-seal reservoir so that the oil-level is at the recommended oil-level, shown in Figure 10, item 2. You can operate the pump as long as the oil-level is above the bottom of the reflector plate. Do not allow the shaft-seal oil-level to fall below the bottom of the reflector plate or the pump may be damaged. You must use the same oil you used to fill the coupling-cover.

(Continued on page 14



1. Shaft-seal reservoir sight-glass
2. Shaft-seal reservoir recommended oil-level
3. Coupling-cover sight-glass
4. Coupling-cover reflector plate
5. Coupling-cover recommended oil-level
6. Shaft-seal reflector plate
7. Direction of rotation sight-glass (the arrow shows the correct direction of rotation)

Figure 10 - Sight-glasses

1. Remove the shaft-seal reservoir vented oil filler-plug (Figure 1, item 3).
2. Refer to Figure 10. Fill the shaft-seal reservoir with PFPE oil until the oil-level is at the recommended oil-level (2) at the top of the reflector plate (6).
3. Refit the vented oil filler-plug.

3.4.3 Gear-cover (QMB1200F only)

Use the following procedure to fill the gear-cover on the QMB1200F pump. You must fill the gear-cover with the same oil you used to fill the coupling-cover and shaft-seal reservoir.

1. Refer to Figure 1. Remove the oil filler-plug (16) on the top of the gear-cover; take care not to accidentally remove the plug from the external evacuation port (7).
2. Fill the gear-cover with oil until the oil-level is at the middle of the reflector plate in the gear-cover oil-level sight-glass (18).
3. Refit the oil filler-plug.

3.5 Cooling-water connections

> WARNING
>
> Do not turn on the cooling-water supply before you have finished all electrical installation. If you do, condensation may form inside the motor terminal-box and there may be a risk of electric shock.

Connect the cooling-water supply and return pipelines to the quick connectors on the cooling-water brackets on the pump (see Figure 1).

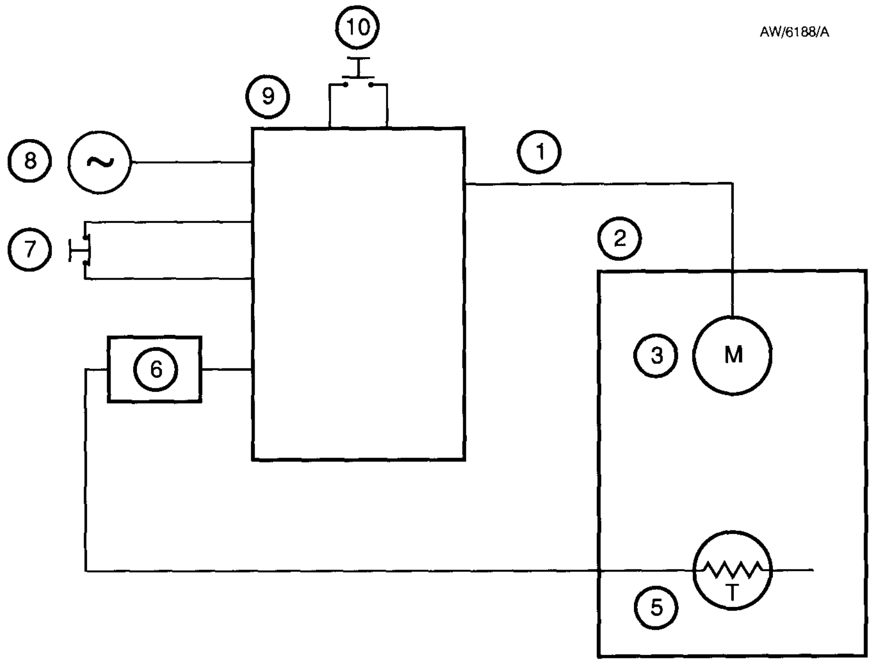
Refer to Section 2 for the minimum cooling-water flow rate required. Do not turn on the cooling-water supply yet.

3.6 Connect to your emergency stop system

The QMB pump must be connected to an emergency stop facility. The operation of the emergency stop function should immediately disconnect power from the QMB pump when the emergency stop control is operated. Returning the emergency stop control to its normal position should not result in power being re-applied to the QMB pump; a separate start or reset control should be used for this.

The excess temperature detected by the motor protection thermistors should also be connected to an emergency stop facility to cause the QMB pump to stop immediately, in the same way as the emergency stop function.

Refer to Figure 11 and to Section 3.7 for more information about the electrical connections.



1. Electrical supply to QMB pump-motor
2. QMB pump
3. QMB pump-motor
4. Not used
5. Motor-protection thermistors
6. Thermistor interface
7. Emergency stop control
8. External electrical supply
9. Emergency stop system
10. Reset/start controls

Figure 11 - Schematic diagram of the emergency stop system

3.7 Electrical connections

WARNING

Use suitable cable-glands so that the seals of the electrical supply and thermistor cable entries into the motor terminal-box meet the requirements of IP44 (or higher), as defined by IEC 529. If you do not, condensation may form inside the terminal-box and there may be a risk of electric shock.

3.7.1 High and low-voltage operation

The universal motors are supplied configured for 'low-voltage' operation (200-208 V at 50 Hz or 200-230 V at 60 Hz). Figures 12 and 14 show the low voltage configurations for the QMB250/500F and QMB1200F pumps.

To change the QMB250/500F pump-motor to 'high-voltage' operation (380-415 V at 50 Hz or 460 V at 60 Hz), remove the pump-motor terminal-box cover, then remove the three links from the U, V and W terminals. Link the U1, V1 and W1 terminals as shown in Figure 13.

To change the QMB1200F pump-motor to 'high-voltage' operation (380-415 V at 50 Hz or 460 V at 60 Hz), remove the pump-motor terminal-box cover, then remove the wires from the U1, V1 and W1 terminals. Reconnect the wires to the terminals as shown in Figure 15.

3.7.2 Motor connections

CAUTION

The motor must be correctly configured and you must make the correct electrical connections for your electrical supply. If you do not, you can damage the motor.

Connect the motor to the electrical supply as described below. Connect the supply through a contactor which has overload-protection, or use a controller which incorporates a contactor. You must use a contactor which has a manual reset control. If you do not, the pump could automatically restart after an electrical overload or an electrical supply failure.

1. Remove the motor terminal-box cover.
2. Check your electrical supply voltage and frequency. If necessary, configure the motor to operate with your supply voltage (see Section 3.7.1).
3. Remove the plug from the cable entry-hole you will use for the electrical supply cable. Choose the most suitable entry-hole for your application.
4. Fit a suitable 20 mm cable-gland to the hole. If your cable is too large to pass through a 20 mm cable-gland, fit a 20 mm to 25 mm female thread-adaptor to the cable entry-hole, and fit a 25 mm cable-gland to the adaptor. The cable-gland (and adaptor, if fitted) must provide a protective seal to IP44 (or higher), as defined by IEC 529.

5. Pass the supply cable through the cable-gland and connect the wires of the electrical supply cable to the appropriate terminals (see Figures 12 to 15).
6. Tighten the cable-gland.

3.7.3 Motor-protection thermistors

Connect the output of the motor-protection thermistors to your control equipment to switch off the pump if the motor is too hot. Refer to Section 2 for the specification of a suitable control-unit. To connect the thermistors output:

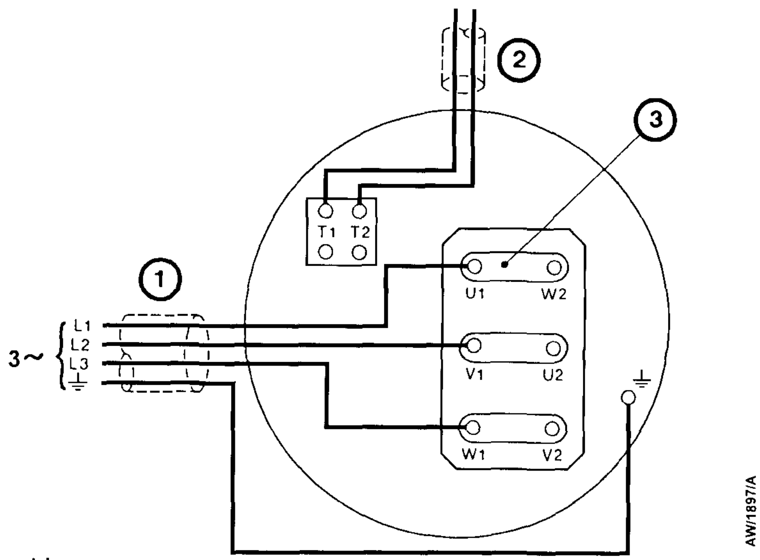
1. Remove the plug from the other cable entry-hole.
2. Fit a suitable 20 mm cable-gland to the entry-hole. The cable-gland must be a protective seal to IP44 (or higher) as defined by IEC 529.
3. Pass the thermistor cable through the cable-gland.
4. Refer to Figures 12 to 15. Connect the two wires of the thermistor cable to the thermistor terminals (T1 and T2). Connect the other ends of the wires to your control equipment.
5. Tighten the cable-gland, then refit the motor terminal-box cover.

3.8 Check the pump rotation

> WARNING
>
> Blank the inlet or connect the pump to the vacuum system before you check the direction of pump rotation. If you do not, there is danger of objects being trapped in the rotating rotors.

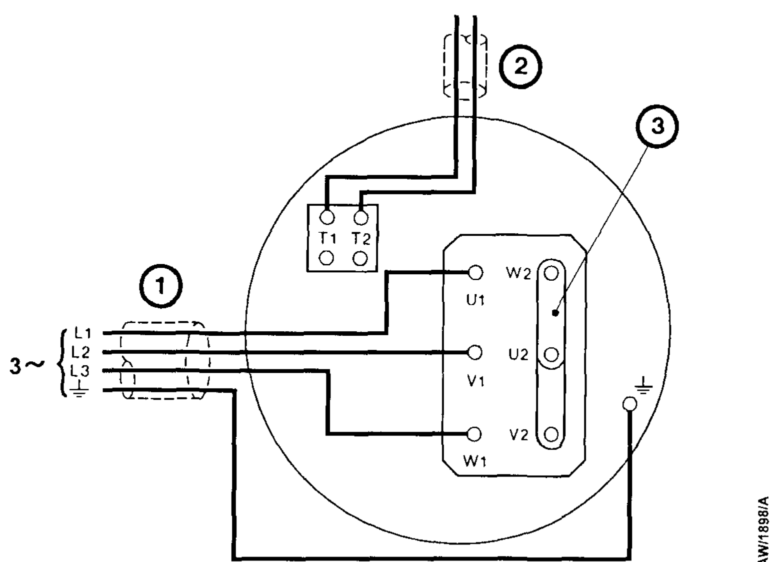
It is possible for the three-phase electrical supply to the motor to be phased incorrectly. If the supply is phased incorrectly, the rotors will rotate slowly in the reverse direction or remain stationary. Look through the direction of rotation sight-glass in the coupling-cover (Figure 1, item 11) to check the direction of rotation of the motor-coupling. An enlarged view of the sight-glass is shown in Figure 10. The correct direction of rotation is indicated by an arrow. Check the direction of rotation as described below.

1. Check that the pump is connected to the vacuum system or that the inlet is blanked off.
2. Connect the backing-pump and switch the backing-pump on.
3. Watch the motor-coupling in the sight-glass (Figure 10, item 7) and switch on the QMB pump for two or three seconds.
4. Check that the direction of rotation of the coupling is the same as that indicated by the rotation arrow on the motor and shown in Figure 10.
5. If the direction of rotation of the coupling is incorrect, switch off the backing-pump and isolate the QMB pump from the electrical supply. Reverse any two of the phase-wires in the motor terminal-box.
6. Repeat the check to ensure that the direction of rotation is now correct.



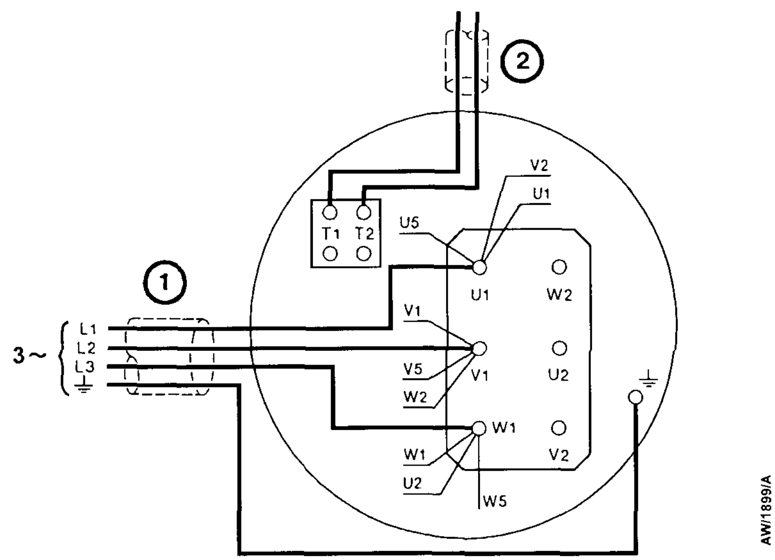
1. Electrical supply cable
2. Thermistors cable
3. Links

Figure 12 - QMB250/500F low-voltage configuration



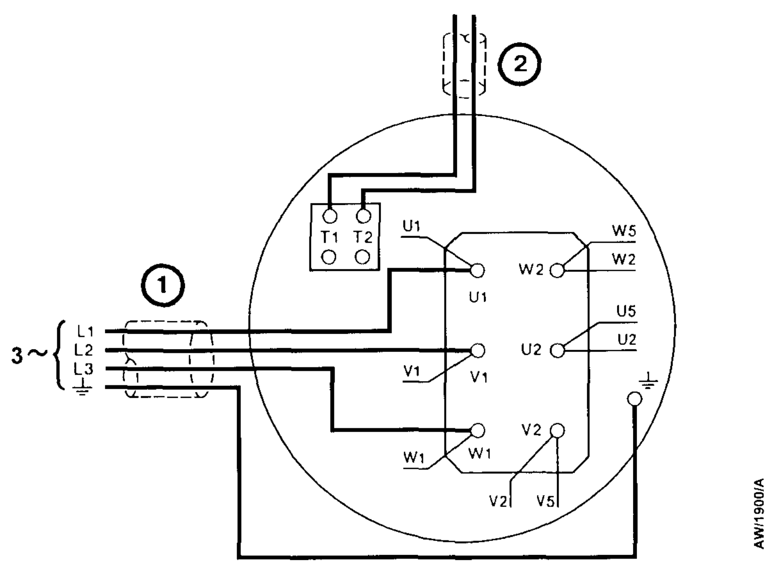
1. Electrical supply cable
2. Thermistors cable
3. Links

Figure 13 - QMB250/500F high-voltage configuration



1. Electrical supply cable
2. Thermistors cable

Figure 14 - QMB1200F low-voltage configuration



1. Electrical supply cable
2. Thermistors cable

Figure 15 - QMB1200F high-voltage configuration

3.9 Connect the pump-inlet and outlet

Consider the following points when you connect your pump:

- You must use a suitable backing pump: refer to Section 2.
- For optimum pumping speeds, ensure that the pipeline connected to the pump-inlet is as short as possible and has a bore size not less than the inlet-port diameter.
- On very dusty applications, use a low-impedance inlet-filter to minimise abrasion in the pump. A range of inlet-filters is available; if necessary, contact your supplier or BOC Edwards for advice.
- Adequately support vacuum pipelines to stop the transmission of stress to the pipeline joints.
- If necessary, incorporate flexible pipelines in your system pipelines to reduce the transmission of vibration and to prevent loading of coupling-joints. If you use flexible pipelines, you must ensure that you use flexible pipelines which have a maximum pressure rating which is greater than the highest pressure that can be generated in your system.
- You must be able to isolate the pump-inlet and exhaust from the atmosphere and from your vacuum system if you have used corrosive chemicals in the pump.
- You can incorporate a suitable control system so that the QMB pump is only switched on if the inlet pressure is below the maximum inlet pressure.

Before you connect the QMB pump to your vacuum system, remove the blanking-plates fitted to the pump-inlet and outlet. Retain the nuts, bolts and washers for future use. Retain the blanking-plates for future use as temporary covers, for uncontaminated pumps only.

Ensure that debris does not get into the pump when you install it. If the pump is to replace a pump in an existing system, purge the existing pump with nitrogen for 15 minutes before you disconnect it.

Use standard ISO flanges to connect the pump-inlet and outlet. Use a BOC Edwards trapped 'O' ring to seal the pump-inlet connection and use a BOC Edwards trapped 'O' ring or (on the QMB250F only) a BOC Edwards Co-Seal to seal the pump-outlet connection.

3.10 External evacuation of coupling-cover (optional)

You can use an external pump to evacuate the coupling-cover. A description of the connections required is beyond the scope of this manual. Contact your supplier or your nearest BOC Edwards company for advice if you wish to use this facility.

4 OPERATION

4.1 Operational safety

> WARNING
>
> Do not touch any part of the pump when it is switched on. Surfaces of the pump are very hot, especially at high inlet pressures, and can cause injury to people and damage to equipment.

If you operate the QMB250F or QMB500F pump in an area with poor ventilation, the temperature of the coupling-cover can reach 100 ^{o}C and above. Take all necessary precautions to avoid accidental contact with the coupling-cover; if necessary, use a pump enclosure or fit a guard to the pump.

If you operate the QMB1200F pump with the inlet pressure higher than 1 mbar (100 Pa) for a long period, the stator and the coupling-cover will reach very high temperatures. Take all necessary precautions to avoid accidental contact with the stator and the coupling-cover; if necessary, use a pump enclosure or fit a guard to the pump.

4.2 Start-up

Start-up the pump as described in the procedure below. This procedure assumes that the pump and the vacuum system are at atmospheric pressure.

1. Check that the pump oil-levels are correct (see Section 3.4).
2. Switch on the cooling-water supply and check that there is an adequate flow of cooling-water.
3. Close all valves to atmospheric pressure and ensure that all other openings are closed.
4. Switch on the backing pump and open the backing valve (if fitted).
5. When the inlet pressure is below the maximum inlet pressure for the pump, switch on the pump.
6. Slowly open the pump-inlet isolation-valve (if fitted).
7. Allow the pump to operate for approximately fifteen minutes to achieve normal operating temperature.
8. Inspect the cooling-water connections and pipes and check that there are no leaks. If there are any leaks, shut down the pumping system (refer to Section 4.3) and seal the leaks.

4.3 Shut-down

1. Close the pump-inlet isolation-valve (if fitted).
2. Switch off the mechanical booster pump.
3. Open the backing-pump air-admittance valve (if fitted) and switch off the backing-pump.
4. Turn off the cooling-water supply.

5 MAINTENANCE

5.1 Safety

> WARNING
>
> Obey the safety instructions given below and take note of appropriate precautions. If you do not, you can cause injury to people and damage to equipment.

- A suitably trained and supervised technician must maintain the pump.
- Ensure that the maintenance technician is familiar with the safety procedures which relate to the products pumped. Wear the appropriate safety-clothing when you come into contact with contaminated components. Dismantle and clean contaminated components inside a fume-cupboard.
- Allow the pump to cool to a safe temperature before you start maintenance work
- Vent and purge the pumping system with nitrogen before you start any maintenance work.
- Check that all the required parts are available and of the correct type before you start work.
- Isolate the pump and other components from the electrical supply so that they cannot be operated accidentally.
- Recheck the pump rotation direction if the electrical supply has been disconnected.
- Do not reuse any 'O' ring or 'O' ring assembly, and do not allow debris to get into the QMB pump during maintenance.
- Dispose of components safely (see Section 6.2).
- Take care to protect sealing-faces from damage.
- Do not touch or inhale the thermal breakdown products of fluorinated materials which may be present if the pump has been overheated to 260 °C and above. These breakdown products are very dangerous. Fluorinated materials in the pump may include oils, greases and seals. The pump may have overheated if it was misused, if it malfunctioned or if it was in a fire. BOC Edwards Material Safety Data Sheets for fluorinated materials used in the pump are available on request: contact your supplier or BOC Edwards.
- Leak-test the system after maintenance work is complete if you have connected or disconnected any vacuum joints. Seal any leaks found to prevent leakage of dangerous substances out of the system, and leakage of air into the system.
- Fit suitable blanking-plates to the pump-inlet and outlet as soon as you have disconnected the QMB pump from your vacuum system. Do not operate the pump unless the inlet blanking-plate is fitted, or the pump is connected to your vacuum system.
- Do not operate the QMB pump without a suitable backing pump: refer to Section 2.
- Wipe up any water or oil spilt during maintenance, so that people cannot slip over any spillages.
- Safely route and secure all cables, hoses and pipes during maintenance, so that people cannot trip over them.

5.2 Maintenance plan

The plan shown in Table 3 details the maintenance operations necessary to maintain QMB pumps in normal use. Instructions for each operation are given in the section shown.

More frequent maintenance may be required if the pump has been used to pump corrosive or abrasive gases and vapours. If necessary, adjust the maintenance plan according to your experience.

Operation	Frequency	Refer to Section
Check the oil-levels	3 monthly	5.3
Inspect the pump connections	Monthly	5.4
Lubricate the rear-bearing *	12 monthly	5.5
Change the pump oil	As required	5.6

* QMB250F and QMB500F only

Table 3 - Maintenance plan

5.3 Check the oil-levels

CAUTION

Ensure that the oil-levels in the pump are correct. If an oil-level is incorrect, pump performance may be affected and the pump may be damaged.

Note: *If there is a loss of oil from the shaft-seal reservoir, the shaft-seal may have failed. You cannot replace the shaft-seal ; contact your supplier or a BOC Edwards Service Centre for advice.*

Use the following procedure to check the oil-levels in the sight-glasses. Refer to Figure 1 for the location of the filler-plugs and sight-glasses. During normal operation, the coupling-cover sight-glass (Figure 10, item 2) may appear empty or show a froth because the oil is in circulation around the coupling.

1. Refer to Figure 10. Check the shaft-seal oil-level. If the oil-level is below the bottom of the reflector plate (6), refer to Section 3.4 and refill the shaft-seal reservoir.
2. Check the coupling-cover oil-level. If the oil-level is below the top of the reflector plate, refer to Section 3.4 and refill the coupling-cover reservoir.
3. On the QMB1200F only, check the gear-cover oil-level in the gear-cover sight-glass (Figure 1, item 18). If the oil-level is below the middle of the reflector plate, refer to Section 3.4 and refill the gear-cover.

5.4 Inspect the pump connections

1. Check that the cooling-water connections are secure. Tighten any connections that are loose.
2. Inspect the cooling-water pipelines and connections and check that they are not corroded or damaged and do not leak. Replace any pipelines and connections which are corroded or damaged or leak.
3. Check that the electrical connections are secure. Tighten any connections that are loose.
4. Check the electrical supply cables for damage. Replace any cable which is damaged.
5. Check that all the vacuum connections are secure. Tighten any connections that are loose.
6. Inspect all the vacuum pipelines and connections and check that they are not corroded or damaged. Replace any pipelines and connections which are corroded or damaged.

5.5 Lubricate the rear-bearing (QMB250F and QMB500F only)

1. Switch off the pump and isolate it from the electrical supply. Vent the pump to atmospheric pressure.
2. Refer to Figure 16. Remove the four plastic cover-caps (8) from the end-cover (6).
3. Undo and remove the socket-head screws (7) located under the four plastic cover-caps.
4. Remove the end-cover (6) and 'O' ring (5). Dispose of the 'O' ring safely.
5. Note the exact location of the shims (4) and spacers (3) inside the end-cover (6). Clean off all visible grease from the end-cover; take care not to misplace or damage the shims and spacers.
6. Use a clean, lint-free cloth or a plastic or wooden spatula to remove all visible grease from both bearings (2).
7. Fill the visible side of each bearing (2) with clean grease, then lightly force the grease into the bearings.
8. Apply a light wipe of high-vacuum grease to the new 'O' ring (5) and fit it into the groove in the end-cover (6).
9. Check that the shims (4) and spacers (3) are correctly located in the end-cover (6).
10. Fit the end-cover (6) and secure with the four socket-head screws (7). Tighten the screws evenly and refit the plastic cover-caps (8).

5.6 Change the pump oil

WARNING

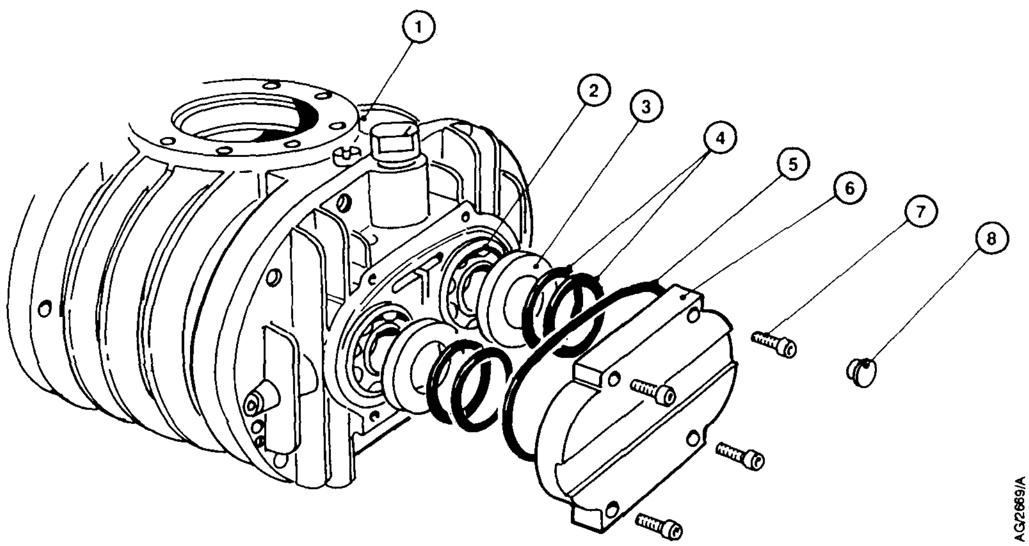
Ensure that the correct vented filler-plug is replaced in the shaft-seal reservoir. If you use a non-vented plug, the reservoir will be pressurised and the oil sight glass may fracture.

CAUTION

Ensure that the oil-levels in the pump are correct. If an oil-level is incorrect, pump performance may be affected and the pump may be damaged.

Replace the pump oil as described below. Refer to Figure 1 for the location of the oil-filler and drain-plugs.

1. Switch off the pump and allow it to cool.
2. Remove the coupling-cover oil filler-plug (4).
3. Remove the coupling-cover oil drain-plug (10) from the underside of the coupling-cover and allow the oil to drain into a suitable container.
4. Remove the shaft-seal vented oil filler-plug (3). Use a suitable pump to suck the oil out of the shaft-seal reservoir.
5. Refit the coupling-cover oil drain-plug (10).
6. Refer to Section 3.4 and fill the coupling-cover and shaft-seal reservoir with oil.
7. Refit the coupling-cover oil filler-plug (4) and the shaft-seal vented oil filler-plug (3).
8. On QMB1200F pumps only:
    - Remove the filler-plug on the gear-cover; take care not to accidentally remove the plug from the external evacuation port (7).
    - Remove the drain-plug from the underside of the gear-cover and allow the oil to drain into a suitable container.
    - Refit the drain-plug and refer to Section 3.4 to refill the gear-cover with oil.



1. Pump-body
2. Bearing
3. Spacer
4. Shims
5. 'O' ring
6. End-cover
7. Socket-head screw
8. Cover-cap

Figure 16 - Lubricate the rear bearing (QMB250F and QMB500F only)

6 STORAGE AND DISPOSAL

6.1 Storage

Use the procedure below to store the pump.

1. Shut-down the pump as described in Section 4.
2. Isolate the pump from the electrical supply and disconnect it from the vacuum system.
3. Clean the pump and change the oil as described in Section 5.
4. Place protective covers over the inlet and outlet-flanges.
5. Store the pump in cool, dry conditions until required for use. When required, prepare and install the pump as described in Section 3.

6.2 Disposal

Dispose of the pump and any components safely in accordance with all local and national safety and environmental requirements.

Take particular care with components which have been contaminated with dangerous process substances.

7 SERVICE, SPARES AND ACCESSORIES

7.1 Introduction

BOC Edwards products, spares and accessories are available from BOC Edwards companies in Belgium, Brazil, China, France, Germany, Israel, Italy, Japan, Korea, Singapore, United Kingdom, U.S.A and a world-wide network of distributors. The majority of these centres employ Service Engineers who have undergone comprehensive BOC Edwards training courses.

Order spare parts and accessories from your nearest BOC Edwards company or distributor. When you order state for each part required:

- Model and Item Number of your equipment
- Serial number
- Item Number and description of part.

7.2 Service

BOC Edwards products are supported by a world-wide network of BOC Edwards Service Centres. Each Service Centre offers a wide range of options including: equipment decontamination; service exchange; repair; rebuild and testing to factory specifications. Equipment which has been serviced, repaired or rebuilt is returned with a full warranty.

Your local Service Centre can also provide BOC Edwards engineers to support on-site maintenance, service or repair of your equipment.

For more information about service options, contact your nearest Service Centre or other BOC Edwards company.

7.3 Spares

The spare parts listed below are available for the QMB Mechanical Booster Pump:

Product	Item Number
RT15 Fomblin grease (100gm)	H113-50-003
End-cover 'O' ring (QMB250F and QMB500F)	H021-22-091
Gear-cover 'O' ring (QMB1200F)	H021-22-159
Fomblin YVAC 16/6 fluid (1kg)	H113-06-019
Fomblin YVAC 16/6 fluid (5kg)	H113-06-020
Krytox 1514 fluid (1kg)	H113-08-018
Krytox 1514 fluid (5kg)	H113-08-020

7.4 Accessories

Note The accessories listed in Sections 7.4.2 and 7.4.3 are designed to be used together with the Booster Frame described in Section 7.4.1.

7.4.1 QMB Booster Frames

The QMB Booster Frame supports the QMB pump and allows you to leave the QMB pump installed in the vacuum system while you install or remove a QDP dry pump.

Product	Item Number
QMB Booster Frame for QDP40/QMB250F	A528-37-000
QMB Booster Frame for QDP40/QMB500F, QDP80/QMB250F and QDP80/QMB500F	A528-38-000
QMB Booster Frame for QDP80/QMB1200F	A528-39-000

7.4.2 QMB Booster Frame Connection Kits

These kits enable a QMB pump fitted in a Booster Frame to be mounted onto a QDP dry pump. Each kit contains a sub-frame to support the QMB pump before you install the QDP pump, a flange adaptor (if necessary) and cooling-water pipes and connections to connect the QMB pump cooling-system to the QDP pump cooling-system.

Product	Item Number
QMB Booster Frame Connection Kit for QDP40/QMB250F	A528-65-000
QMB Booster Frame Connection Kit for QDP40/QMB500F	A528-66-000
QMB Booster Frame Connection Kit for QDP80/QMB250F	A528-67-000
QMB Booster Frame Connection Kit for QDP80/QMB500F	A528-68-000
QMB Booster Frame Connection Kit for QDP80/QMB1200F	A528-69-000

7.4.3 QMB Booster Frame Acoustic Enclosures

When fitted to a QMB Booster Frame, an Acoustic Enclosure reduces noise from the QMB and QDP pumps.

Product	Item Number
QMB Booster Frame Acoustic Enclosure for QDP40/QMB250F	A528-70-000
QMB Booster Frame Acoustic Enclosure for QDP40/QMB500F	A528-71-000
QMB Booster Frame Acoustic Enclosure for QDP80/QMB250F	A528-72-000
QMB Booster Frame Acoustic Enclosure for QDP80/QMB500F	A528-73-000
QMB Booster Frame Acoustic Enclosure for QDP80/QMB1200F	A528-74-000

7.4.4 QMB to QMKII Connection Kits

These kits enable a QMB pump to be mounted onto the QDP dry pump in a QMKII system.

Product	Item Number
QMB250F to QMKII Connection Kit	A529-33-000
QMB500F to QMKII Connection Kit	A529-34-000
QMB1200F to QMKII Connection Kit	A529-35-000

SEREN

INDUSTRIAL POWER SYSTEMS INC.

MODEL R600
RADIO FREQUENCY
POWER SUPPLY
OPERATOR'S MANUAL

Release 1.08
Air Cooled
Standard Configuration

SEREN Industrial Power Systems, Inc.
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E-mail: info@serenips.com

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WARNING

INSTALLATION OF THIS POWER SUPPLY SHOULD BE PERFORMED IN COMPLIANCE WITH NATIONAL ELECTRICAL CODE ANSI C1 TO AVOID SHOCK OR FIRE HAZARD. SERVICE SHOULD BE PERFORMED BY QUALIFIED PERSONNEL.ONLY

PROPRIETARY INFORMATION

1.0 Introduction

This operator's manual provides the operating instructions for the R600 Radio Frequency power supply.

1.1 Purpose

The R600 Radio Frequency power supply is a precision microprocessor controlled power source with a flexible set of controls.

1.2 Scope

This document discusses characteristics, installation, operation and service of the equipment.

1.3 General Description

The R600 power supply is an RF module with a rated power output of 650 watts (open loop power output is 850 watts for a nominal 30% margin).

The generator has several control modes. The R600 may be controlled via the front panel, an analog interface or serial interface. The front panel consists of a 40 character display for operating and programming, a set of key switches for menu movement and function selects and an rotary encoder for data entry.

The analog interface, described in detail in section 1.5.0, has optical isolation for the digital inputs and outputs and instrumentation inputs and outputs for the analog control signal. The serial interface is RS232C, operates to 19.2 kbaud, and is optically isolated.

TABLE OF CONTENTS (CONT.)

CONTROL AND INTERFACE

1.4.0 FRONT PANEL CONTROLS

The R600 is supplied with the following front panel controls and indicators:

AC SWITCH - The rocker switch turns on all power supplies and control circuits.

PROGRAM - Switches the unit from normal "RUN" screen to "PROGRAM" mode. The program mode is used to set and verify parameter selections.

RUN - Returns unit to "RUN" screen after program is complete.

UP/DOWN - Menu movement keys. "Down" takes user through menu. "UP" returns through menu.

KNOB - The knob is used for parameter selection and numerical entry. Turn clockwise to increase number and counter- clockwise to decrease. When used as a select turn clockwise to select, counter-clockwise to deselect.

DISPLAY- The vacuum fluorescent display (VFD) is used to indicate forward and reflected power, mode and time in the "RUN" mode. The second line is also used to display fault conditions. In addition to forward and reflected power, the programming parameters are displayed in "PROGRAM" mode.

RFON LIGHT - The red light-emitting diode (LED) is illuminated when the RF power is on.

1.5.0 REAR PANEL CONNECTIONS

The following connections are available on the rear panel of the R600.

AC LINE CORD - Plug unit into AC Mains power source.
100-125V units are equipped with a 125V 15A, NEMA type 5-15P power plug
198-250V units are equipped with a 250V 15A, NEMA type L6-15 locking power plug.

RF OUT - Type "N" female connector for RF output

CEX OUT - Type “BNC” female connector, Common EXciter output; 5V P-P @ 13.56 MHZ

CEX IN - Type “BNC” female connector, Common EXciter input; requires 3V P-P @ 13.56 MHZ

RS232 - Serial Interface. 25 pin male “D” connector for serial communication and control

ANALOG INT - Analog Interface. 37 pin male “D” connector for remote analog control

1.3.1 SEREN R600 TECHNICAL SPECIFICATIONS

FREQUENCY	13.56 MHZ, +-.005%
FREQUENCY STABILITY	.005% SHORT TERM
RF POWER OUTPUT	650 WATTS INTO 50 OHMS
OUTPUT IMPEDANCE	50 OHMS +-5 OHMS NOMINAL
METERING ACCURACY	FORWARD +-.5%F.S. +-3% READING
TEMP COEFFICIENTS	.025% PER DEGREE C.
POWER STABILITY	.5% LONG TERM
FORWARD POWER REGULATION	1 % INTO 50 OHMS
LOAD TOLERANCE	NO OSCILLATION OR FAILURE INTO MISMATCH
NOISE, HUM, RIPPLE	-40 DBC
HARMONIC DISTORTION	ALL HARMONICS DOWN -45 DB
CONTROLS	FRONT PANEL, RS232, RS485 OPTICALLY ISOLATED ANALOG
COMMON EXCITER	INPUT: 50 OHMS 2V to 10V P-P AT SPECIFIED FREQUENCY. OUTPUT:5V P-P INTO 50 OHMS.
PROTECTION	FORWARD POWER LIMITS ON CURRENT, TRANSISTOR POWER DISSIPATION, AND EXCESSIVE REFLECTED POWER. UNIT IS OPEN AND SHORT CIRCUIT PROTECTED.
SPURIOUS RADIATION	UNIT MEETS OR EXCEEDS FCC SPECIFICATIONS.
OPERATING TEMPERATURE	0 TO 45 DEGREES C
HUMIDITY	80% NON-CONDENSING
POWER REQUIRED	100-125 VAC 47/63 HZ SINGLE PHASE 12 AMPS OR 198-250 VAC 47/63 HZ SINGLE PHASE 5 AMPS
CIRCUIT PROTECTION	100-125V: 15 AMP OVER-CURRENT CIRCUIT BREAKER 198-250V: 10 AMP OVER-CURRENT CIRCUIT BREAKER WITH 1000 AMP INTERRUPT CAPACITY.
MECHANICAL DIMENSIONS	8.75"H X 8"W X 19"D.
WEIGHT	APPROX. 45 LBS
COOLING	AIR, 110 CFM FAN

PIN	SIGNAL NAME	DESCRIPTION
		Active in Panel, Analog, or Serial control modes.
6	GATEN*	Selects Continuous Wave (CW) or Pulse Operation. TTL – compatible input with an internal pull-up resistor. A contact closure between pin 6 and pin 25 or applying a TTL "low" signal to pin 6 enables pulse operation. Apply the external pulse train to Pin 7.
7	GATE	External Pulse Train input. Toggles output power between setpoint value 0 Watts. TTL - compatible input with internal pull-up resistor. An open circuit or TTL "high" signal applied to pin 7 holds the RF output the setpoint level. A contact closure between pin 7 and pin 26 or a TTL 'low" signal applied to pin 7 switches the RF output power to 0 Watts.
8	No connection	-
9	No connection	-
10	RFENABLED*	RF output status signal. Active low, open collector output with internal pull-up resistor to +5VDC. Signal output is 0V (low) for an RF on condition; signal output is +5VDC for an RF off condition. Use pin 29 for a reference return.
11	TEST*	Reserved. No function assigned.
12	No connection	-
13	FWDMON	Forward power monitor output signal. Analog output, selectable 0 to +5VDC or 0 to +10VDC range via front panel controls. Output scaling is 5.0VDC at 650 Watts (7.7mV/Watt) or 10.0VDC at 650 Watts (15.4mv/Watt), depending on output range selected. Measure monitor voltage with respect to pin 32 (FWD RTN).
14	COMMON	Connected to chassis ground.
15	REFMON	Reflected power monitor output signal. Analog output, selectable 0 to +5VDC or 0 to +10VDC range via front panel controls. Output scaling is 5.0VDC at 150 Watts (33.3mV/Watt) or 10.0VDC at 150 Watts (66.64mv/Watt), depending on output range selected. Measure monitor voltage with respect to pin 34 (REF RTN).
16	FEEDBACK	External feedback voltage signal. Analog input, selectable range of 0 to 5VDC or 0 to 10VDC and selectable polarity - positive (+) or negative (-) via front panel control. Use pin 35, FEEDBACK RTN, for return reference. The external feedback signal is derived from a voltage probe (RF or DC) located elsewhere in the plasma or process system. Refer to the controls section of the operator's manual for detailed instructions on how to configure and use this mode

1.5.1 ANALOG INTERFACE PIN LIST AND FUNCTIONAL DESCRIPTION

Asterisk (*) denotes an active-low signal

PIN	SIGNAL NAME	DESCRIPTION
1	AC INTERLOCK	Optional feature. A contact closure between pin 1 and pin 20 is required to allow AC mains power to engage. An open circuit between pin 1 and pin 20 disables AC mains power. 100 mA maximum current.
2	EXT INTERLOCK*	External Interlock. TTL – compatible input, active low, with an internal pull-up resistor. A contact closure between pin 2 and pin 21 or a TTL "low" signal applied to pin 2 is required before RF output can be enabled. An open circuit or a TTL "high" signal applied to pin 2 while the RF output is enabled, will cause the RF output to turn off. An open circuit or a TTL "high" signal applied to pin 2 while the RF output is off, will prevent the RF output from being enabled. This signal is active in Panel, Analog, or Serial control modes.
3	RFON*	RF Output Enable/Disable. TTL – compatible input, active low, edge triggered, with an internal pull-up resistor. A contact closure between pin 3 and pin 22 or a TTL signal transition from "high" to "low" applied to pin 3 enables the RF output, provided Pin 2 is at TTL "low" state. An open circuit between pin 3 and pin 22 or a TTL signal transition from "low" to "high" applied to pin 3 disables the RF output. This signal is active only in "Analog" control mode.
4	PWR/VLT*	Power or Voltage control mode select. TTL – compatible input with internal pull-up resistor. An open circuit or TTL "high" signal applied to pin 4 selects the power supply's internal power sensor for power regulation. A contact closure between pin 4 and pin 23 or a TTL "low" signal applied to pin 4 selects forward power regulation based on an external feedback signal (FEEDBACK signal - Pins 16 and 35). Refer to the controls section of the operator's manual for detailed instructions on how to configure and use this mode. Active only in "Analog" control mode.
5	SLAVE*	Selects internal oscillator/exciter or external oscillator/exciter as frequency source (Slave / Common Exciter / CEX) operation. TTL – compatible input with an internal pull-up resistor. A contact closure between pin 5 and pin 24 or applying a TTL "low" signal to pin 5 selects external frequency source (CEX) operation. The external frequency source is connected to the "CEX IN" connector on the rear panel. An open circuit or TTL "high" applied to pin 5 selects the power supply's internal oscillator/exciter as the frequency source.

PIN	SIGNAL NAME	DESCRIPTION
35	FEEDBACK RTN	Signal return reference for FEEDBACK signal.
36	SETPOINT	Power setpoint input. Analog, high-impedance, differential input with selectable 0 to 5VDC or 0 to 10VDC range and selectable polarity – positive (+) or negative (-) via front panel controls. Refer to the controls section of the operator's manual for detailed instructions on how to configure and use this mode NOTE: Setpoint return (pin 18) ***MUST*** be referenced to common or ground at the setpoint voltage source (system controller) or the RF output power will behave erratically. Sensitivity is 650 Watts at 5.0VDC (7.7mV per Watt) or 650 Watts at 10.0VDC (15.4mV per Watt) depending on range selected. NOTE: Feedback voltage range and polarity must match setpoint voltage range and polarity for proper operation in voltage control mode. Pin 36 is the positive (+) input of the differential setpoint amplifier. Active only in ANALOG control mode.
37	RL-IN	Remote Limit input. Analog input, 0 to +5VDC range. Used in dual-bias (multiple power supply) systems to fold-back the power supply's output power if reflected power is detected by another power supply in the system. Consult factory for assistance. The R600 power supply is shipped with this feature disabled (factory default).

1.5.2 RS-232 CONNECTOR PIN LIST

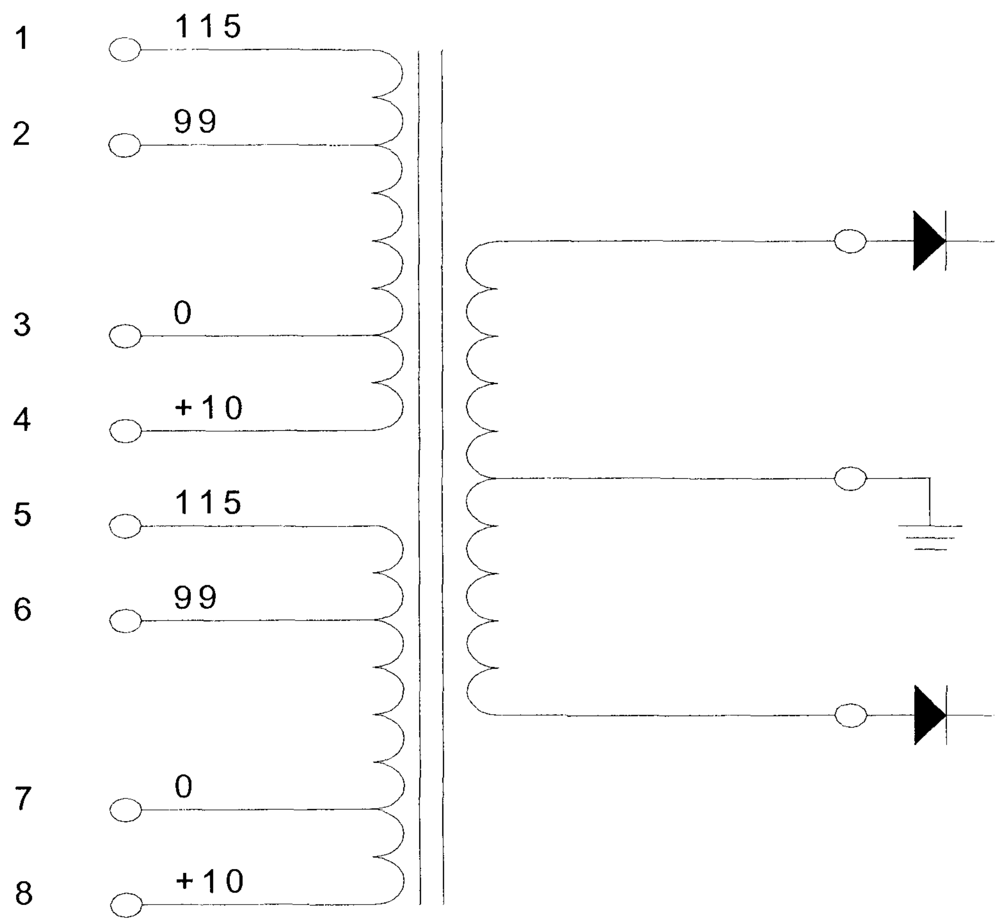
Model R600 RF power supplies built after June 14, 2000 (serial numbers 6299 and up) are constructed to be CE-compliant. Design changes were made to obtain CE compliance. The serial interface connector was changed from a 25 pin male "D" connector to a 9 pin female "D" connector.

The RS-232 interface uses a simple 3-wire connection. The 9-pin and 25-pin R600 serial interface connections are defined in the tables below:

9 PIN SERIAL CONNECTOR		
PIN	**SIGNAL**	**DESCRIPTION**
2	XMIT	Transmit Data
3	RCV	Receive Data
5	GND	Common
Mating Connector: 9 pin male "D" type		

25 PIN SERIAL CONNECTOR		
PIN	**SIGNAL**	**DESCRIPTION**
1	GND	Common
2	RCV	Receive Data
3	XMIT	Transmit Data
Mating Connector: 25 pin female "D" type		

PIN	SIGNAL NAME	DESCRIPTION
		Note: feedback voltage range and polarity must match setpoint voltage range and polarity for proper operation of voltage control mode. Active only in ANALOG control mode.
17	COMMON	Connected to chassis ground.
18	SETPOINT RTN	Power setpoint return. Differential analog input NOTE: Setpoint return (pin 18) ***MUST*** be referenced to common or ground at the setpoint voltage source (system controller) or the RF output power will behave erratically. Pin 18 is the negative (-) input of the differential setpoint amplifier.
19	RLI-OUT	Remote Limit Output. Analog output. Buffered, non-linearized reflected directional coupler signal. Used on dual-bias (multiple power supply) systems. Consult factory for assistance.
20	AC INTERLOCK	Optional feature. A contact closure between pin 20 and pin 1 is required to allow AC mains power to engage. An open circuit between pin 20 and pin 1 disables AC mains power.
21	EXT INTERLOCK* RTN	Return for External Interlock input. Internally connected to chassis ground
22	RFON* RTN	Return for RFON* input. Internally connected to chassis ground.
23	PWR/VLT* RTN	Return for PWR/VLT* input. Internally connected to chassis ground.
24	SLAVE* RTN	Return for SLAVE* input. Internally connected to chassis ground.
25	GATEN* RTN	Return for GATEN* input. Internally connected to chassis ground.
26	GATE RTN	Return for GATE input. Internally connected to chassis ground.
27	No connection	-
28	No connection	-
29	RF ENABLED* RTN	Return for RF ENABLED* output. Internally connected to chassis ground.
30	TEST* RTN	Return for TEST* input. Internally connected to chassis ground.
31	No connection	-
32	FWD RTN	Return for FWDMON output. Internally connected to chassis ground.
33	COMMON	Internally connected to chassis ground.
34	REF RTN	Return for REFMON output. Internally connected to chassis ground.



VOLTAGE	INPUT	JUMPER
250	1 & 8	4 TO 5
240	1 & 7	4 TO 5
230	1 & 7	3 TO 5
218	2 & 8	4 TO 6
208	2 & 8	3 TO 6
198	2 & 7	3 TO 6
125	1 & 4	4 TO 8, 1 TO 5
115	1 & 3	3 TO 7, 1 TO 5
109	2 & 4	2 TO 6, 4 TO 8
99	2 & 3	2 TO 6, 3 TO 7

TRANSFORMER TAP SCHEMATIC

1.6.0 Installation

The R600 should have the proper transformer taps set prior to turn on.

NOTE: The transformer taps may be changed in the field within a given operational range. Changing the unit from 198-250VAC operating range to 99-125VAC operating range or from 99-125VAC to 198-250VAC operating range must be performed at the factory – component and internal wiring changes are required.

WARNING!

THE TRANSFORMER TAPS FOR THE R600 MUST BE SET WITH THE AC MAINS UNPLUGGED. A SEVERE SHOCK, INJURY, OR DEATH MAY RESULT IF THE EQUIPMENT IS CONFIGURED WITH THE MAINS CONNECTED.

CONNECTIONS FOR 198-250VAC OPERATION:

NOMINAL LINE	CONNECT TOGETHER	INPUT
250	4,5	1,8
240	4,5	1,7
230	3,5	1,7
218	4,6	2,8
208	3,6	2,8
198	3,6	2,7

CONNECTIONS FOR 99-125VAC OPERATION:

NOMINAL LINE	CONNECT TOGETHER	CONNECT TOGETHER	INPUT
125	4,8	1,5	1,4
115	3,7	1,5	1,3
109	2,6	4,8	2,4
99	2,6	3,7	2,3

TO CHANGE TRANSFORMER TAPS:

1) Disconnect the unit from AC Mains power.

2) Remove top cover and drop front panel to expose terminal block.

3) Connect jumper wires as shown in table.

4) Connect input lines from circuit breaker as shown in table.

2.0 CONTROLS AND INDICATORS

There are three ways to operate the Generator: from the front panel, from the analog interface, and from the serial interface. This section of the manual describes how to operate and configure the Generator from the front panel. Front Panel operation means that when the Generator is in RUN mode the front panel controls are used to select the setpoint and turn RF power on and off. The front panel is also used to configure the Generator for the intended application.

The following controls and indicators are mounted on the front panel:
- 20-Character, 2-Line Display
- * Data Entry Knob
- * PROG Key
- * RUN Key
- * DOWN Key
- * UP Key
- * RF ON/OFF Key
- * RF ON Indicator

20 - Character, 2-Line Alphanumeric Display	DATA KNOB

PROG	RUN	DOWN	UP	RF ON/OFF

The data knob is used to change the SETPOINT in RUN mode, the RF ON/OFF key is used to activate or deactivate RF power, and the display shows status information such as current power output and alarms. The PROG key is used to enter the PROGRAM mode for configuration.

In PROGRAM mode, the DOWN and UP keys are used to access various configuration settings and the data knob is used to change the settings. The PROG key is used to store new settings. The display shows the selected values and shows abbreviated status information. The RUN key is used to exit the PROGRAM mode and return to RUN mode.

2.1.0 RUN MODE

2.1.1 RF POWER OFF CONDITION

The data knob is used to change the setpoint with RF power off. The display will appear as follows:
Power Control:

SET 100W	MAX 650W
PWR PANEL	01:14:27

The top line shows the current setpoint and max setpoint in watts. The bottom line shows the output control mode (PWR = power control), the operating mode (PANEL = front panel operation), and the RF On clock (optional).

1.7.0 Generator Checkout - Front Panel

1) Select taps per section 1.6. Unit is tapped for voltage indicated on serial tag.

2) Connect RG213 cable to type "N" output connector. Terminate the output cable into a 50 Ohm dummy load or matching network.

3) Install "Analog Interface" connector DB37. At a minimum the EXT* external interlock must be closed. Connect pin (2) to pin (21)

4) Press rocker switch on front panel to turn on ac power.

5) Select desired power with front panel knob. Turn clockwise to increase or counterclockwise to decrease power.

6) Press RFON button to enable RF power.

1.8.0 Generator Checkout - Analog Interface

1) Select taps per section 1.6. Unit is tapped for voltage indicated on serial tag.

2) Connect RG213 cable to type "N" output connector. Terminate in 50 ohm dummy load or matching network

3) Install "Analog Interface" connector DB37. To configure the unit for power control make the following connections:

   a) Jumper EXT* (2) TO EXT* Ret (21) -Close external interlock.

   b) SPST switch RFON* (3) TO RFON* Ret (22) Closing switch enables RF.

   c) Apply variable 0-5v setpoint voltage to Setpoint (36). Use Setpoint Ret as the ground reference.

4) Press rocker switch on front panel to turn on ac power.

5) Close RFON* switch to enable RF output

In pulse mode, the data knob has no effect. The power level shown after the "PLS" indicator is the power output during the high portion of the pulse train.

Power Control, Ramping:

```
RMP  157W        REF   0W
PWR PANEL
```

During Ramp interval the data knob has no effect until the output reaches the setpoint that was in effect at the time RF was turned on. Once the output has stabilized the data knob can be used to change the setpoint. If the setpoint is changed, the "RMP" indicator changed to "FWD".

Voltage Control:

```
V: 1000    F:200  R:    4
DCV  PANEL
```

The top line shows the feedback voltage after "V:", forward power after "F:", and reflected power after "R:". The bottom line shows the output control mode (DCV = DC Voltage) and the operating mode (PANEL = front panel operation). The RF On clock is not shown in this example.

Voltage Control, Setpoint Changing:

```
S: 1050    F:210  R:    4
DCV  PANEL
```

If the data knob is turned while RF is on, the indicator "V:" on the top line changes to "S:" and the setpoint is shown in place of the feedback voltage. The display returns to normal about one second after the data knob stops moving.

2.13 ALARMS

The following alarm messages may appear on the bottom line:

ALARM MESSAGE	ALARM CONDITION
EXT	The external interlock is not closed
CVR	The cover interlock is not asserted
REFP	Reflected power is greater than limit
MAXP	Forward power is greater than limit
PAC	Power Amp. Current is more than 30A
DISS	Dissipation/device is more than 100W

Voltage Control:

SET 1000	
DCV PANEL	

The top line shows the current setpoint in volts. The bottom line shows the output control mode (DCV = DC Voltage) and the operating mode (PANEL = front panel operation). The RF On clock is not shown in this example.

If the Generator is configured for analog operation, the bottom line will indicate ANALOG. Serial operation will be indicated by the word SERIAL. In either case, the data knob will do nothing. The data knob controls the setpoint only while operating in front panel control mode. The front panel RF ON/OFF key will enable RF power output only while operating in front panel control mode.

NOTE: The front panel RF ON/OFF key can always be used to turn RF power OFF.

2.12 RF POWER ON CONDITION

The data knob is used to change the setpoint with RF on, unless the Generator is pulsing or ramping. If pulsing, the data knob has no effect. During Ramp interval the data knob has no effect until the output reaches the setpoint value in effect when RF was turned on.

The top line of the display shows forward and reflected power in watts. In voltage control the top line also shows the feedback voltage. The bottom line shows the output control mode, operating mode, and either the RF On clock (if enabled) or the Target Life clock (if enabled). The RF On clock shows hours, minutes, and seconds up to 99:59:59 and is reset to 00:00:00 whenever RF is turned off. The Target Life clock show hours and minutes up to 99999:59 and must be manually reset via front panel or serial port command.

If there are any alarm conditions, the bottom line will show the most important alarm alternating with the normal information. Examples:

Power Control:

FWD 100W	REF 2W
PWR PANEL	01:14:27

The top line shows the forward and reflected power in watts. The bottom line shows the output control mode (PWR), the operating mode (PANEL), and the RF On clock (optional).

Power Control, Setpoint Changing:

SET 130W	REF 3W
PWR PANEL	01: 42:18

If the data knob is turned while RF is on, the indicator "FWD" on the top line changes to "SET" and the setpoint is shown in place of the forward power. The display returns to normal about one second after the data knob stops moving. The target life clock is shown in the example.

Power Control, Pulsing:

PLS 100W	REF 0W
PWR PANEL	

Function: Enables or disables analog operation and the

Analog Column. If disabled, Generator is set for front panel operation.

NOTE: Setting cannot be changed while RF power is on. The display above indicates that RF is off. With RF on, the top line shows both the forward and reflected power without units. Since the setpoint unit is watts, the Generator is set for power control; a "V" would indicate the setpoint for voltage control.

The bottom line indicates Analog operation is disabled, as it would be with the Generator set for front panel operation. As long as RF is off, the data knob and PROG key can be used to enable Analog operation and access the rest of the Analog Column.

2.2.02 ANALOG: CONTROL

150W	ANALOG
Control	RF Power

Data knob: Selects either "RF Power" or "DC Volts".

Function: Determines generator output feedback source.

NOTE: Setting cannot be changed while RF power is on.

2.2.03 ANALOG: POLARITY

150W	ANALOG
Polarity	Positive

Data knob: Selects either "Positive" or "Negative".

Function: Determines polarity of analog setpoint and voltage feedback inputs.

NOTE: Setting cannot be changed while RF power is on.

2.2.04 ANALOG: RANGE

150W	ANALOG
Range	10V

Data knob: Selects either "5V" or "10V".

Function: Determines full-scale range of analog setpoint and voltage feedback inputs.

NOTE: Setting cannot be changed while RF power is on.

2.2.05 ANALOG: EXCITER

150W	ANALOG
Exciter	Master

Data knob: Selects either "Master" or "Slave".

2.20 PROGRAM MODE

Use the program mode to configure the Generator for your application. Press the PROG key to enter PROGRAM mode, and press the RUN key to return to normal operation. There are many different parameters which may be accessed and changed, but just about all settings are handled the same way:

1) Press the PROG key to enter PROGRAM mode
2) Use the UP and DOWN keys to find the desired parameter
3) Use the data knob to select the desired value or enable/disable
4) Press the PROG key to accept the new value or UP or DOWN to cancel
5) Press UP or DOWN to select another parameter or press RUN to quit

The parameters are organized into groups called Columns. Each Column may be separately enabled or disabled so you don't have to step through every single parameter to find the one you want. The Columns are as follows:

COLUMN	COLUMN DESCRIPTION
Analog	Parameters related to analog operation
Pulse	Parameters related to pulsing
Max Power	Allows you to set a limit for the setpoint
Ramp	Parameters related to ramping
System	Various system parameters
Service	Special purpose calibration and test functions

The first parameter in each column (except for Max Power) is the column and function enable/disable. For example, when entering the Pulse column, if you select "disable" and press the PROG key, you disable not only the rest of the Pulse column but also the pulsing function of the Generator. If you enable the Pulse column and function, the next time RF is turned on the Generator will pulse according to the parameters set in the Pulse column.

Some settings cannot be changed while RF is on. If you attempt to change them, the message "Can't change - RF on" appears briefly on the bottom line of the display. If this happens and you want to change the setting, press the RF ON/OFF key to turn off the RF power output.

If the Generator is set for front panel control, the RF ON/OFF key can be used to turn RF power back on while in PROGRAM mode. In PROGRAM mode, the Column name appears on the top right on the display.

If RF is on, forward and reflected power is displayed on the top left. If RF is off, the setpoint is displayed on the top left. The bottom line identifies the parameter within the Columns and the selected value. New values are not saved unless the PROG key is pressed and the message "------accepted------" appears on the bottom line. To cancel a change in setting, press the UP, DOWN, or RUN key.

2.2.01 ANALOG: ANALOG ENABLE/DISABLE

150W	ANALOG
Analog	Disabled

Data knob: Selects either "Enabled" or "Disabled".

Data knob: Selects value from 0 to 10000 milliseconds.

Function: Sets duration of "low" portion of pulse.

2.2.11 MAX POWER

150W	MAX POWER
Max Power	500

Data knob: Selects value from 0 to rated power in watts.

Function: Sets power level during "high" portion of pulse. The Max Power setting puts a limit on the power setpoint for front panel operation and analog operation. As an additional safeguard, the Power Limit setting in the Service Column limits Max Power.

2.2.12 RAMP: ENABLE/DISABLE

150W	RAMP
Ramping	Disabled

Data knob: Selects either "Enabled" or "Disabled".

Function: Enables or disables ramping operation and the Ramp Column. If RF is turned on with ramping enabled, the Generator will smoothly increase the power from zero to the setpoint over a period of time specified by the Ramp Time. The data knob is disabled while ramping is in progress.

When ramping is done, the data knob may be used to change the setpoint the same as if ramping were disabled. If you try to turn RF on with both ramping and pulsing enabled, the message "Ramp/pulse conflict" will appear on the top line of the display and RF will not be turned on.

2.2.13 RAMP: RAMP TIME

150W	RAMP
Ramp Time	01:30:00

Data knob: Selects value from 00:00:00 to 09:00:00

Function: Sets duration of ramp.

2.2.14 SYSTEM: COLUMN ENABLE/DISABLE

150W	SYSTEM
System	Disabled

Data knob: Selects either "Enabled" or "Disabled".

Function: Enables or disables the System Column.

Function: Determines generator excitation source, either internal (master) or external (slave).

NOTE: Setting cannot be changed while RF power is on.

2.2.06 PULSE: ENABLE/DISABLE

150W	PULSE
Pulse	Disabled

Data knob: Selects either "Enabled" or "Disabled".

Function: Enables or disables pulsing operation and the Pulse Column.

If you enable pulsing, the Generator will provide pulsed output the next time RF is turned on. If you try to turn RF on with both ramping and pulsing enabled, the message "Ramp/Pulse conflict" will appear on the top line of the display and RF will not be turned on.

2.2.07 PULSE: HIGH POWER

150W	PULSE
Hi Power	500

Data knob: Selects value from 0 to Max Power in watts.

Function: Sets power level during "high" portion of pulse.

2.2.08 PULSE: LOW POWER

150W	PULSE
Lo Power	50

Data knob: Selects value from 0 to Max Power in watts.

Function: Sets power level during "low" portion of pulse.

2.2.09 PULSE: HIGH TIME

150W	PULSE
Hi Time	100

Data knob: Selects value from 0 to 10000 milliseconds.

Function: Sets duration of "high" portion of pulse.

2.2.10 PULSE: LOW TIME

150W	PULSE
Lo Power	50

2.2.20 SYSTEM: PROBE ATTENUATION

150W	SYSTEM
Prob Attn	1000

Data knob: Selects value from 1 to 10000.

Function: Specifies attenuation of probes used for voltage setpoint and voltage feedback.

NOTE: Setting cannot be changed while RF power is on.

2.2.21 SYSTEM: REFLECTED POWER ALARM LEVEL

150W	SYSTEM
Ref Alarm	25

Data knob: Selects value from 0 to rated reflected power, watts.

Function: Determines reflected power alarm threshold.

2.2.22 SYSTEM: VOLTAGE CONTROL SETPOINT SCALE CONSTANT

150W	SYSTEM
REAR RF ON	DISABLED

Data knob: Selects Rear RFON in Panel Mode enabled/disabled

2.2.23 SYSTEM: BAUD RATE

150W	SYSTEM
Baud Rate	19200

Data knob: Selects 150, 300, 600, 1200, 2400, 4800, 9600, or 19200

Function: Sets baud rate for serial operation

2.2.24 SYSTEM: SERIAL MODE

150W	SYSTEM
Serial Mode	Human

Data knob: Selects between "Human" and "Computer"

Function: Determines command syntax for serial operation. Two command sets are offered for serial operation. Both sets provide identical functions, but "Human" commands are easier to remember while "Computer" commands are more See the section on serial operation for complete descriptions of all commands.

2.2.15 SYSTEM: CLOCK DISPLAY CONTROL

150W	SYSTEM
Show Clk:	-none-

Data knob: Selects "-none-", "RF On", or "Targ Life".

Function: Determines whether RF On clock or Target Life clock is displayed on bottom line. The RF On clock counts seconds since RF was turned on (up to 99:59:59) and is reset whenever RF is turned off. The Target Life clock, if enabled, accumulates total RF ON time (up to 99999:59) and must be reset via front panel or serial port command (see below).

2.2.16 SYSTEM: TARGET LIFE CLOCK ENABLE/DISABLE

150W	SYSTEM
Show Clk:	-none-

Data knob: Selects either "Enabled" or "Disabled".

Function: Enables or disables the Target Life clock. If disabled, the clock will not accumulate time while RF is on and will remain at whatever value it had when it was disabled.

2.2.17 SYSTEM: TARGET LIFE CLOCK RESET

150W	SYSTEM
Show Clk	: -none-

Data knob: Selects either "Reset? Yes" or "Reset? No".

Function: Allows Target Life clock to be reset.

2.2.18 SYSTEM: DEFAULT WATTS

150W	SYSTEM
Dflt Watts	100

Data knob: Selects value from 0 to Max Power in watts.

Function: Determines default power setpoint.

2.2.19 SYSTEM: DEFAULT VOLTS

150W	SYSTEM
Dflt Volts	0

Data knob: Selects value from 0 to 9999 volts.

Function: Determines default voltage setpoint.

2.2.29 SERVICE: VOLTAGE CONTROL GAIN ADJUST

150W	SERVICE
VCtl gain	200%

Data knob: Selects value from 0% to 1000%

Function: Determines the amount of the error signal to be used in the voltage control loop algorithm. The smaller the number, the longer the Generator takes to respond to load or setpoint changes. Too high a value will results in overshoot or oscillation. The value is optimized at the factory and should not be changed.

2.2.30 SERVICE: VOLTAGE CONTROL 1ST GUESS GAIN ADJUST

150W	SERVICE
PGuess amt	100%

Data knob: Selects value from 0% to 200%

Function: Determines the amount of a calculated guess to use when RF power is turned on.

NOTE: This parameter has no effect at this time.

2.2.31 SERVICE: MONITOR SUBCOLUMN ENABLE

150W	SERVICE
Monitor	Disabled

Data knob: Selects between "Enabled" and "Disabled".

Function: Enables or disables the Monitor Subcolumn.

2.2.32 SERVICE/MONITOR: RAW DAC CONTROL & ADC MONITOR

150W	SERVICE
DA0 0.000	AD0 0.000

Data knob: Selects various parameters. See notes.

Function: Allows direct control of 4-channel Digital-to-Analog Converter (DAC) and direct display of readings from the 10-channel Analog-to-Digital converter (ADC). This is a special mode, which allows direct examination and manipulation of the measurement and control circuits used by the microprocessor to operate the Generator.

The circuits involved are a 4-channel Digital-to-Analog Converter (DAC) and a 10 - channel Analog-to-Digital Converter (ADC). All DAC channels are DC voltage outputs, adjustable from zero to +10V. All of the ADC channels measure DC voltage from -3V to +3V. Signals measured by the ADC are scaled in hardware to fit the -3V to +3V range; for example, when +10V is applied to the analog setpoint input of the generator, the associated ADC channel should measure +2.5V.

2.2.25 SERVICE: SERVICE COLUMN ENTRY CODE

150W	SERVICE
Entry Code	0000

Data knob: Selects value from 0 to 9999

Function: Correct number allows access to Service Column

NOTE: Call your Seren representative if you feel you need access to the Service Column.

2.2.26 SERVICE: POWER CONTROL GAIN ADJUST

150W	SERVICE
PCtl gain	40%

Data knob: Selects value from 0% to 200%

Function: Determines the amount of the error signal to be used in the power control loop algorithm. The smaller the number, the longer the Generator takes to respond to load or setpoint changes. Too high a value will results in overshoot or oscillation. The value is optimized at the factory and should not be changed.

2.2.27 SERVICE: POWER CONTROL 1ST GUESS GAIN ADJUST

150W	SERVICE
PGuess amt	100%

Data knob: Selects value from 0% to 200%

Function: Determines the amount of a calculated guess to use when RF power is turned on. When RF power is turned on, the microprocessor calculates an initial power amplifier setting so that the output power is close to the setpoint before the control loop is enabled.

Normally the initial setting, or guess, causes the output to reach the setpoint almost immediately after RF is turned on, with little if any overshoot. It may sometimes be desirable to adjust the amount of the initial guess.

2.2.28 SERVICE: POWER CONTROL LINEARIZATION THRESHOLD

150W	SERVICE
PGuess thr	50

Data knob: Selects value from 0 to 9999 watts.

Function: Determines the power above which directional coupler measurements are linearized. In power control, the output power of the Generator is measured using internal directional couplers. The couplers may be measured directly or a linearization circuit may be employed; the choice can be changed "on the fly" by the microprocessor.

2.2.35 SERVICE: SCALES SUBCOLUMN ENABLE

150W	SERVICE
Scales	Disabled

Data knob: Selects between "Enabled" and "Disabled".

Function: Enables or disables the Scales Subcolumn.

2.2.36 SERVICE/SCALES: POWER LIMIT

150W	SERVICE
Power Limit	650

Data knob: Selects value from 0 to rated power

Function: Sets limit on power setpoint and Max Power setting.

2.2.37 SERVICE/SCALES: FORWARD MONITOR F.S.

150W	SERVICE
Fwd Mon FS	650

Data knob: Selects value from 0 to rated power.

Function: Sets scale of the forward power monitor so that the voltage output will be full scale (5V or 10V) when the Generator power output is equal to or greater than the specified power.

NOTE: This parameter has no effect at this time.

2.2.38 SERVICE/SCALES: REFLECTED MONITOR F.S.

150W	SERVICE
Ref Mon FS	130

Data knob: Selects value from 0 to rated reflected power.

Function: Sets scale of the reflected power monitor so that the voltage output will be full scale (5V or 10V) when the Generator power output is equal to or greater than the specified power.

NOTE: This parameter has no effect at this time.

2.2.39 SERVICE/SCALES: ANALOG SETPOINT F.S.

150W	SERVICE
Setpoint FS	650

Data knob: Selects value from 0 to rated power.

Function: Sets scale of the analog setpoint so that a full-scale input (5V or 10V) will result in a setpoint equal to the specified power.

The DAC and ADC channels are as follows:

DAC 0 With RF on, changing this voltage from zero to 10V causes the output power to change from zero to max possible power, which is more than the rated power. This is potentially dangerous. This feature is intended for use only at the factory under controlled safety conditions.

DAC 1 Has no function at this time.
DAC 2 Reflected power monitor output voltage.
DAC 3 Forward power monitor output voltage.
ADC 0 Forward power directional coupler, linearized.
ADC 1 Reflected power directional coupler, linearized.
ADC 2 PA current.
ADC 3 DC voltage from Generator internal power supply.
ADC 4 Feedback used for voltage control.
ADC 5 Temperature.
ADC 6 Analog control setpoint.
ADC 7 Forward power directional coupler, non-linearized.
ADC 8 Reflected power directional coupler, non-linearized.
ADC 9 Dissipation per power transistor.

From left to right, the bottom line on the display shows the selected DAC channel, the DAC setting in volts for the selected channel, the selected ADC channel, and the voltage applied to the selected ADC channel.

The PROG key is used to move a cursor under the parameter you wish to change. The data knob changes the value indicated by the cursor.

For example: to change the forward power monitor output, press the PROG key until the cursor is under the number after "DA", use the data knob to set the DAC channel to 3, then press the PROG key again to move the cursor under the output voltage; the data knob may now be used to change the forward power monitor output. Likewise, to select a different ADC channel to examine, press the PROG key to place the cursor under the number after "AD" and use the knob to select the desired channel.

2.2.33 SERVICE/MONITOR: DCV/PAC MONITOR

150W	SERVICE
DCV 40.3V	PAC 0.0A

Data knob: Controls the setpoint.

Function: Monitors the Generator's internal DC power supply and power amplifier (PA) current.

2.2.34 SERVICE/MONITOR: DISSIP/TEMP MONITOR

150W	SERVICE
DIS 0.5W	TEMP 45C

Data knob: Controls the setpoint.

Function: Monitors the dissipation per power transistor and the temperature.

to adjust the setpoint for the lowest power needed to maintain a plasma under all expected conditions, then press the PROG key to save. Set the Generator for voltage control to activate this feature.

2.2.45 SERVICE: CALIBRATE SUBCOLUMN ENABLE

150W	SERVICE
Calibrate	Disabled

Data knob: Selects between "Enabled" and "Disabled".

Function: Enables or disables the Calibrate Subcolumn.

2.2.46 SERVICE/CALIBRATE: LINE DC VOLTAGE

150W	SERVICE
Line DC	40.0

Setup: Measure the internal DC supply voltage.

Data knob: Adjust until the value on the bottom line agrees with the measurement.

2.2.47 SERVICE/CALIBRATE: PA CURRENT

300	0	SERVICE
PA Current		15.0

Setup: With RF on and a setpoint of about 1/2 rated power, measure the PA current.

Data knob: Adjust until the value on the bottom line agrees with the measurement.

2.2.48 SERVICE/CALIBRATE: DISSIPATION

300	0	SERVICE
Dissip/dev		65.0

Setup: With RF on and a setpoint of about 1/2 rated power, measure the dissipation per device.

Data knob: Adjust until the value on the bottom line agrees with the measurement.

2.2.49 SERVICE/CALIBRATE: TEMPERATURE

300	0	SERVICE
Temperature		50

Setup: With RF on and a setpoint of about 1/2 rated power, measure the temperature.

Data knob: Adjust until the value on the bottom line agrees with the measurement.

2.2.40 SERVICE/SCALES: FORWARD POWER CORRECTION

150W	SERVICE
Fwd Correct	0.0

Data knob: Selects value from -12.5 to +12.5 percent.

Function: Correction factor for forward power measurement.

2.2.41 SERVICE/SCALES: REFLECTED POWER CORRECTION

150W	SERVICE
Ref Correct	0.0

Data knob: Selects value from -12.5 to +12.5 percent.

Function: Correction factor for reflected power measurement.

2.2.42 SERVICE/SCALES: NOMINAL LINE VOLTAGE

150W	SERVICE
Nom Line DC	40.0

Data knob: Selects value from 0 to 99.9 volts.

Function: Sets nominal value for internal DC supply.

2.2.43 SERVICE/SCALES: TEMPERATURE ALARM

150W	SERVICE
Temp Alarm	40.0

Data knob: Selects value from 0 to 99.9 degrees C

Function: Sets temperature alarm threshold

2.2.44 SERVICE/SCALES: MINIMUM COUNTS

2W	SERVICE
Min Counts	78

Data knob: Used to change Generator setpoint for lowest power needed to maintain plasma. Press PROG button to save.

Function: Establishes minimum power output with RF on in voltage control.

NOTE: This parameter is active only with the Generator set for voltage control, but can be programmed only in power control mode. This feature allows you to specify a minimum Generator output while operating with RF on in voltage control. To set, the Generator must be set for power control. With RF on, use the data knob

2.2.55 DESCRIPTION OF FRONT PANEL CALIBRATION

CAL (LIN)	- RF ON
Pt01 37	12.0W

CAL (LIN)	- RF ON
Pt01 37	12.0Wnor

CAL (LIN)	- RF ON
Pt64 4095	700.0Wmax

The top line of the display indicates whether you are calibrating for linearized (LIN) or non-linearized (NLIN) coupler readings along with an indication of "RF ON" or "RF OFF". Initial calibration must be performed with RF on. The bottom line shows the selected calibration point, the control DAC setting for that point, and the measured power for that point. For each calibration point, the corresponding table entry is filled in using the following steps:

1) Turn RF on.

2) Press the PROG key until the cursor is under the point number and use the data knob to select a calibration point. Press the PROG key to accept the point selection. The cursor will now be under the power value.

3) Wait for the Generator to adjust its output until the target ADC reading is achieved. You should see the DAC setting change and the indicator "nor" after the power on the bottom line. When the "nor" (for normalizing) indicator goes away and the DAC setting stops changing, the target has been reached. If "max" appears instead f "nor", the output is at its maximum and the target ADC reading cannot be reached.

4) Measure the actual power and use the data knob to enter the power value. Press the PROG key to accept the power value. The cursor will now be under the point number, ready for a new point selection. If the "max" indicator is showing, enter a power value higher than the power value of the previous point. All points must have power values, and the power value for each point must be larger than the value for the previous point

5) **WRITE DOWN** the DAC setting and power value for each point. When the calibration table is filled, use the DOWN key to access the calibration table save function.

2.2.56 RESTORING LOST CALIBRATION DATA

As previously mentioned, the initial calibration must be done with RF on so that actual power measurements may be made and entered into the calibration table. Once calibration is complete, if you've followed step 5 above you should have a list of the DAC settings and measured power values for each point. If for some reason the Generator loses its calibration data, you can enter the data manually with RF off. For each calibration point, the corresponding table entry is filled in using the following steps:

1) Turn RF off.

2) Press the PROG key until the cursor is under the point number and use the data knob to select a calibration point. Press the PROG key to accept the point selection. The cursor will now be under the DAC setting.

3) Refer to the calibration table listing and use the data knob to enter the DAC setting for the selected point. Press the PROG key to accept the DAC setting. The cursor will now be under the power value.

2.2.50 SERVICE/CALIBRATE: FEEDBACK VOLTAGE

300W	SERVICE
Feedback	10.000

Setup: Apply about 5V DC to the voltage feedback input and measure the voltage with a calibrated digital multimeter.

Data knob: Adjust until the value on the bottom line agrees with the measurement.

2.2.51 SERVICE/CALIBRATE: ANALOG SETPOINT VOLTAGE

300W	SERVICE
Analog Set	10.000

Setup: Apply about 10V DC to the analog setpoint input and measure the voltage with a calibrated digital multimeter.

Data knob: Adjust until the value on the bottom line agrees with the measurement.

2.2.52 SERVICE CALIBRATE: REFLECTED POWER MONITOR OUTPUT VOLTAGE

300W	SERVICE
Adj ref mon =	5.000V

Setup: Measure the reflected power monitor output.

Data knob: Adjust until the output voltage is 5.000V.

2.2.53 SERVICE/CALIBRATE: FORWARD POWER MONITOR OUTPUT VOLTAGE

300W	SERVICE
Adj fwd mon =	5.000V

Setup: Measure the forward power monitor output.

Data knob: Adjust until the output voltage is 5.000V.

2.2.54 SERVICE/CALIBRATE: FILL CALIBRATION TABLE, LINEARIZED COUPLER, EXPLANATION OF CALIBRATION TABLES

An internal directional coupler allows the microprocessor to measure the power output of the Generator. The coupler signal is applied to a linearization circuit, the output of which is connected to one of the analog-to-digital converter (ADC) channels. The direct, or non-linearized, coupler signal is connected to another ADC channel. For both linearized and non-linearized signals, a separate calibration table is used by the microprocessor to convert the ADC readings into output power values.

Each calibration table contains 64 entries. Each entry contains the control digital-to-analog converter (DAC) setting and actual power measured for one calibration point. Calibration points are numbered from 1 to 64. Calibration point "n" represents the DAC setting and resulting power needed to achieve an ADC reading of n/64 of full scale from the coupler signal.

Declaration of Conformity According to EN 45014

Manufacturer's Name: SEREN IPS, Inc.

Manufacturer's Address: 1717 Gallagher Drive
Vineland, NJ 08360
U.S.A.

Declares the following product,

MODELR600 RF POWER SUPPLY

Complies with the following specifications:

EMV:
EMC (emissions):
Radiated: CISPR 11 (EN 55011): 1998, Class A, Group2, 150 KHz to 1000 MHz
Conducted: CISPR 11 (EN 55011): 1998, Class A, Group 2, 150 KHz to 30 MHz

EMV:
EMC (immunity):
EN 61000-4-3: 1996, ENV 50204: 1995, EN 61000-4-4: 1995, IEC 1000-4-2: 1995, IEC 61000-4-6: 1996,

Product Safety: EN 61010-1: 1993

Complimentary Information:

This product complies with the EMC directive 89/336/EEC and the Low Voltage Directive 73/23/EEC.

Location and Date:
Seren IPS Inc.
1717 Gallagher Drive
Vineland, NJ 08360
USA

June 23, 2000

Head Of Engineering

Lawrence A. Hooper

4) Refer to the calibration table listing and use the data knob to enter the power value for the selected point. Press the PROG key to accept the power value. The cursor will now be under the point number. When the calibration table is filled, use the DOWN key to access the calibration table save function.

2.2.57 SERVICE CALIBRATE: SAVE CALIBRATION TABLE, LINEARIZED

150W	SERVICE
LCal Save	Disabled

Data knob: Selects between "Enabled" and "Disabled".

Function: Enables or disables saving the calibration table for linearized coupler readings. To save the calibration table, select "Enabled" and press the PROG key.

2.2.58 SERVICE/CALIBRATE: FILL CALIBRATION TABLE, NON-LINEARIZED COUPLER READINGS

See the description for "Fill calibration table, linearized coupler readings".

2.2.59 SERVICE/CALIBRATE: SAVE CALIBRATION TABLE, NON LINEARIZED

150W	SERVICE
NCal Save	Disabled

Data knob: Selects between "Enabled" and "Disabled".

Function: Enables or disables saving the calibration table for non-linearized coupler readings. To save the calibration table, select "Enabled" and press the PROG key

3.0.0 SERIAL CONTROL FUNCTIONS

3.1.0 GENERAL

The serial commands listed are of the "HUMAN" mode (English language) command set. All terminators are CRLF. The generator responds with a prompt of "OK" for an accepted command.

3.1.1 SERIAL

The RS232 command to allow serial remote control is "SERIAL". The default power-on state of the generator is the "PANEL" control mode. The generator does not retain the control mode state when powered down. If serial control is desired after a power down/power-up cycle, the "SERIAL" command must be re-asserted. Send "SERIALcrlf" to place the unit in serial control mode.

3.1.2 POWER SETPOINT

Modifies power output setpoint. Send "Power XXXcrlf", where XXX is the desired output power. From 0 to maximum power, use 1 to 3 characters.

Send "POWERcrlf" to query unit. The generator will respond by returning "XXXcrlf" where XXX is the current power setpoint.

3) Enable the RF output with the "RFON" command. The generator's software waits for the reflected power to drop below the threshold level before starting the timer. The RF output turns off on timeout.

3.3.0 RS232 CONNECTIONS

See section 1.5.2 for RS-232 connector pin list

SEREN

INDUSTRIAL POWER SYSTEMS INC.

MC2 MATCHING NETWORK CONTROLLER

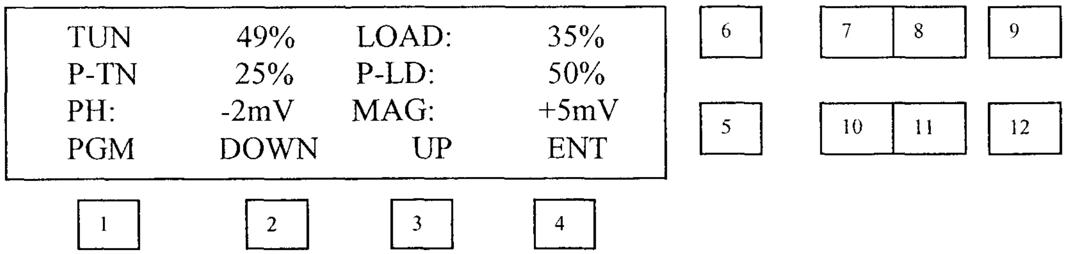
OPERATOR'S MANUAL

Revision: PRELIMINARY 06/24/02
Standard Configuration

SEREN Industrial Power Systems, Inc.
1717 Gallagher Drive
Vineland, New Jersey, 08360
U.S.A

Telephone: 856-205-1131
Fax: 856-205-1141
E-mail: info@serenips.com

Front Panel Controls and Display:



(1) Program Button:	Changes Characters of Line 3 from default programmed Characters to Programmable Menu Entries.
(2) Menu Down Button:	Moves down the menu
(3) Menu Up Button:	Moves up the menu
(4) Enter Button:	Programs changes made to parameter.
(5) Up	Change Parameter Value
(6) Down	Change Parameter Value
(7) Load Min	Manually moves Load cap to minimum capacitance
(8) Load Max	Manually moves Load cap to maximum capacitance
(9) Load Mode	Selects Load capacitor automatic or manual mode
(10) Tune Min	Manually moves Tune cap to minimum capacitance
(11) Tune Max	Manually moves Tune cap to maximum capacitance
(12) Tune Mode	Selects Tune capacitor automatic or manual mode

- **Line 1: Tune and Load Position**
- **Line 2: Preset Tune/Load Set Point**
- **Line 3: Phase and Magnitude Error Signals**

MENU:

Depress Program Button: Line 3 becomes:	RECORD STRIKE PRESET	
Depress Down Button:	Load Preset	ON/OFF
Depress Down Button:	Tune Preset	ON/OFF
Depress Down Button:	Set Load Preset	00%
Depress Down Button:	Set Tune Preset	00%
Depress Down Button:	DCV Probe Selected	DCV/RFV
Depress Down Button:	DC Probe Attn.	0-9999
Depress Down Button:	RF Probe Attn.	0-9999
Depress Down Button:	LD/TN Display	ON/OFF
Depress Down Button:	PH/MAG Display	ON/OFF
Depress Down Button:	FWD/FRL Display	ON/OFF
Depress Down Button:	RF/DCV Display	ON/OFF
Depress Down Button:	Forward F. S.	0-9999
Depress Down Button:	Reflected F. S.	0-9999

Depress Down Button:	Load Limit High	2-98 %
Depress Down Button:	Load Limit Low	2-98 %
Depress Down Button:	Tune Limit High	2-98 %
Depress Down Button:	Tune Limit Low	2-98 %
Depress Down Button:	***(presets local/remote)***	***(select)***

Enter Secure Setup	**PASS CODE**	**000**
Depress Down Button:	Load Dead-band	mV
Depress Down Button:	Tune Dead-band	mV
Depress Down Button:	Mag. Error Adj.	0-9999
Depress Down Button:	Phase Error Adj.	0-9999

Alarms:

Cable disconnected

Tune/Load Feedback Missing

Rear Panel Connections And Interfacing

Power Inlet / Fuse Holder /Voltage Selector

> CAUTION: UNLESS OTHERWISE SPECIFIED, THE MC2 CONTROLLER IS SHIPPED FROM THE FACTORY WITH THE LINE VOLTAGE SELECTOR SET FOR 110 VOLT OPERATION.
>
> CHECK YOUR LINE VOLTAGE OR CONSULT A QUALIFIED ELECTRICIAN BEFORE CONNECTING THE MC2 CONTROLLER TO MAINS POWER. SELECTING THE WRONG LINE VOLTAGE MAY DAMAGE THE MC2 CONTROLLER AND VOID THE WARRANTY.

Power Inlet Connector: IEC320 type male, filtered
Mating Connector: IEC320-C13

Fuses: 1.6A 250V Time Delay, 5mm x 20mm

Matching Network Connector

Control signals and motor drive for matching network. Connector Type: 15 pin "D" female. Connect to matching network's "CONTROL" connector.

Pin	Signal	Description
1	TUNEMOTOR	Drive voltage output for tune capacitor motor –15VDC to +15VDC
2	GROUND	Return for load capacitor motor. Internally connected to chassis ground.
3	TUNEPOS	Tune capacitor position feedback input. Analog signal, 0.00VDC = minimum capacitance, 5.00VDC = maximum capacitance.
4	+5.25VREF	Current limited +5.25VDC reference voltage output for capacitor feedback signals. Do not connect external equipment to this pin.
5	-0.25VREF	Current limited -0.25VDC reference voltage output for capacitor feedback signals. Do not connect external equipment to this pin.
6	+12V	Current limited +12VDC output for operation of control circuits within the matching network. Do not connect other equipment to this pin.

7	PHASE	Phase (tune) error signal input. Analog input, -10VDC to +10VDC range.
8	MAG	Magnitude (load) error signal input. Analog input, -10VDC to +10VDC range
9	LOADMOTOR	Drive voltage output for load capacitor motor –15VDC to +15VDC
10	GROUND	Return for tune capacitor motor. Internally connected to chassis ground.
11	LOADPOS	Load capacitor position feedback input. Analog signal, 0.00VDC = minimum capacitance, 5.00VDC = maximum capacitance.
12	GROUND	Internally connected to chassis ground.
13	DC-PROBE	DC Probe signal input. Analog, -10VDC to +10VDC range
14	RF-PROBE	DC Probe signal input. Analog, -10VDC to +10VDC range
15	GROUND	Internally connected to chassis ground.

Analog Control Connector

Analog control signals for system interfacing. Connector Type: 25 pin "D" female.

Pin	Signal	Description
1	No Connection	No connection
2	PRELOAD	Load capacitor preset enable input. TTL/HCMOS compatible logic input, active low, internally pulled-up to +5V. Apply a logic low signal to enable preset, apply a logic high signal to disable preset.
3	PRELOAD-ON	Load capacitor preset active output. TTL/HCMOS compatible logic output, active low. Internally pulled up to +5VDC. Logic low when controller is presetting the load capacitor, logic high when the load capacitor is not being pre-set.
4	PRETUNE-ON	Tune capacitor preset active output. TTL/HCMOS compatible logic output, active low. Internally pulled up to +5VDC. Logic low when controller is presetting capacitors, logic high when the tune capacitor is not being pre-set.

Pin	Signal	Description
5	PRETUNE	Tune capacitor preset enable input. TTL/HCMOS compatible logic input, active low, internally pulled-up to +5V. Apply a logic low signal to enable preset, apply a logic high signal to disable preset.
6	-TUNELIMIT	Tune capacitor minimum limit signal output. TTL/HCMOS compatible logic output, active high. Output is a logic high when the tune capacitor has reached its minimum limit. Output is a logic low when the tune capacitor is not at its minimum limit.
7	+TUNELIMIT	Tune capacitor maximum limit signal output. TTL/HCMOS compatible logic output, active high. Output is a logic high when the tune capacitor has reached its maximum limit. Output is a logic low when the tune capacitor is not at its maximum limit.
8	FAIL	General purpose fail condition signal output. TTL/HCMOS compatible logic output, active high. Output state is a logic high if a fail condition is detected (control cable disconnected or other software-determined condition), output state is a logic low if there is no fail condition.
9	-LOADLIM	Load capacitor minimum limit signal output. TTL/HCMOS compatible logic output, active high. Output is a logic high when the load capacitor has reached its minimum limit. Output is a logic low when the load capacitor is not at its minimum limit.
10	+LOADLIM	Limit capacitor maximum limit signal output. TTL/HCMOS compatible logic output, active high. Output is a logic high when the load capacitor has reached its maximum limit. Output is a logic low when the load capacitor is not at its maximum limit.
11	LOADMETER	Load capacitor position output signal. Analog, 0.00VDC to +5.00VDC, linearly proportional 0 to 100% of load capacitor position. 0.00VDC = minimum capacitance, 5.00VDC = maximum capacitance.
12	LOADPSETV	Tune capacitor position preset voltage input. Analog input, 0.00VDC to +5.00VDC. 0.00VDC = minimum capacitance, +5.00VDC = maximum capacitance.
13	LOADPSETV	Load capacitor position preset voltage input.

Pin	Signal	Description
		Analog input, 0.00VDC to +5.00VDC. 0.00VDC = minimum capacitance, +5.00VDC = maximum capacitance.
14	No Connection	No Connection
15	Ground	Internally connected to chassis ground.
16	Ground	Internally connected to chassis ground.
17	Ground	Internally connected to chassis ground.
18	Ground	Internally connected to chassis ground.
19	Ground	Internally connected to chassis ground.
20	Ground	Internally connected to chassis ground.
21	Ground	Internally connected to chassis ground.
22	Ground	Internally connected to chassis ground.
23	TUNEMETER	Tune capacitor position output signal. Analog, 0.00VDC to +5.00VDC, linearly proportional 0 to 100% of tune capacitor position. 0.00VDC = minimum capacitance, 5.00VDC = maximum capacitance.
24	Ground	Internally connected to chassis ground.
25	Ground	Internally connected to chassis ground.

Loop-Thru Connectors

These connectors are provided to interface the MC2 matching network controller with an RF generator. This enables the MC2 to monitor and display the generator's setpoint, forward power, and reflected power, supply the RF or DC probe voltage signal to the RF generator (for voltage control), and disable the RF generator's output if matching network fault condition is detected. All other control signals are passed from the SYSTEM connector to the GENERATOR connector without modification.

The Loop-Thru connectors are designed to be plug-compatible with the Seren IPS Inc. R/L20XX/30XX/50XX series of RF generators. Other RF generators can be connected with external cabling - contact Seren IPS Inc. customer service for assistance.

System Connector

Connects to the user's system controller. Connector type: 25 pin "D" male.

Pin	Signal	Description
1	Loop-Thru	Connected to pin 1 of GENERATOR connector
2	Loop-Thru	Connected to pin 2 of GENERATOR connector
3	RFON	RFON signal input. TTL/HCMOS compatible logic input, active low. Internally pulled up to +5VDC.
4	Loop-Thru	Connected to pin 4 of GENERATOR connector
5	Loop-Thru	Connected to pin 5 of GENERATOR connector
6	Loop-Thru	Connected to pin 6 of GENERATOR connector
7	Loop-Thru	Connected to pin 7 of GENERATOR connector
8	Loop-Thru	Connected to pin 8 of GENERATOR connector
9	Loop-Thru	Connected to pin 9 of GENERATOR connector
10	GROUND	Internally connected to chassis ground.
11	REFLECTED	Reflected Power monitor signal. Analog loop-thru, -10VDC to +10VDC. Connected to pin 11 of GENERATOR connector.
12	PROBE	RF or DC probe signal (from matching network controller). Analog, -10VDC to +10VDC. Connected to pin 12 of GENERATOR connector.
13	SETPOINT	Forward Power Setpoint signal. Analog loop-thru, -10VDC to +10VDC, single-ended. Connected to pin 13 of GENERATOR connector.
14	Loop-Thru	Connected to pin 14 of GENERATOR connector.
15	GROUND	Internally connected to chassis ground.
16	GROUND	Internally connected to chassis ground.
17	GROUND	Internally connected to chassis ground.
18	GROUND	Internally connected to chassis ground.
19	Loop-Thru	Connected to pin 19 of GENERATOR connector.
20	Loop-Thru	Connected to pin 20 of GENERATOR connector.
21	Loop-Thru	Connected to pin 21 of GENERATOR connector.
22	FWDRET	Forward Power Monitor return signal. Internally connected to chassis ground.

Pin	Signal	Description
23	REFRET	Reflected Power Monitor return signal. Internally connected to chassis ground.
24	FBRET	External Feedback (Probe) return signal. Internally connected to chassis ground.
25	SETRET	Forward Power Setpoint return signal. Internally connected to chassis ground.

Generator Connector

Connects to the generator's analog interface connector. Connector type: 25 pin "D" female

Pin	Signal	Description
1	Loop-Thru	Connected to pin 1 of SYSTEM connector
2	Loop-Thru	Connected to pin 2 of SYSTEM connector
3	RFON1	RFON signal output. TTL/HCMOS compatible logic output, active low. The logic state is the same as the pin 3 of the SYSTEM connector unless a matching network fault condition is detected. If a matching network fault condition is detected, the MC2 controller holds pin 3 at a "high" logic state, disabling the generator's RF output.
4	Loop-Thru	Connected to pin 4 of SYSTEM connector
5	Loop-Thru	Connected to pin 5 of SYSTEM connector
6	Loop-Thru	Connected to pin 6 of SYSTEM connector
7	Loop-Thru	Connected to pin 7 of SYSTEM connector
8	Loop-Thru	Connected to pin 8 of SYSTEM connector
9	Loop-Thru	Connected to pin 9 of SYSTEM connector
10	GROUND	Internally connected to chassis ground.
11	REFLECTED	Reflected Power monitor signal. Analog loop-thru, -10VDC to +10VDC. Connected to pin 11 of SYSTEM connector.
12	PROBE	RF or DC probe signal (from matching network controller, derived from the matching network). Analog, -10VDC to +10VDC. Connected to pin 12 of SYSTEM connector.

Pin	Signal	Description
13	SETPOINT	Forward Power Setpoint signal. Analog loop-thru, -10VDC to +10VDC, single-ended. Connected to pin 13 of SYSTEM connector.
14	Loop-Thru	Connected to pin 14 of SYSTEM connector.
15	GROUND	Internally connected to chassis ground.
16	GROUND	Internally connected to chassis ground.
17	GROUND	Internally connected to chassis ground.
18	GROUND	Internally connected to chassis ground.
19	Loop-Thru	Connected to pin 19 of SYSTEM connector.
20	Loop-Thru	Connected to pin 20 of SYSTEM connector.
21	Loop-Thru	Connected to pin 21 of SYSTEM connector.
22	FWDRET	Forward Power Monitor return signal. Internally connected to chassis ground.
23	REFRET	Reflected Power Monitor return signal. Internally connected to chassis ground.
24	FBRET	External Feedback (Probe) return signal. Internally connected to chassis ground.
25	SETRET	Forward Power Setpoint return signal. Internally connected to chassis ground. Note: Seren IPS Inc. RF generators use a differential setpoint input. To prevent erratic operation, this signal ***must*** be connected to the generator's setpoint return terminal.

Serial RS-232 Connector

Allows remote control and monitoring of the matching network and generator parameters (requires use of the SYSTEM/GENERATOR Loop-Thru connectors)

For serial operation, see the Serial Commands section of this manual.

Connector Type: 9 pin "D" female

Pin	Signal	Description
1	No Connection	No Connection
2	TXB	Transmit Data
3	RXB	Receive Data

Pin	Signal	Description
4	No Connection	No Connection
5	No Connection	No Connection
6	No Connection	No Connection
7	CTS	Clear To Send
8	RTS	Request To Send
9	No Connection	No Connection

PHASE Test Point

Buffered PHASE detector output from the matching network. Used while nulling (calibrating) the matching network's phase detector. See Troubleshooting instructions for details.

MAG Test Point

Buffered MAGnitude detector output from the matching network. Used while nulling (calibrating) the matching network's magnitude detector. See Troubleshooting instructions for details.

COM Test Point

Common return for PHASE and MAG test points. Internally connected to chassis ground.

Vari-Q™ Throttling Valve

U.S. Patent No. 4,393,896

Owners Manual

Models VQ-SM & VQ-PA

MeiVac, Inc.
5830 Hellyer Avenue
San Jose, CA 95138, USA

Safety Procedures and Precautions

WARNING

Owners of MeiVac Vari-Q Throttle Valves *should not* open chamber/pump isolation valve unless the Vari-Q Valve is in the 100% open position.

Throttle valves not fully open when subjected to high pressure differential across the valve, could cause the vanes of the throttle valve to be pulled from the center hub and/or otherwise damaged. This will void the MeiVac warranty.

WARNING

Pneumatically actuated (PA) type valves with micrometer adjustment *must have exhaust restrictors* installed to control the speed of the valve movement thereby minimizing the potential for the valve to slam open or closed. Maximum air pressure to the pneumatic actuator is not to exceed 55 PSI.

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1. GENERAL DESCRIPTION

1.1 Introduction
This manual details the operation and maintenance of the Vari-Q pressure control system, a new dimension in pressure control technology manufactured by MeiVac Incorporated. Procedures are given for installation, use and maintenance of the various system elements. This manual should be carefully read prior to installation of the equipment or use of the system. And, the procedures described in this manual should be followed to maximize the system's unique capabilities.

1.2 VARI-Q Throttle Valve
The MeiVac Vari-Q throttle valve consists of a flange and a number of triangular vanes radially disposed around a central split hub. The number of vanes depends upon the flange diameter. For example, the VQ-6-ASA (6-inch valve) has 12 vanes while the VQ-10-ASA (10-inch valve) has 20 vanes.

Each vane has a rotating pin (shaft) brazed to the vane point end, and a pulley, with a spherical machined rear or outside surface, brazed to the vane wide end. Each pulley has a short shaft protruding from the center of the back surface, which acts as a rotational hinge point when installed in the flange body. The vanes are actuated by a narrow continuous stainless steel cable, which threads sequentially over and under each succeeding pulley. Both ends of the cable are secured to a driver vane assembly that incorporates the drive and vacuum shaft seal. All vane-pulley assemblies are physically attached to the stainless steel cable for precise alignment and to prevent vane slippage.

As the vanes open, the conductance changes linearly to modulate the pumping speed of the chamber. Vane shape and operation (counter rotation) provide very high OPEN pump-down throughput and linear control resolution during throttle operation.

The Vari-Q throttle valve has been used with most high vacuum pumps, including cryogenic, diffusion, conventional (ceramic) bearing turbo-molecular and mag-lev bearing turbo-molecular pumps.

1.3 Functional Description
Vari-Q Throttle Valves can be used with multiple actuator types and come in variety of flange styles, sizes and operating modes:

- Actuators
  - Pneumatic actuators (PA) stop valves at two positions, fully open or a fixed throttle position adjustable by a micrometer on the valve body. These actuators are typically used for upstream pressure control (see below).
  - Servo Motor (SM) actuators position the vanes anywhere between full open and full closed. This configuration is normally coupled with a controller, such

as an MKS 2252 or 651C. These actuators may be used for upstream or downstream pressure control (see below).

- Flange Styles, Materials and Sizes
  - MeiVac valves are available in a wide variety of sizes, materials and styles. Contact MeiVac or your local MeiVac sales representative for more details

1.4 Pressure Control Methods

In normal applications there are two forms of pressure control. MeiVac Vari-Q throttle valves are capable of handling one or both of these control methodologies.

Upstream Pressure Control

Upstream pressure control is control of the vacuum level in the chamber by varying process gas flow against a fixed pumping speed. A common configuration has an MFC (mass flow controller) operating closed loop with an external pressure set point and a pressure measurement device.

A PA model Vari-Q valve is designed specifically for this application. On actuation, the vanes are moved to a fixed throttle position. This position is mechanically adjustable, with a precision micrometer, external to the valve body.

<u>PA Advantages</u>:

- Lower cost,
- Ease of installation and configuration.

<u>PA Disadvantages</u>:

Operation:

- Only 2 positions, e.g. fully open or a single adjustable position.
- Adjustment to the throttle position must be made at the valve body.

Process:

- Poor response to residual gas events

  In instances where a pressure burst of non-process gas occurs, such as initiation of plasma, upstream control can be problematic. Upstream's reaction to this occurrence is to REDUCE the flow of process gas to control pressure. The result of this action is the worsening of the process gas to contaminant ratio and a higher residual gas presence in the first critical layers of a process. Without increased pumping speed, the event lasts longer than Downstream.

SM driven valves may also be used for upstream pressure control. An advantage of SM over PA is the ability of the SM actuator to adjust valve position from its controller.

Downstream Pressure Control

Downstream pressure control is control of the vacuum level in the chamber by varying pumping speed (valve position in this case) against a <u>fixed process gas</u> flow. Common configurations would have one or more MFCs flowing a fixed rate and/or ratio of process gas(es). A motor driven throttle valve would have its valve position drive motor controlled by a pressure controller that was monitoring vacuum level vs. set points.

SM and MK versions of the MeiVac Vari-Q throttle valve normally are used in these applications. Pressure controllers are available in standard commercially available rack mounted or valve mounted models.

SM Advantages:

- Flexibility in process control   Ratios of gas flow and pumping speed can easily be changed prior to or during process steps.
- Potentially higher quality process results

  In instances where a pressure burst of non-process gas occurs, such as initiation of plasma, process gas flow and pressure remain constant. The duration of the event is significantly reduced, compared to upstream pressure control, due to increasing pump throughput. Less process gas dilution and faster recovery time combine to improve deposited film quality. This is particularly true during the first few adhesion promoting monolayers.

1.5 Control Options

Three options are available for valve control.

- PA - Used for upstream pressure control.
- SM - Used in conjunction with a pressure controller such as an MKS 651.
- MK - An integrated servo motor and pressure controller that mounts on the valve body. The only such actuator currently available is the MKS 2153**.**

Pneumatically Actuated VQ Throttle Valve

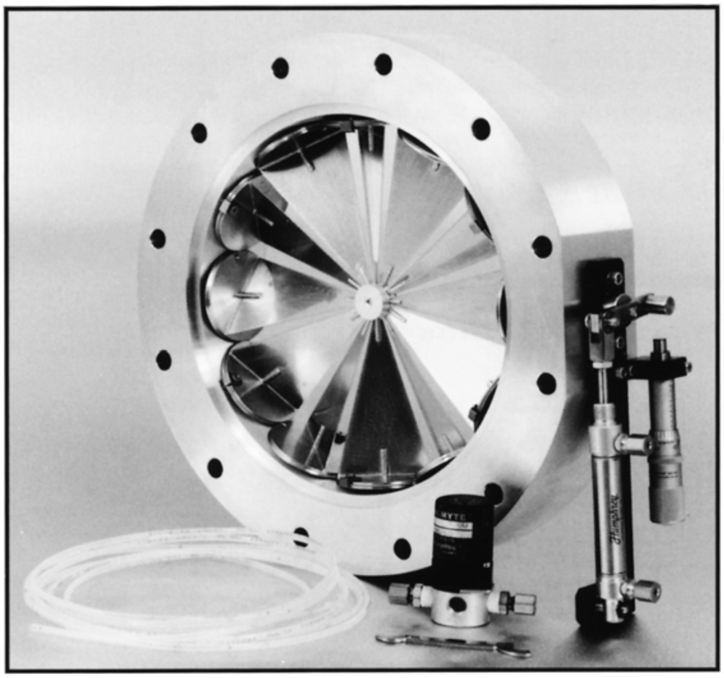

Figure 1

PA type valves with micrometer adjustment *must have exhaust restrictors* installed to control the speed of the valve movement thereby minimizing the potential for the valve to slam open or closed. Maximum air pressure to the pneumatic actuator is not to exceed 55 PSI.

Servo Motor Driven VQ Throttle Valve

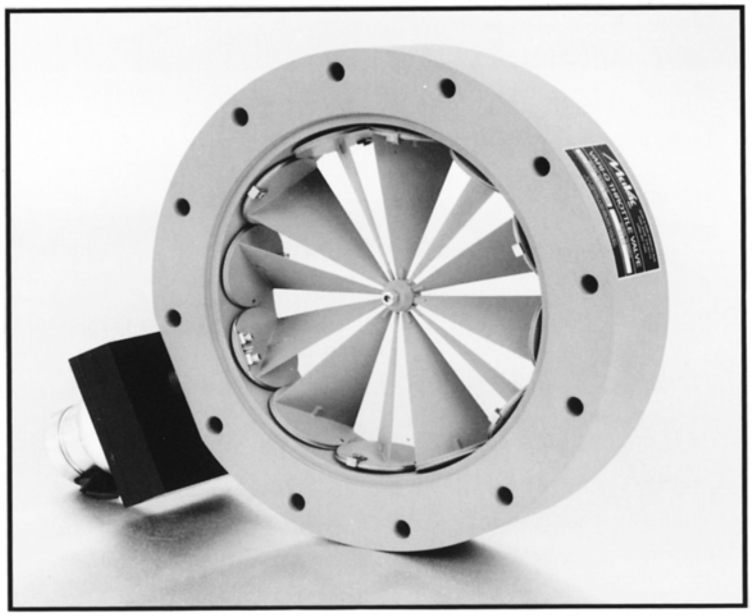

Figure 2

2. SPECIFICATIONS: VARI-Q VALVE

Dimensions:

See size diagram Figure 3 and Table 1. Other sizes may be available by special order.

Conductance:

Infinite adjustment from less than 20 l/sec to greater than 61,000 l/sec depending upon model. (See Table 2)

Size Diagram of VQ Throttle Valves

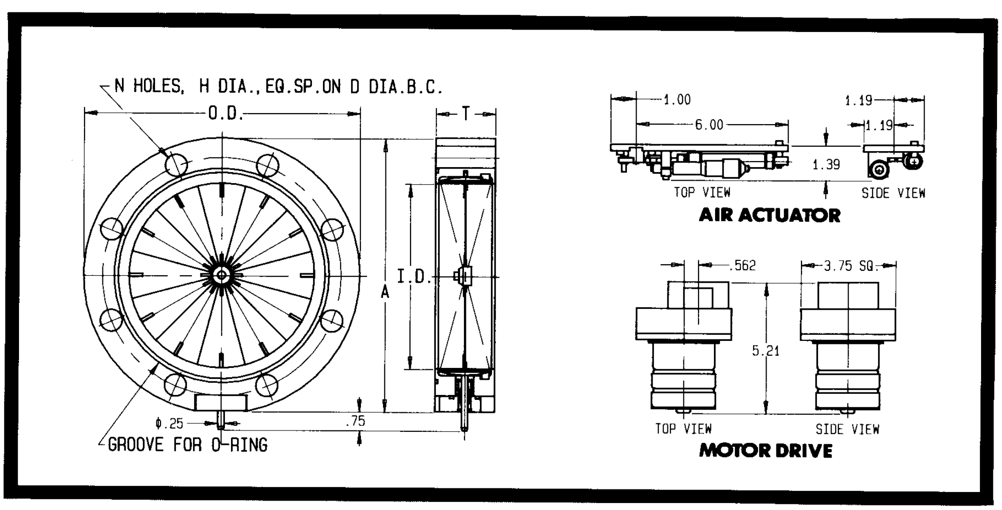

Figure 3,

DIMENSIONS OF VQ THROTTLE VALVE

Model	O.D.	I.D.	T	A	N	H	D	O-Ring
VQ-200-JIS-XX-0	11.811	7.376	2.375	11.30	8	0.593	10.603	225mm ID x 6mm C/S
VQ-250-JIS-XX-0	13.780	9.898	2.500	14.32	12	0.594	12.598	275mm ID x 6mm C/S
VQ-300-JIS-XX-0	15.748	11.875	2.375	15.67	12	0.594	14.567	325mm ID x 6mm C/S
VQ-400-JIS-XX-0	20.472	16.000	2.750	20.57	12	0.748	18.899	430mm ID x 6mm C/S
VQ-450-JIS-XX-0	22.638	18.000	2.750	22.81	16	0.750	21.063	480mm ID x 10mm C/S
VQ-100-ISO-XX-0	6.496	4.016	1.750	6.87	8	0.354	5.709	NA
VQ-160-ISO-XX-0	8.858	6.024	2.250	9.32	8	0.433	7.874	NA
VQ-200-ISO-XX-0	11.220	7.376	2.375	11.00	12	0.437	10.236	NA
VQ-250-ISO-XX-0	13.190	10.291	2.750	13.72	12	0.437	12.205	NA
VQ-320-ISO-XX-0	16.730	12.520	2.375	16.75	12	0.547	15.551	NA
VQ-400-ISO-XX-0	20.079	15.758	2.750	20.38	16	0.546	18.899	NA
VQ-6-CF-SS-0	5.97	3.699	1.000	6.16	16	0.330	5.130	Cu Gasket
VQ-8-CF-SS-0	7.97	5.702	0.870	8.30	20	0.332	7.128	Cu Gasket
VQ-10-CF-SS-0	9.997	6.438	0.970	10.35	24	0.332	9.128	Cu Gasket
VQ-12-CF-SS-0	12.000	9.868	2.500	12.51	32	0.344	11.181	Cu Gasket
VQ-4-ASA-XX-0	9.000	4.016	2.250	8.87	8	0.688	7.500	#2-431
VQ-6-ASA-XX-0	11.000	7.376	2.375	10.89	8	0.875	9.500	#2-267
VQ-8-ASA-XX-0	13.500	7.376	2.375	13.00	8	1.062	11.750	#2-272
VQ-10-ASA-XX-0	16.000	11.875	2.375	15.89	12	0.937	14.250	#5-905
VQ-16-ASA-XX-0	23.500	18.000	2.750	23.68	16	1.125	21.250	#2-466
VQ-20-ASA-XX-0	27.500	21.000	3.250	27.62	20	1.250	25.000	#2-471
VQ-32-ASA-XX-0	38.000	32.120	5.250	38.19	16	0.880	36.250	32.750 ID x .275 C/S
VQ-35-ASA-XX-0	41.750	35.000	5.250	41.68	14	1.625	38.500	35.000 ID x .275 C/S

MeiVac will custom design throttle valves to your specifications. Consult factory for details.

Table 1

TYPICAL CONDUCTANCE PERFORMANCE CHARACTERISTICS

Model	Minimum Conductance (l/s)	Maximum Conductance (l/s)
VQ-200-JIS	31	2443
VQ-250-JIS	56	4587
VQ-400-JIS	139	12168
VQ-450-JIS	158	12510
VQ-100-ISO	16	660
VQ-160-ISO	19	1591
VQ-200-ISO	31	2443
VQ-250-ISO	56	5085
VQ-320-ISO	88	7685
VQ-400-ISO	139	16356
VQ-6-CF	10	627
VQ-8-CF	28	1612
VQ-10-CF	26	2177
VQ-4-ASA	11	619
VQ-6-ASA	31	2443
VQ-8-ASA	31	2443
VQ-10-ASA	69	6884
VQ-16-ASA	158	16261
VQ-20-ASA	178	22023
VQ-32-ASA	273	51249
VQ-35-ASA	300	61685

Table 2

3. INSTALLATION AND OPERATION

3.1 PLEASE READ AND UNDERSTAND ALL INSTRUCTIONS BEFORE OPERATION.

1. Remove the equipment from the shipping containers. Save the containers and packing materials for possible future use.
2. Inspect the Vari-Q Valve and the Controller for any physical damage, which might have occurred in transit. If damage is visible, refer to the instructions under "Claims & Returns" in this manual.

3.2 PREPARATION FOR USE

- The shipment MAY contain the following items. Check your packing slip:
  - Vari-Q Valve with Pneumatic Actuator or with Servo Motor
  - *O-Rings
  - *Controller with AC Power Cord
  - *Interconnecting Cable with Connectors, Instruction Manual(s)

**Notes:*

- *Controller and interconnect cable are sold separately, not included in Valve part number.*
- *ASA and JIS models include flange o-ring.*
- *ISO flanges do NOT include a centering ring assembly.*
- *CF^{TM} flanges do NOT include a metal gasket.*

If any of the items on the packing slip are missing, contact your local representative or MeiVac, Inc. Customer Support, 5830 Hellyer Avenue, San Jose, CA 95138, USA, Telephone: 1.408.362.1000.

3.3 PRELIMINARY OPERATION

The Vari-Q valve should be cycled prior to installation in the vacuum system to verify that all components are correctly adjusted and operating properly. Proceed as follows.

1. For valves with controllers, place the valve and controller (sold separately) on a bench. A source of 115 or 230 VAC will be required.

2. Install the interconnecting cable (sold separately).

3. Prior to connecting the controller to 115 VAC or 230 VAC, be sure that the voltage selector switch on the rear panel is in the proper position.

4. Put the valve controller in the Manual mode.

5. Have the valve controller command the valve to open. The orifice blades should move to the fully open position.

   Note: The Vari-Q valve is designed so that the vanes are self-adjusting and always end up either fully open or fully closed. Over-driving the valve a small amount will have no effect on the vane orientation.

6. Have the valve controller command the valve to close. The orifice blades should move to the fully closed position.

7. The orifice blades should move freely through their entire range of travel. If any binding is evident, refer to Section 7.

3.4 SYSTEM DESIGN

Figure 4 shows the usual setup for standard downstream pressure control. The VQ-SM valve should be in series with an isolation high vacuum valve. The pressure transducer can be one of a number of units (See Table 3).

Connect the sensor to the vacuum chamber using the shortest possible tubing lengths with minimum restrictions. For ½ inch diameter tubing, lengths should be no longer than 6 inches. Never reduce the tubing diameter to less than that of the transducer. Fittings should be checked to make sure that they do not have restrictions (small passages). Antechambers off the main vacuum chamber or other small volumes should be kept to a minimum, as they can make system stabilization difficult or impossible to achieve. If the chamber is repeatedly opened to the atmosphere, an isolation valve should be installed to protect the transducer.

An important consideration is the peculiarity associated with diffusion pumps known as choking. If too much gas is introduced into the vacuum chamber at too high a pressure, the diffusion pump pumping speed changes radically and erratically. This behavior is easily recognized by lack of stability at set point, making control impossible at times. Closing down the inlet to the pump is the only solution. Note: Diffusion pumps should never be operated at inlet pressures above that at which the "top jet" will experience a pressure in excess of 5×10^{-4} Torr.

3.5 INSTALLATION OF THE VARI-Q VALVE

1. Follow normal procedures to bring the vacuum chamber to atmosphere.
2. Normally the Vari-Q valve will be installed in series with the vacuum chamber, the high-vacuum valve, a high-vacuum pump, a cryogenic trap (if used) and a roughing pump. Remove the appropriate nuts and bolts to create sufficient space above the high vacuum pump.
3. Lubricate the O-ring furnished with the Vari-Q valve.

4. Install the o-ring in the groove machined in the Vari-Q valve. *For an ISO flange, this is a centering ring (sold separately). For a CF flange, this is a metal gasket (sold separately).*
5. Place the Vari-Q valve in the open space between the high-vacuum pump and cryogenic trap (or vacuum valve if no cryo trap is used) and bolt it in place.
6. After completing the installation verify the system's vacuum integrity.

Caution!
Do not inject alcohol, acetone, or other solvents around the valve. Damage to the shaft seals may result.

7. If included, position the controller in a convenient location. It may be mounted in a standard 19-inch equipment rack or left free-standing, as desired.
8. Connect the appropriate cable between the Vari-Q valve and the rear panel of the controller.
10. Before plugging in the AC line cord, turn the power switch OFF and confirm that the voltage selector on the rear panel is in the proper position.
11. Connect the AC power cord from the rear panel of the controller to a source of main power.
12. Exercise the throttle valve as described above under **Preliminary Operation** (Section 3.3) and verify that all components continue to move freely.

3.6 PRESSURE CONTROLLER INTERFACE,

Refer to appropriate manufacturer's manual for controller set up. Links to selected controller manuals are provided here:

SM-651C CONTROLLER
SM-2153D CONTROLLER
SM-2252E CONTROLLER

3.7 PRESSURE TRANSDUCERS

Pressure transducer compatible with the pressure controller you select can be used as the feedback element of your pressure control loop. A number of pressure transducer options and their corresponding interconnecting cables are listed in Table 3.

Refer to appropriate manufacturer's manual for transducer set up.

Example Pressure Transducers

Transducer MKS	Recommended Pressure Ranges Available Torr	Interconnecting Cable	Output Voltage F.S. Volts
310/170M-6	1, 10, 100, 1000	CB-254-6	10
220 or 220B	1, 10, 100, 1000	CB-254-10	10
220A	10, 100, 1000	CB-254-4	10
221	10, 100, 1000	CB-254-1	10
222	10, 100, 1000	CB-254-2	10
227	1, 10, 100, 1000	CB-254-11	10

Table 3

Typical VQ-SM Control Loop

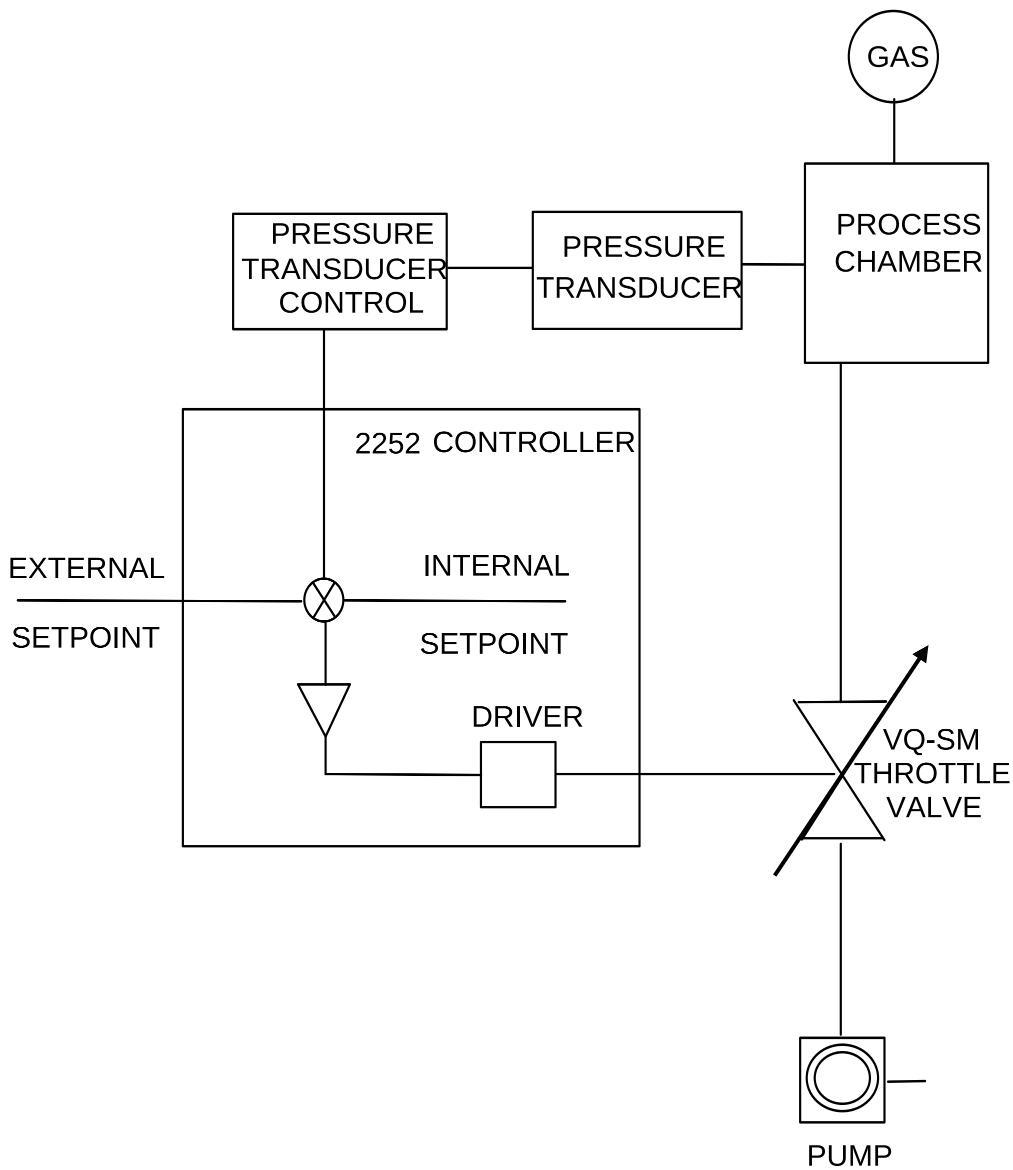

Figure 4

4. BASIC CONTROL THEORY, DOWNSTREAM PRESSURE CONTROL

The purpose of a pressure controller is to compare the desired pressure level (set point) with the actual pressure level (feedback input) and make appropriate corrections in pumping speed, via adjustments on the valve, until the actual pressure equals the desired pressure.

Figure 4 shows a simple pressure control loop consisting of a pressure transducer, controller, control valve, process chamber and pump. The pressure transducer converts pressure to an electrical signal, which is compared in the controller to the set point. Set points can originate from pressure controllers, system controllers or a precision potentiometer.

Any error between the feedback and set point signals is amplified by the controller and fed to the valve. For example, if the pressure is higher than the set point, the controller will open the valve allowing the pump to remove more gas than is entering, thereby reducing the pressure.

An additional capability of many controllers is to provide a stabilizing control. This control allows the operator to compensate for the different delays or lags, which occur in different systems. This capability is called “Phase Lead” in MKS controllers.

5. TROUBLESHOOTING SEQUENCE

1. Check for obvious problems such as power off, open fuse, defective line cord, input power failure, or loose connections.
2. Check all control settings. *Refer to appropriate control manuals*
3. If the trouble is traced to a MeiVac supplied Vari-Q valve or a pressure controller or other component that has been supplied by MeiVac, contact your local representative or MeiVac, Inc. Customer Support for problem disposition instructions. If it is necessary to return any part to MeiVac, Inc., follow the instructions for Authorized Returns found in the Claims & Returns section of this manual.

6. ALIGNMENT AND MAINTENANCE

Pressure control is a demanding process. It is highly recommended that if calibration or service is required on a Vari-Q valve that it is accomplished at the MeiVac factory or by a distributor using factory trained service personnel.

6.1 SERVICING OF THE VARI-Q VALVE

The O-ring, stainless steel cable, shaft seal and motor drive are the only items that are ever likely to need service. Maintenance procedures for these elements are listed below. The Vari-Q valve is pre-adjusted at the factory; no calibrations or further adjustments should be required under normal use.

6.2 VARI-Q VALVE DISASSEMBLY

To disassemble the Vari-Q valve, use the following procedure and refer to the items called out on Figure 5.

1. Remove motor assembly or pneumatic actuator assembly from driver shaft. Refer to Figure 6 or Figure 7 respectively.

2. Remove both driver cable clamps (1) and all pulley clamps.

3. Carefully unlace or pull out stainless steel cable (2).

4. Unscrew and remove split central hub (3).

> **CAUTION:**
> COMPLETE DISASSEMBLY WITH THE VALVE HORIZONTAL, OR ALL VANES WILL FALL OUT.

5. Remove all vanes (4).

6. Remove driver vane assembly (5).

> **NOTE:**
> IF THE VALVE IS KEPT FLAT ON A TABLE TOP THE SHAFT SEAL ELEMENTS MAY BE REMOVED AS DESCRIBED IN SECTION 6.6.

7. Reassemble in reverse order.

   IMPORTANT: See NOTE in section 6.4

6.3 FREEPLAY ADJUSTMENT

Perform the following adjustments to assure that the Vari-Q vanes open and close smoothly.

1. With the stainless steel cable threaded and clamped at one end, pull on the other end with needle nose pliers.
2. While maintaining tension on the cable with the pliers, rotate the vanes back and forth until all vanes work uniformly.
3. Install clamp on free end of the cable.
4. Adjust all vanes to the closed position and clamp vanes to cable.

NOTE: Vanes are universal and may be clamped to the cable to allow left or right rotation. Select the correct rotation direction and then tighten the clamps.

VALVE COMPONENTS

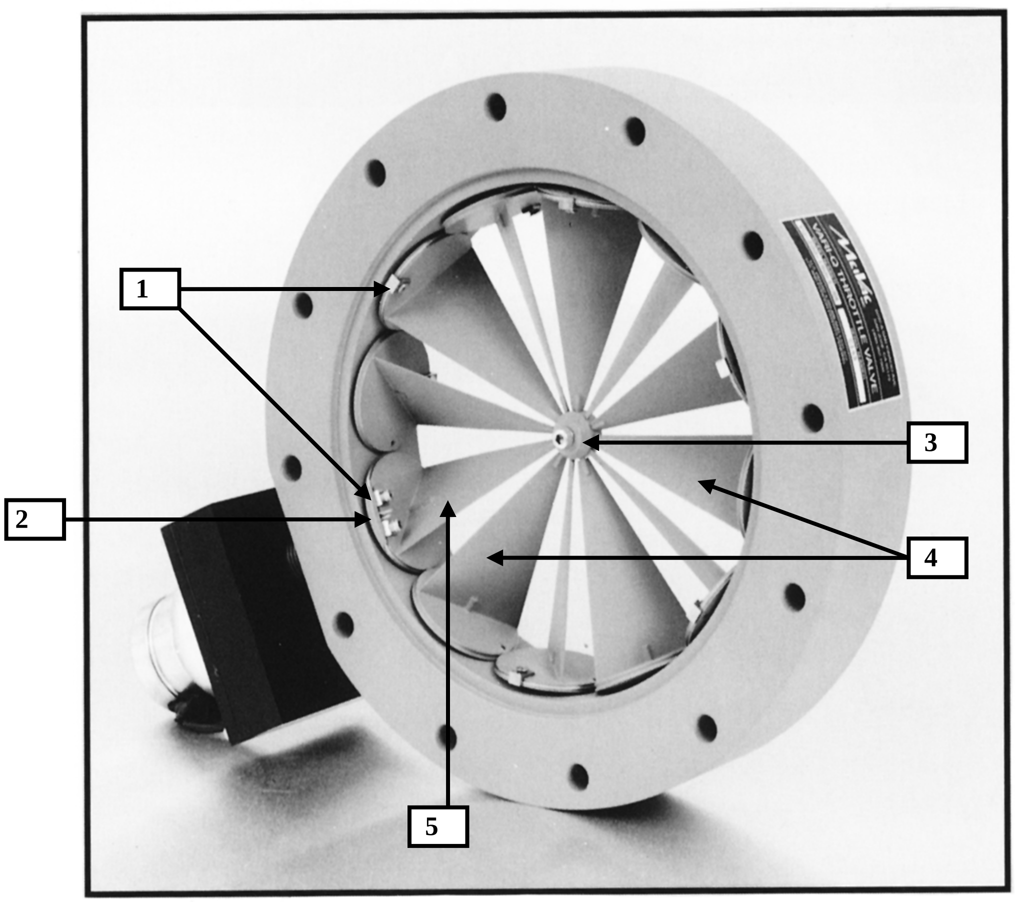

Figure 5

6.4 MOTOR DRIVE REMOVAL

Caution: Before starting the removal operation, connect the motor to the control power supply and close the throttle valve.

Refer to Motor drive assembly drawing Figure 6. The item numbers below are keyed to this drawing.

1. Loosen flexible shaft coupling (1) by unscrewing retaining screw, which is accessed through an opening in the locking plate (5).
2. Remove four socket head screws (2).
3. Remove motor plate (3) by pulling straight out away from the gear box (4).

Caution: Throttle valves manufactured after October 1, 1997 will have a 1/8" shaft key installed in the flexible coupler. Locate key and set aside for reuse later, when motor is reinstalled.

4. Remove two socket head screws holding the gear box (4), to the flange.
5. Remove gear box (4) and Locking Plate (5).
6. The shaft seal elements are now free to come out. Refer to Section 6.6.

NOTE:

Throttle valves manufactured before October 1997

Before replacing motor assembly, connect the motor to the control power supply and rotate the motor to the open and closed position, checking both limit switches. **Rotate the motor assembly and the throttle valve vanes to their closed position before installing.** After replacing motor assembly, tighten the shaft coupler screw to 30 in/lb. Use of a calibrated torque tool is required.

Throttle valves manufactured after October 1, 1997

Before replacing motor assembly, connect the motor to the control power supply and rotate the motor to the open and closed position, checking both limit switches. **Rotate the motor assembly and the throttle valve vanes to their closed position before installing.** Insert the 1/8" key in the shaft, then while holding motor plate assembly (3) slide the coupler into position. Replace the four screws (2), and then tighten setscrew on shaft coupler. If the vanes moved and are not in the fully closed position, (rotated cw or ccw),
you will need to readjust the coupler position, reference to the stop limit switch. Refer to Figure 6A.

Remove the motor assembly plate (3), and connect the motor to the controller power supply. rotate the motor to the closed position. Check the alignment of the coupler slit. If the alignment not correct, loosen the cam (7), locking screw and jog the motor one way or the other until the coupler slit is parallel with the sides of the cover (3). With the coupler aligned, push the cam (7), tightly against the close limit switch and tighten the cam (7), clamping screw.
Reassemble motor assembly plate (3) per instructions. Repeat cam adjustment until vanes remain closed with all screws tight.

Motor Drive Assembly

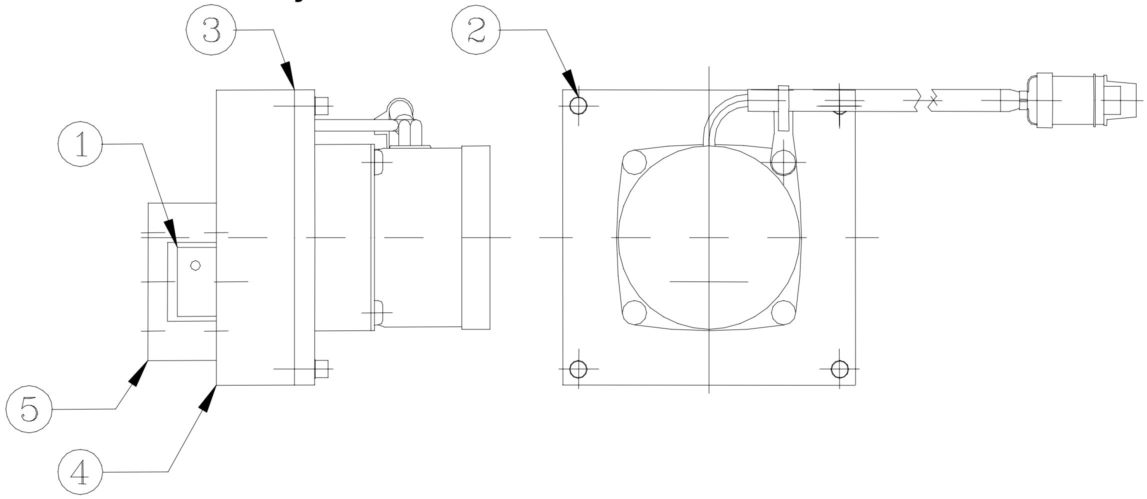

Figure 6, Motor Shown with Hex Connector

Motor Drive Inside View

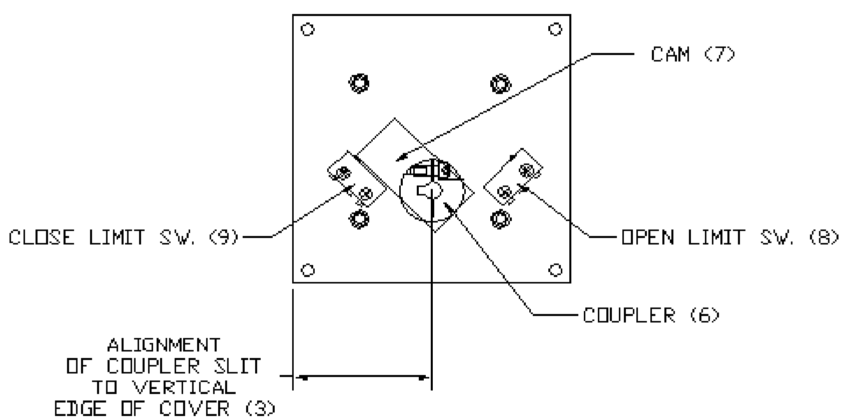

Figure 6 A

6.5 MANUAL ACTUATOR REMOVAL

Refer to drawing Figure 7. Note that when the pneumatic piston is all the way in, the vanes are in the fully open position.

1. Loosen the screw on the shaft clamp. (1)
2. Remove the two screws (2) holding the assembly to the valve and set aside.

NOTE: When reinstalling actuator assembly, adjust the driver shaft so that all vanes are in the fully open position, then tighten the clamp.

PA type valves with micrometer adjustment *must have exhaust restrictors* installed to control the speed of the valve movement thereby minimizing the potential for the valve to slam open or closed. Maximum air pressure to the pneumatic actuator is not to exceed 55 PSI.

Pneumatic Drive Assembly

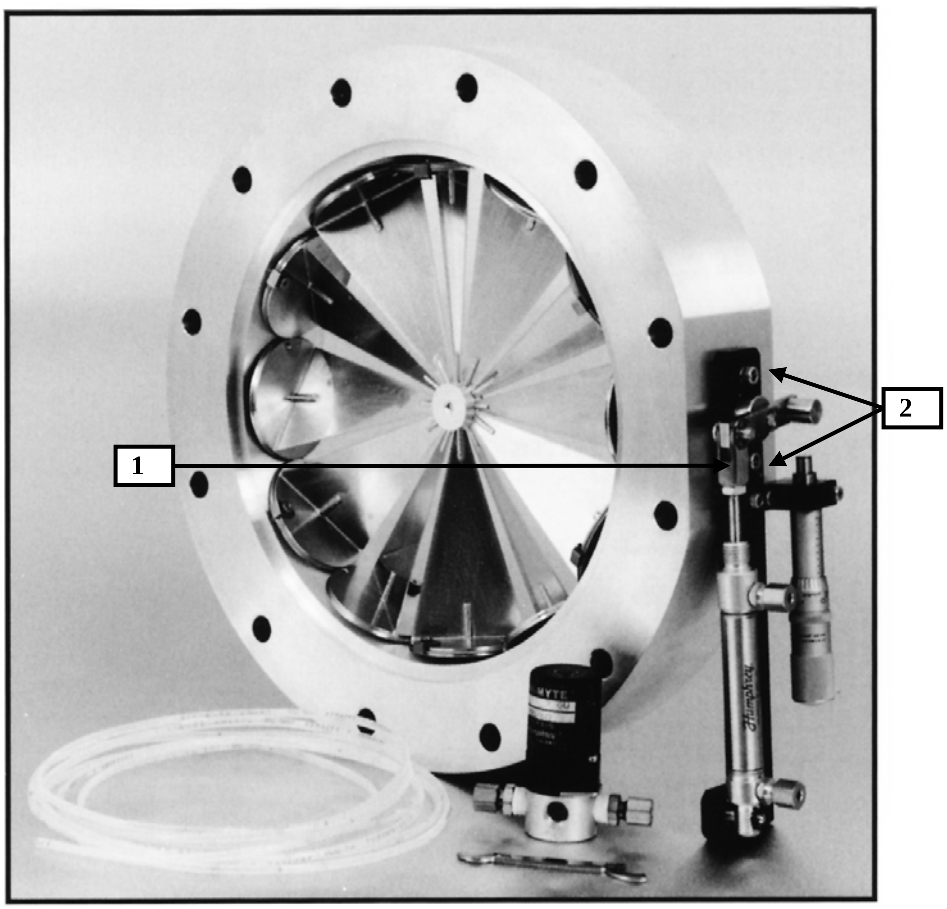

Figure 7

6.6 SHAFT SEAL DISASSEMBLY

The shaft seal has more than a dozen elements and should be disassembled only by an experienced vacuum technician. Refer to items listed on drawing, Figure 8.

1. To access shaft seal elements, go through Vari-Q valve disassembly, Section 6.2, and motor drive removal, Section 6.4, or manual actuator removal, Section 6.5, procedures.

2. With the vane-actuating shaft and locking plate removed, carefully remove the shaft seal elements.

3. Remove each seal element with care, being sure to note the following order of assembly.

Shaft Seal Parts List

Nomenclature	Item.	MeiVac Part #
Bearing spacer	(1)	1767-0806-3
Ball bearing	(2)	1995-0848-3
Bearing spacer	(1)	1767-0806-3
Precision washer	(3)	1765-0845-3
O-ring	(4)	2310-2202-2
Precision washer	(3)	1765-0845-3
Bellville washers	(5)	1770-0804-3
Precision washer	(3)	1765-0845-3
O-ring	(4)	2310-2202-2
Precision washer	(3)	1765-0845-3
Bearing spacer	(1)	1767-0806-3
Ball bearing	(2)	1995-0848-3
Locking plate	(6)	0100-0782-0

Table 4

4. Inspect each element for wear. Clean or replace as required. Lightly coat the O-rings with Apiezon "L" vacuum grease prior to installation.

SHAFT SEAL ASSEMBLY

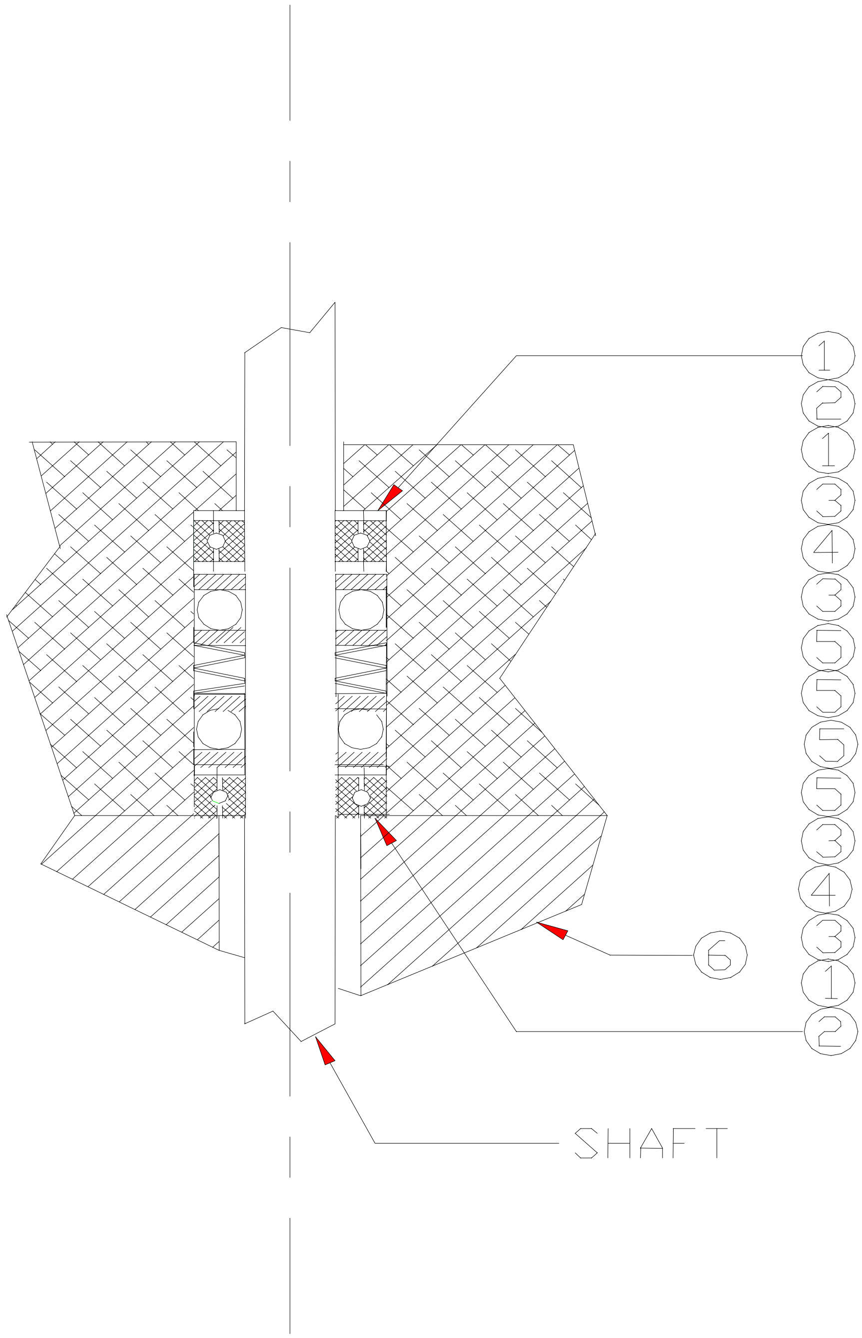

Figure 8

7. Claims & Returns

Shipping and Handling Claims

The Purchaser should inspect the product carefully as soon as it is received and test it in accordance with any instructions that may be provided. If damage is noted, or the product fails to operate properly as the result of transportation damage, a claim should be filed with the common carrier and a copy forwarded to MeiVac or MeiVac's local Distributor. MeiVac or its local Distributor will not recognize any claim for equipment damaged as a result of transportation damage if the claim is submitted more than thirty days after Purchaser's receipt of the product. Failing to report any damage within this thirty day period shall be considered an acknowledgement by Purchaser that the product was received undamaged.

Warranty Claims

For a warranty claim to be valid, it must:

- be made within the applicable warranty period,
- include the product serial number and a full description of the circumstances giving rise to the claim,

  and if a material return is required,
- have been assigned an RMA number (see **Authorized Returns**) by MeiVac or its Distributor.

Purchaser's exclusive remedy and MeiVac's sole responsibility related to warranty claims shall be as set forth in the **MeiVac, Inc. Terms and Conditions of Sale** available from MeiVac, its Distributor or MeiVac's web site (www.meivac.com).

Purchaser is responsible for obtaining authorization to return any defective units, prepaying the freight costs, and ensuring that the units are returned to the location identified by MeiVac on the RMA (see **Authorized Returns**). Provided the work required on the unit is covered under the Warranty, MeiVac will replace the affected unit or repair it at no charge to Purchaser. On completion of said repair or replacement, the unit will be returned (freight prepaid) to the Purchaser. Whoever ships the unit (either Purchaser or MeiVac) will be responsible for properly packaging and adequate insurance.

Authorized Returns

Before returning any product for any reason, Purchaser shall call MeiVac or its Distributor to advise the serial number of the unit and discuss the reason for return. This consultation call shall be at no charge to the Purchaser and will allow MeiVac or its Distributor to determine if the unit must actually be returned. If it is determined that the unit needs to be returned a **Return Material Authorization** (**RMA**) number will be issued. This RMA number must be referenced on all paperwork associated with the return, and be prominently displayed on the outside of any packaging that the unit is being returned in.

Units that are returned without MeiVac's or its Distributor's authorization will be held by MeiVac or its Distributor until such time as Purchaser can identify the reason for the return, after which, action deemed appropriate by MeiVac or its Distributor (including return of the unit to Purchaser freight collect) shall be taken.

Terms governing all products sold by MeiVac, Inc. are the MeiVac Terms and Conditions of Sale. These can be found on the MeiVac, Inc. web site (www.meivac.com) or obtained from your local representative.

Please refer to the MeiVac Website for a
list of representatives in your area.

www.meivac.com

For operational or applications questions
regarding MeiVac products, contact:

support@meivac.com

QUALITY VACUUM PRODUCTS & SERVICES
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Telephone: (408) 362-1000 Fax: (408) 362-1010

Series 94

User's Manual

1/16 DIN Limit Controller

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Registered Company
Winona, Minnesota USA

WATLOW

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Phone: (507) 454-5300, Fax: (507) 452-4507 http://www.watlow.com

0600-0024-0000 Rev C
June 2002
Supersedes 0600-0024-0000 Rev B

Made in the U.S.A.
$10.00

NOTE:
Details of a "Note" appear here in the narrow margin on the outside of each page.

CAUTION:
Details of a "Caution" appear here in the narrow margin on the outside of each page.

WARNING:
Details of a "Warning" appear here in the narrow margin on the left side of each page.

Safety Information

We use note, caution and warning symbols throughout this book to draw your attention to important operational and safety information.

A bold text "NOTE" marks a short message in the margin to alert you to an important detail.

A bold text "CAUTION" safety alert appears with information that is important for protecting your equipment and performance. Be especially careful to read and follow all cautions that apply to your application.

A bold text "WARNING" safety alert appears with information that is important for protecting you, others and equipment from damage. Pay very close attention to all warnings that apply to your application.

The safety alert symbol, ⚠, (an exclamation point in a triangle) precedes a general CAUTION or WARNING statement.

The electrical hazard symbol, ⚠, (a lightning bolt in a triangle) precedes an electric shock hazard CAUTION or WARNING safety statement.

Technical Assistance

If you encounter a problem with your Watlow controller, review all of your configuration information for each step of the setup to verify that your selections are consistent with your applications.

If the problem persists after checking all the steps, you can get technical assistance by calling Watlow Controls at +1 (507) 494-5656, between 7 a.m. and 5 p.m. CST, and asking for an applications engineer. When you call, have the following information on hand: the controller's model number (the 12-digit number is printed on the top of the stickers on each side of the controller's case and on the right-hand or top circuit board); your user's manual; and all configuration information.

Your Feedback

Your comments or suggestions on this manual are welcome, please send them to: Technical Writer, Watlow Winona, 1241 Bundy Boulevard, P.O. Box 5580, Winona, MN 55987-5580, Phone: +1 (507) 454-5300, Fax: +1 (507) 452-4507.

TC Table of Contents

Notes

1 Overview of the Series 94

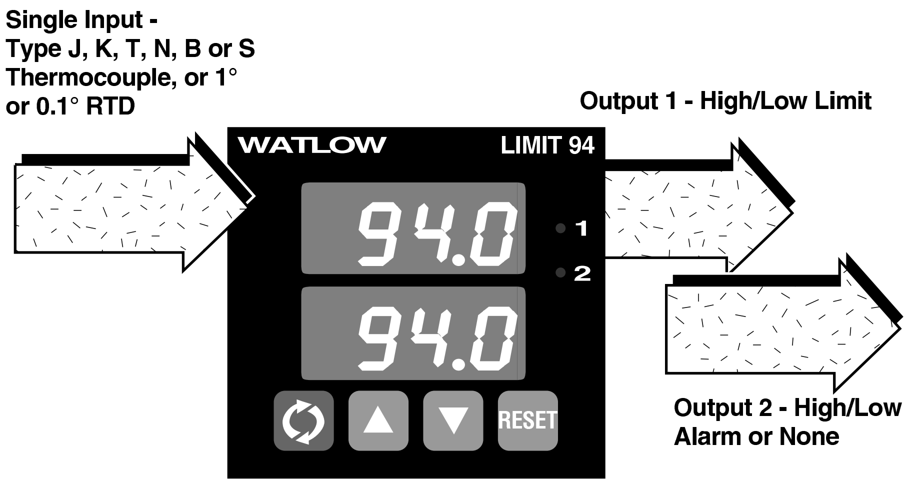


Figure 1.1 - Series 94 Input and Output Overview

General Description

Welcome to the Watlow Series 94, a 1/16 DIN microprocessor-based limit controller. The 94 has a single input that accepts a type B, J, K, T, N or S thermocouple or RTD input.

The Series 94 controller limits over-temperature conditions in thermal applications. The limit controller protects against high-temperature runaway conditions resulting from a shorted input sensor or a failed output device. A limit controller is recommended in any application where thermal runaway could affect operator safety, damage equipment or cause large product scrap costs.

The limit output is latching. An optional process alarm output can be configured as latching or non-latching, with high and low alarm set points.

Special 94 features include the optional NEMA 4X rating, dual four-digit displays in either red or green and optional low-voltage power supply.

Operator-friendly features include automatic LED indicators to aid in monitoring and setup, as well as a calibration offset at the front panel. The Watlow Series 94 automatically stores all information in a non-volatile memory.

Notes

2

Install and Wire the Series 94

NOTE:

For rapid mounting, use Greenlee 1/16 DIN punch, die, draw stud, part number 60287.

NOTE:

Measurements between panel cutouts are the minimum recommended.

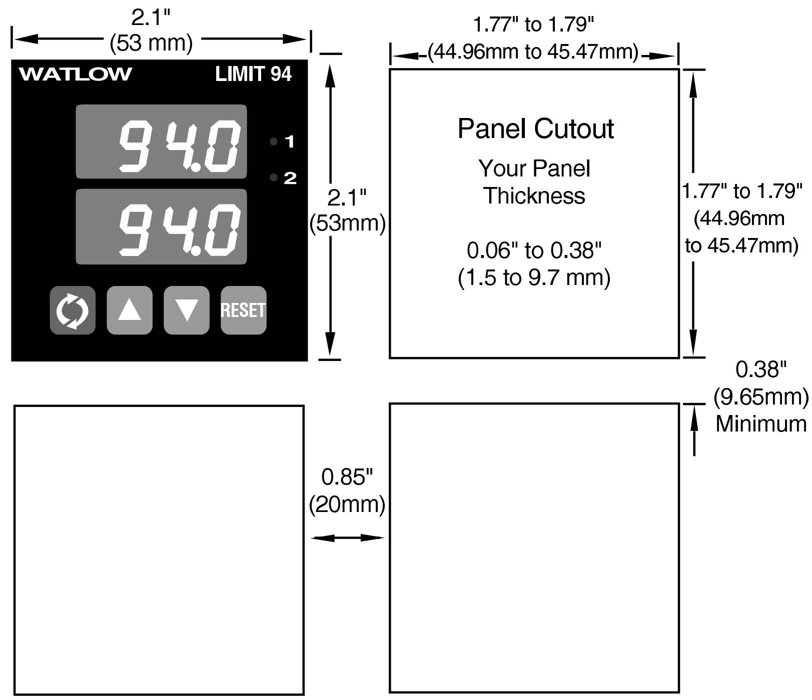


Figure 2.1a - Series 94 Multiple Panel Cutout Dimensions.

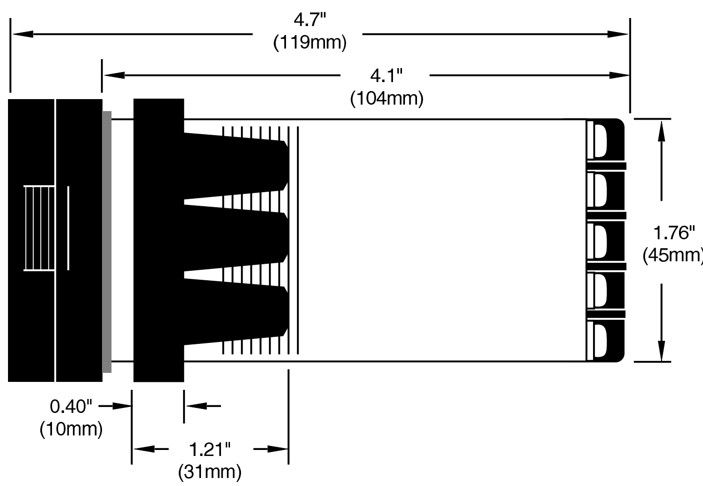


Figure 2.1b- Series 94 Dimensions.

Installation Procedure

Bold print denotes requirement for NEMA 4X seal. Follow this procedure to mount the Watlow Series 94 temperature control:

1. Make a panel cutout using the dimensions in Figure 1a.
2. **If your controller model number begins with 94B, make sure the rounded side of the external case gasket is facing the panel surface.** Check to see that the gasket is not twisted, and is seated within the case bezel flush with the panel. Place the case in the cutout. Make sure the gasket is between the panel cutout and the case bezel.

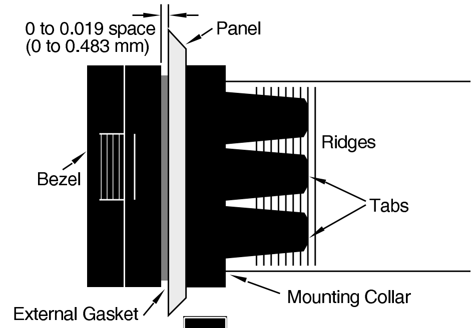


Figure 2.2a -

Mounting Case Side View.

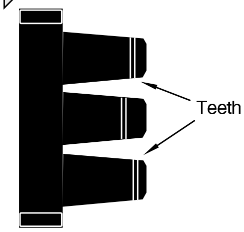


Figure 2.2b -

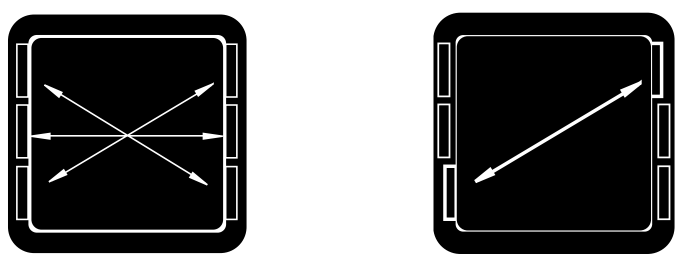
Mounting Collar Cross Section with offset teeth.

3. While pressing the front of the case firmly against the panel, slide the mounting collar over the back of the control. The tabs on the collar must line up with the mounting ridges on the case for secure installation. See Figure 2 a. Slide the collar firmly against the back of the panel getting it as tight as possible.

   To ensure a tight seal, use your thumb to lock the tabs into place while pressing the case from side to side. Don't be afraid to apply enough pressure to install the control. The tabs on each side of the collar have teeth which latch into the ridges. See Figure 2b. Each tooth is staggered at a different height, so only one of the tabs on each side are ever locked into the ridges at any time.

   As depicted in Figure 2.2c, confirm that the tabs on one side of the collar correspond with those on the opposite side. Make sure the two corresponding tabs are the only ones locked in the ridges at the same time.
   If the corresponding tabs are not supporting the case at the same time and the space between the panel and the case bezel is greater than .019", you will will not have a NEMA 4X seal. This applies to units with models designated 94B. However, all units should be mounted in this fashion to guarantee integrity of the mounting system.

CAUTION: Follow the installation procedure exactly to guarantee a proper NEMA 4X seal. Make sure the gasket between the panel and the rim of the case is not twisted and is seated properly. Failure to do so could result in damage to equipment.



Make sure that the two corresponding tabs are locked in the ridges at the same time.

NEMA 4X Seal Example.

Figure 2.2c -

Case Rear View and NEMA 4X Seal Example.

4. Insert the control chassis into its case and press the bezel to seat it. Make sure the inside gasket is also seated properly and not twisted. The hardware installation is complete. Proceed to the wiring section from here.

Removing the Series 94 Controller

When removing the mounting collar, we suggest using a thin tool such as a putty knife or screwdriver to pry gently under each of the six tabs to disengage the teeth. Then rock the collar back and forth until it can be easily pulled off the case.

WARNING: To avoid electric shock, use National Electric Code (NEC) safety practices when wiring and connecting this unit to a power source and to electrical sensors or peripheral devices. Failure to do so could result in injury or death.

Wiring the Series 94

The Series 94 wiring is illustrated by model number option. Check the unit sticker on the controller and compare your model number to those shown here and also the model number breakdown in the Appendix of this manual.

All outputs are referenced to a de-energized state. The final wiring figure is a typical system example.

When you apply power without sensor inputs on the terminal strip, the Series 94 displays [- - -] in the upper display, and [Er 7] in the lower display after 30 seconds on power-up. This error indicates an open sensor or A/D error. All wiring and fusing must conform to the National Electric Code and to any locally applicable codes as well.

Power Wiring

NOTE:

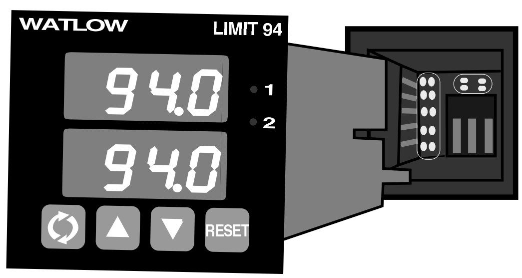
Taking the unit out of the case is not a normal operating condition and should only be done by a qualified maintenance installation technician. Power to the case should be disconnected before removing or installing the controller into its case.

High Voltage

100 to 240~ (ac), nominal (85 to 264 actual) 94_ _-1_ _ **0** - 00_ _

Low Voltage

12-24V≂ (ac/dc) 94_ _- 1_ _ **1** - 00_ _



WARNING: The case terminals may still carry live voltage when the unit is removed.

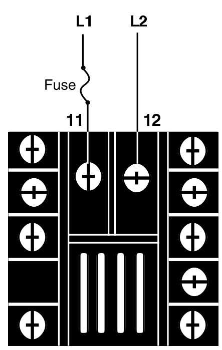
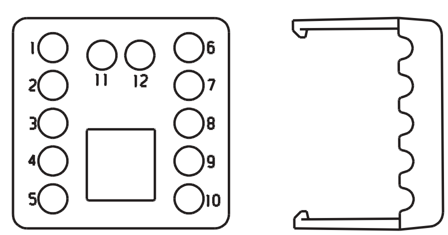


Figure 2.3 – Power wiring.



NOTE: Optional protective rear terminal cover, 0822-0426-P001, is available. Contact Watlow customer service or your local Watlow sales representative.

WARNING: Irreversible damage will occur if high voltage is applied to the low voltage unit.

Install and Wire

WARNING: To avoid electric shock and damage to property and equipment, use National Electric Code (NEC) safety practices when wiring and connecting this unit to a power source and to electrical sensors or peripheral devices. Failure to do so could result in injury or death.

NOTE:

When an external device with a non-isolated circuit common is connected to the dc output, you must use an isolated or ungrounded thermocouple.

Sensor Installation Guidelines

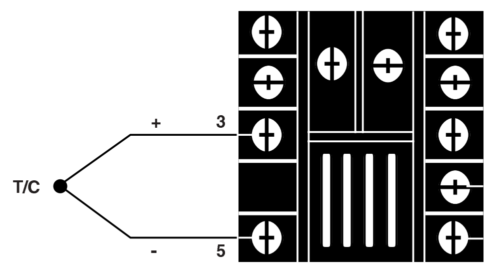
We suggest you mount the sensor at a location in your process or system where it reads an average temperature. Put the sensor as near as possible to the material or space you want to protect. Air flow past this sensor should be moderate. The sensor should be thermally insulated from the sensor mounting.

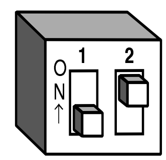
See Chapter 4 for more information on DIP switch location and orientation.

Input Wiring

Figure 2.4a – **Thermocouple**

Extension wire for thermocouples must be of the same alloy as the thermocouple itself to limit errors.

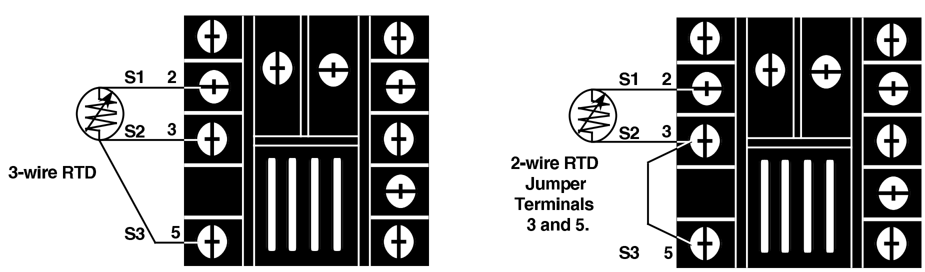


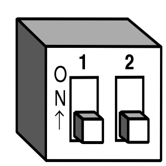


DIP Switch orientation

Figure 2.4b – **RTD (2- or 3-Wire) 100Ω Platinum**

There could be a + 2°F input error for every 1Ω of lead length resistance when using a 2-wire RTD. That resistance, when added to the RTD element resistance, will result in erroneous input to the instrument. To overcome this problem, use a 3-wire RTD sensor, which compensates for lead length resistance. When extension wire is used for a 3-wire RTD, all wires must have the same electrical resistance (i.e. same gauge, same length, multi-stranded or solid, same metal).





DIP Switch orientation

NOTE:

Successful installation requires four steps:

- Choose the controller's hardware configuration and model number (Appendix);
- Choose a sensor (Chapter Two and Appendix);
- Install and wire the controller (Chapter Two);
- Configure the controller (Chapters Three, Four and Five).

NOTE 1:

Switching inductive loads (relay coils, solenoids, etc.) with the mechanical relay, switched dc or solid-state relay output options requires use of an R.C. suppressor.

Watlow carries the R.C. suppressor Quencharc brand name, which is a trademark of ITW Paktron. Watlow Part No. 0804-0147-0000.

WARNING: To avoid damage to property and equipment, and/or injury or loss of life, use National Electric Code (NEC) standard wiring practices to install and operate the Series 94. Failure to do so could result in such damage, and/or injury or death.

Install and Wire

Output 1 Wiring

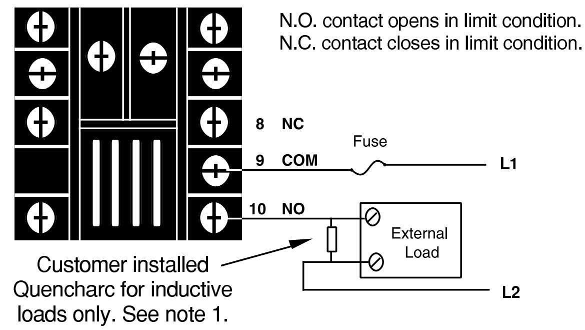
Figure 2.5a – Mechanical Relay Without Contact Suppression

94_ _- 1**D** _ _- 00 _ _

Form C, 5 amps

Minimum load current:

100 mA at 5V⎓ (dc)



Output 2 Wiring

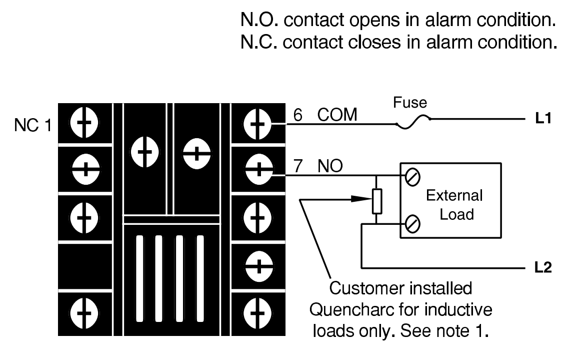
Figure 2.5b – Mechanical Relay Without Contact Suppression

94_ _- 1D **D** _ - 00_ _

Form C, 5 Amp

Minimum load current:

100 mA at 5V⎓ (dc)



NOTE:

Output is in de-energized state in Alarm Condition.

NOTE 1:

Switching inductive loads (relay coils, solenoids, etc.) with the mechanical relay, solid-state relay output options requires use of an R.C. suppressor.

Watlow carries the R.C. suppressor Quencharc brand name, which is a trademark of ITW Paktron. Watlow Part No. 0804-0147-0000.

NOTE 2:

When an external device with a non-isolated circuit common is connected to the dc output, you must use an isolated or ungrounded thermocouple.

WARNING: To avoid damage to property and equipment, and/or injury or loss of life, use National Electric Code (NEC) standard wiring practices to install and operate the Series 94. Failure to do so could result in such damage, and/or injury or death.

Figure 2.6a – **Solid-state Relay Without Contact Suppression**

94_ _- 1D **K** _- 00_ _

0.5 Amp (AC loads only)
Form A

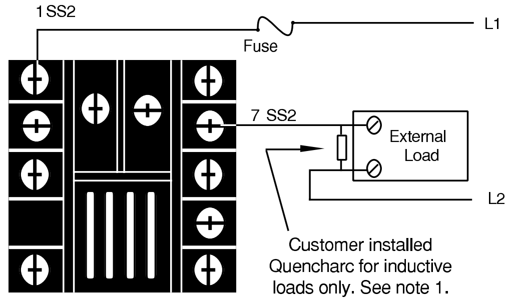
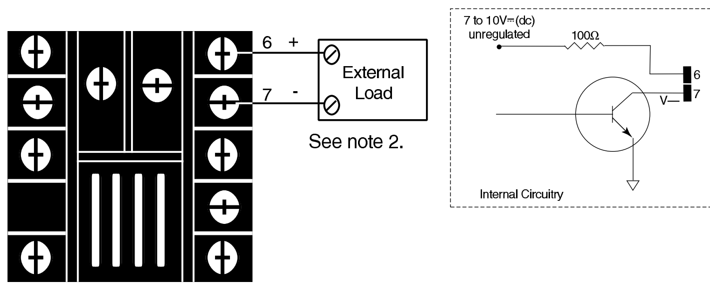


Figure 2.6b – **Switched DC**

94_ _- 1D **C** _ - 00_ _



NOTE:

Successful installation requires four steps:

- **Choose the controller's hardware configuration and model number (Appendix);**
- **Choose a sensor (Chapter Two and Appendix);**
- **Install and wire the controller (Chapter Two);**
- **Configure the controller (Chapters Three, Four and Five).**

NOTE 3:

Output is in open state in Alarm Condition.

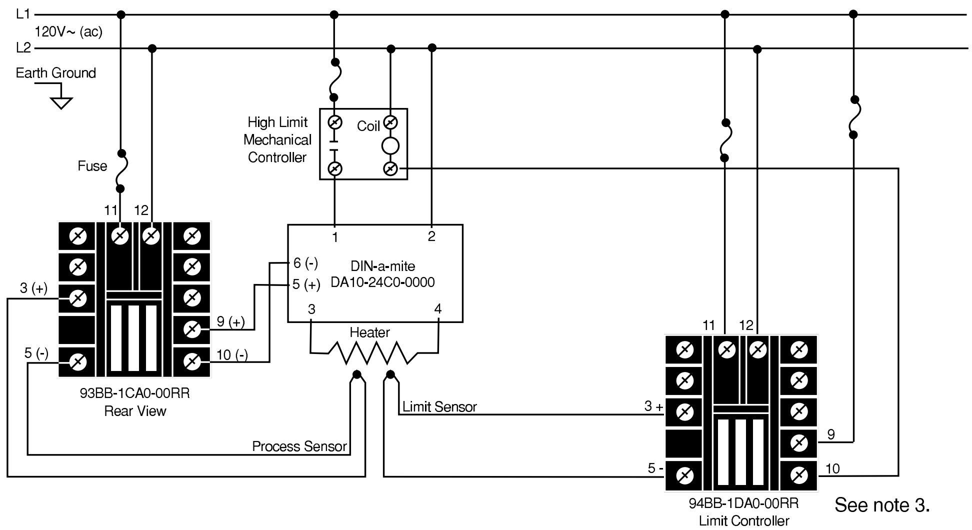
NOTE 1:

Switching inductive loads (relay coils, solenoids, etc.) with the mechanical relay, solid-state relay output options requires use of an R.C. suppressor.

Watlow carries the R.C. suppressor Quencharc brand name, which is a trademark of ITW Paktron. Watlow Part No. 0804-0147-0000.

WARNING: To avoid damage to property and equipment, and/or injury or loss of life, use National Electric Code (NEC) standard wiring practices to install and operate the Series 94. Failure to do so could result in such damage, and/or injury or death.

Wiring Example



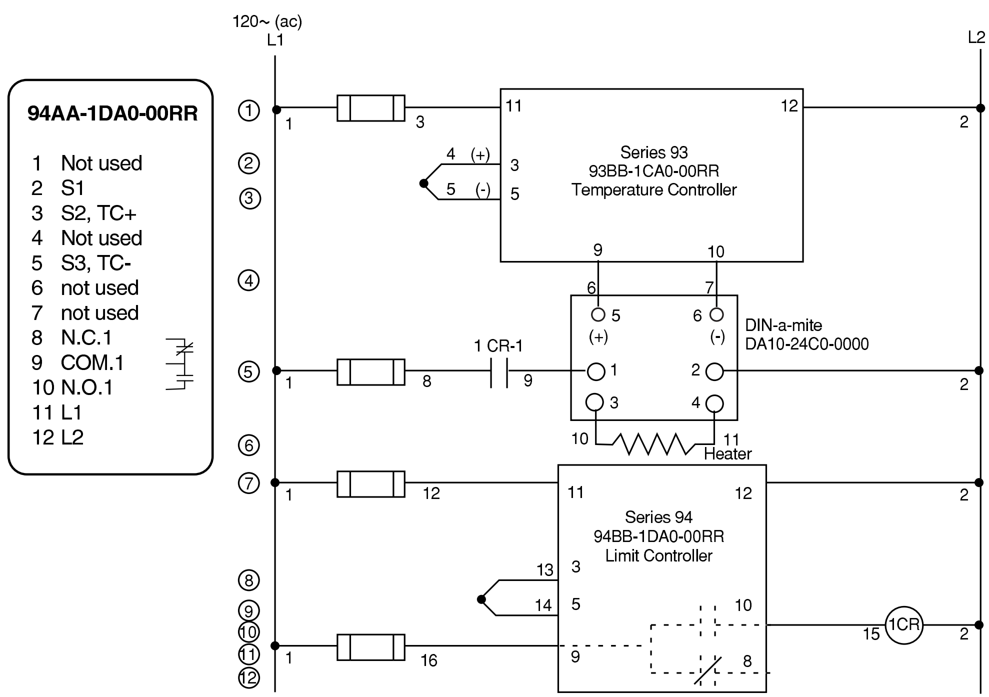


Figure 2.7 - System wiring example.

Wiring Notes

Sketch in your application on this page or a copy of it. See the wiring example in this chapter.

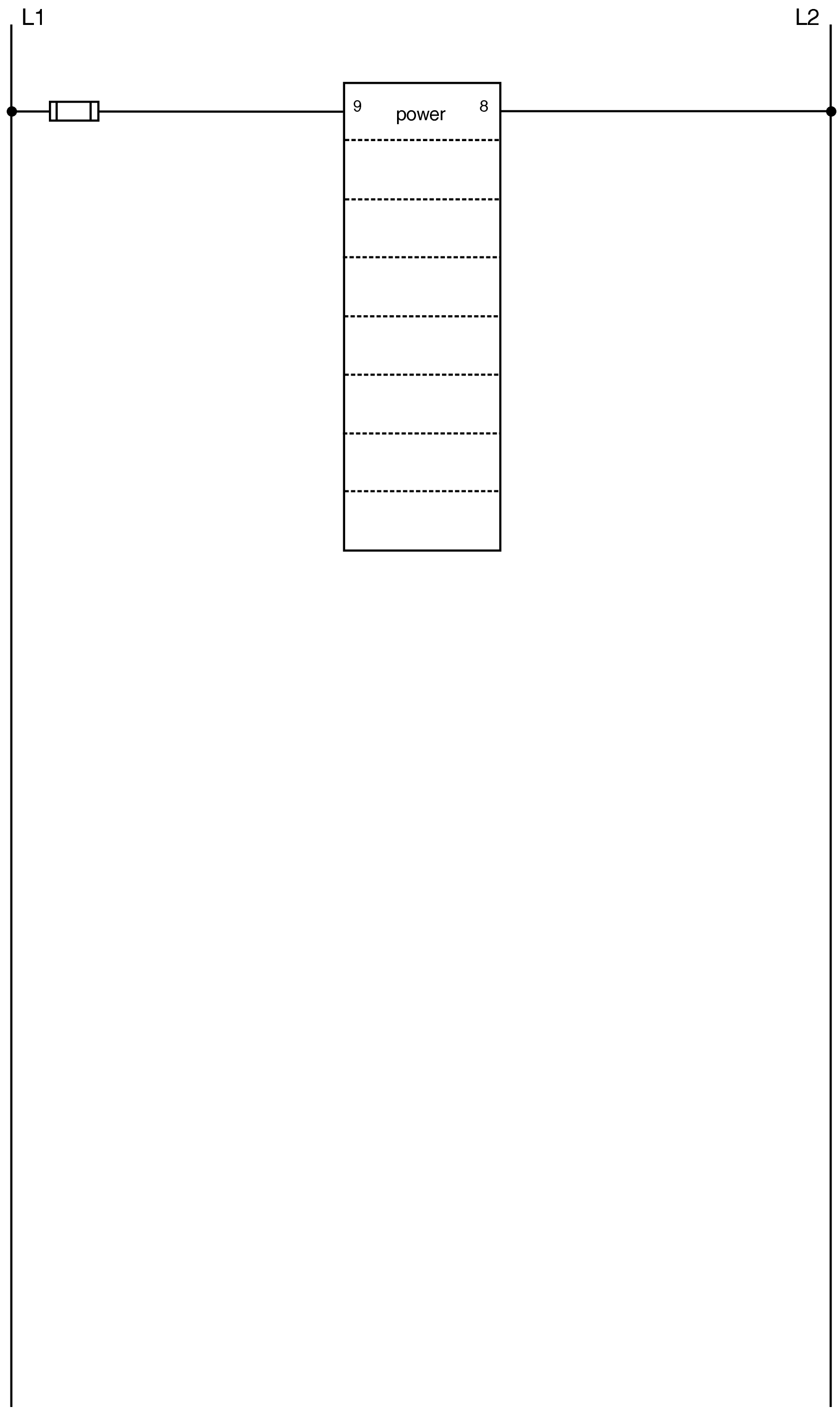


Figure 2.8 - Wiring notes.

3 How to Use the Keys and Displays

After one minute with no key activations, the controller reverts to the default displays.

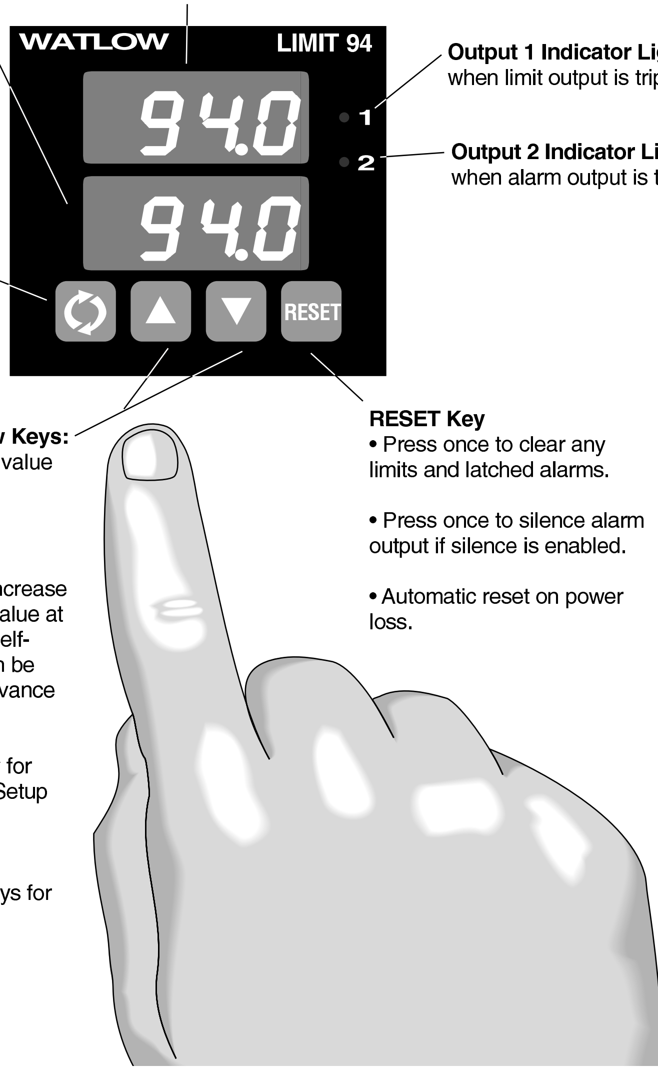
Upper Display: Can indicate actual temperature, alarm low, alarm high, limit low set point value, limit high set point value, operating parameter values or an open sensor. When powering up, the upper display will be blank for five seconds.
• To set to blank: set [UP] to [no] in the Setup Menu.

Lower Display: Can indicate actual temperature, alarm low, alarm high, limit low set point value, limit high set point value, output value, parameters for data in the upper display, or error and alarm codes.
• To set to blank: set [bot] to [no] in the Setup Menu.

Output 1 Indicator Light: Lit when limit output is tripped.

Output 2 Indicator Light: Lit when alarm output is tripped.

Advance Key: Press to step through the Operation, Setup and Calibration Menus.



Up-arrow and Down-arrow Keys: Increases or decreases the value of the displayed parameter.
• Press once to increase or decrease the value by one.

• Press and hold down to increase or decrease the displayed value at a rapid rate. New data will self-enter in five seconds, or can be entered by pressing the Advance Key.

• Press both simultaneously for three seconds to enter the Setup Menu. The [LOC] Lock parameter appears.

• Continue pressing both keys for three seconds to enter the Calibration Menu.

RESET Key
• Press once to clear any limits and latched alarms.

• Press once to silence alarm output if silence is enabled.

• Automatic reset on power loss.

Figure 3.1 - Series 94 Keys and Displays

Notes

Keys and Displays

4 How to Set Up the Series 94

Setting up the Series 94 is a simple process. First set the DIP switches to match your input type. Refer to the orientation below for the [In] Input parameter. Next, configure the 94's features to your application in the Setup Menu, then enter values in the Operation Menu. Both tasks use the Advance key to move through the menus and the Up-arrow/Down-arrow keys to select data.

WARNING:

Remove power from the controller before removing the chassis from the case or changing the DIP switches. Removing the controller from the chassis is not a normal operating condition and should only be done by a qualified technician.

Setting the Input Type DIP Switch

The Series 94 input type can be user selectable at any time via a Dual In-line Package (DIP) switch inside the control, located on the left (viewed from the bottom). To set the DIP switch, remove the control chassis from the case. Holding each side of the bezel, press in firmly on the side grips until the tabs release. You may need to rock the bezel back and forth several times to release the chassis.

The locations of the board and switches appear in Figures 1a and 4.1b. Refer to the input types below for DIP switch orientation. DIP switch selection must match the sensor selected under the [In] Input parameter in the Setup Menu. Set the software selection for the input type to match.

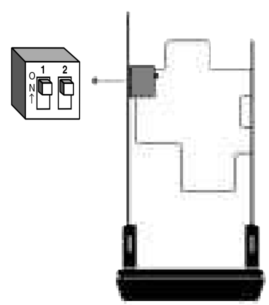


Figure 4.1a - DIP Switch Location and Orientation.

Controller Chassis - Bottom View

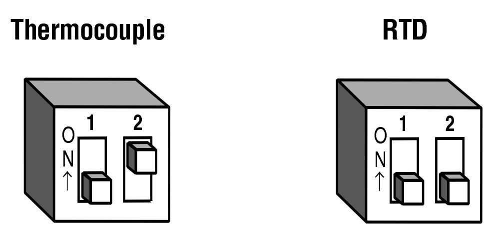


Figure 4.1b - Input DIP Switches.

Input Types

Entering the Setup Menu

The Operation Menu will appear as the default menu of the Series 94. The Setup Menu displays the parameters that configure the Series 94's features to your application.

Enter the Setup Menu by pressing the Up-arrow and Down-arrow keys simultaneously for 3 seconds. The lower display shows the `LOC` Lock parameter, and the upper display shows its current level. All keys are inactive until you release both keys. You can reach the `LOC` Lock parameter from anywhere.

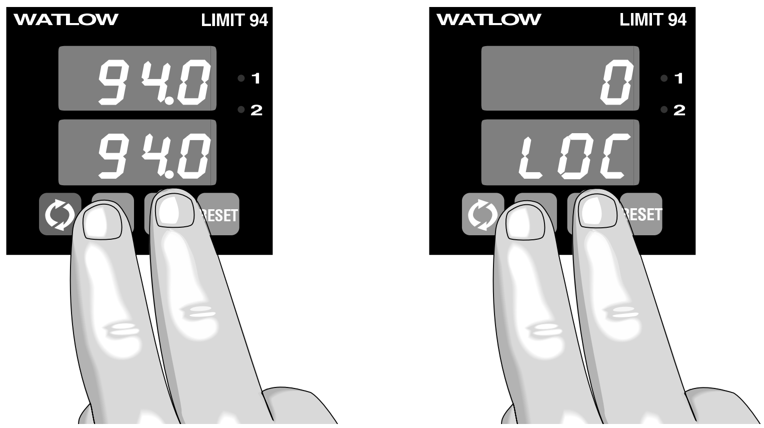


Figure 4.2a - Entering the Setup Menu.

Use the Advance key to move through the menus and the Up-arrow and Down-arrow keys to select data. You will not see all parameters in this menu, depending on the controller's configuration and model number. If no keys are pressed for approximately 60 seconds, the controller returns to the default display.

Setup

NOTE:

While in the Setup Menu, all outputs are off.

Setup Menu

Press and for 3 seconds

- `LOC` Lock
- `In` Input
- `C_F` Celsius - Fahrenheit
- `rL` Range Low
- `rH` Range High
- `Ot 1` Output 1
- `HSL` Limit Hysteresis
- `Ot2` Output 2
- `HSA` Hysteresis Alarm*
- `LAt` Latching*
- `S IL` Silencing*
- `rtd` RTD*
- `UP` Upper Display
- `bot` Bottom Display

* These parameters may be masked or hidden, depending on the settings of your controller. For an explanation of when the parameters will appear, refer to Table 4.5b on page 4.5.

Figure 4.2b - The Setup Menu.

Setup Parameters

NOTE:

Shaded parameters may not appear, depending on the controller's configuration and model number.

At the top of the Setup Menu the Series 94 displays the user level of operation in the upper display and the [LOC] Lock parameter in the lower display.

Press the Advance key and the value of the next parameter appears in the upper display, and the parameter appears in the lower display.

[LOC]

NOTE:

Set the [LOC] Lock parameter value as the final step in programming the Series 94 controller to prevent locking yourself out of the Operation and Setup Menu during initial programming.

Lock: Selects the level of operator lock-out as defined below.
Range: 0 - 3
Default: 0

[0] No level of lockout. The user has full access to all prompts and menus.

[1] The Setup Menu will be locked from view except for the [LOC] prompt, which can be viewed and changed. The user will be able to change and view all prompts in the Operation Menu.

[2] The Setup Menu will be locked from view except for the [LOC] prompt, which can be viewed and changed. The user will be able to change the limit low and limit high set points only. All prompts except for the [LLO] and [LHI] in the Operation Menu will be locked from view.

[3] Full lockout of prompts and menus. All prompts in the Operation and Setup Menus will be locked from view. The operator can use the Reset Key for clearing limits and alarms, and for silencing alarms. The operator can also use the Up-arrow and Down-arrow keys to access the [LOC] prompt in the Setup Menu, which can be viewed and changed.

CAUTION:
Changing the [In] Input parameters lets all parameters to factory defaults. Document all settings before changing this parameter.

[In]

Input: Selects the sensor input type. The internal DIP switch must also match the [In] Input parameter. See Figure 4.1b for DIP switch orientation. Refer to Table 4.5a on page 4.5 for input type temperature ranges.
Range: [J], [H] (K), [t], [n], [S], [b], [rtd], [rt.d]
Default: [J]

[C_F]

Celsius _ Fahrenheit: Selects the units of temperature measurement for the control.
Range: [C], [F]
Default: [F]

[rL]

Range Low: Selects the low range of the limit set point. See the specifications information in the Appendix for your range values, or refer to Table 4.5a on page 4.5.
Range: Sensor range low to [rH]
Default: Low range of sensor type

[rH]

Range High: Selects the high range of the limit set point. See the specifications information in the Appendix for your range values, or refer to Table 4.5a on page 4.5.
Range: Sensor range high to [rL]
Default: High range of sensor type

Setup

Ot1

Output 1: Selects which side or sides the limit setpoints can be programmed for. Select [HI] for high side, select [LO] for low side or [H_L] for both.
Range: [HI], [LO], [H_L]
Default: [H_L]

HSL

Hysteresis - Limit: Selects the switching hysteresis for Output 1.
Range: 1 to 9999, 0.1 to 999.9°F/1 to 5555, 0.1 to 555.5°C
Default: 3, 0.3°F/2, 0.2°C

Ot2

Output 2: Selects the output action for Output 2.
Range: [PrA] Process alarm with alarm message displayed
[Pr] Process alarm with no alarm message displayed
[no] None
Default: [no]

HSA

Hysteresis - Alarm: Selects the switching hysteresis for Output 2 when [Ot2] is an alarm. Appears only if [Ot2] is set to [PrA] or [Pr].
Range: 1 to 9999, 0.1 to 999.9°F/1 to 5555, 0.1 to 555.5°C
Default: 3, 0.3°F/2, 0.2°C

LAt

Latching: Selects whether the alarm is latching or non-latching. Latching alarms must be cleared by pressing the Reset Key. Selecting non-latching will automatically reset the alarm output when the condition clears. Appears only if [Ot2] is set to [PrA] or [Pr].
Range: [LAt] or [nLA]
Default: [nLA]

SIL

Silencing: Selects alarm silencing (inhibit) for the alarm. Appears only when [Ot2] is set to [PrA] or [Pr]. For more information see Chapter 5.
Range: [On] or [OFF]
Default: [OFF]

rtd

RTD: Selects the RTD calibration curve for RTD inputs. Will not appear unless [In] is set to [rtd] or [rt.d]. [JIS] is 0.003916Ω/Ω°C, [din] is 0.003850Ω/Ω°C.
Range: [din] or [JIS]
Default: [din]

UP

Upper Display: Selects what parameter appears on the upper display.
Range: [no] No display
[Pro] Process temperature
[LoL] Low limit set point
[HiL] High limit set point
[LoA] Low alarm set point
[HiA] High alarm set point
Default: [Pro]

bot

Bottom Display (Lower): Selects what parameter appears on the lower display.
Range: [no] No display
[Pro] Process temperature
[LoL] Low limit set point
[HiL] High limit set point
[LoA] Low alarm set point
[HiA] High alarm set point
Default: [HiL]

Table 4.5a - Input Ranges.

Input Type	Sensor Range Low	Sensor Range High
J	32°F/0°C	1382°F/750°C
H (K)	-328°F/-200°C	2282°F/1250°C
t	-328°F/-200°C	662°F/350°C
n	32°F/0°C	2282°F/1250°C
S	32°F/0°C	2642°F/1450°C
b	32°F/0°C	3308°F/1820°C
rtd (1°)	-328°F/-200°C	1292°F/700°C
rt.d (0.1°)	-199.9°F/-199.9°C	999.9°F/700.0°C

Setup Menu

Table 4.5b - Setup Menu Prompts and Descriptions.

NOTE:

Document your setup menu parameters. Do not enter any values here; make photocopies instead.

Parameter	Value	Range	Factory Default	Appears If:
LOC		0 - 3	0	
In		J, H (K), t, n, S, b, rtd, rt.d	J	DIP switch selectable.
C_F		C or F	F	LOC is set to 0
rL		rL to rh	Input dependent.	LOC is set to 0
rh		rh to rL	Input dependent.	LOC is set to 0
Ot 1		H I, LO, H_L	H_L	LOC is set to 0
HSL		1 - 9999, 0.1 - 999.9°F 1 to 5555, 0.1 to 555.5°C	3, 0.3°F 2, 0.2°C	LOC is set to 0
Ot2		PrA = Process Alarm Pr = Process with no alarm message no = None	no	LOC is set to 0
HSA		1 - 9999, 0.1 - 999.9°F 1 - 5555, 0.1 - 555.5°C	3, 0.3°F 2, 0.2°C	Ot2 is set to Pr or PrA and LOC is set to 0
LAt		LAt or nLA	nLA	Ot2 is set to Pr or PrA and LOC is set to 0
S IL		On or OFF	OFF	Ot2 is set to Pr or PrA and LOC is set to 0
rtd		J IS or d in	d in	In is set to rtd or rt.d and LOC is set to 0
UP		no = no display shown Pro = Process LoL = Low limit set point H iL = High limit set point LoA = Alarm low set point H iA = Alarm high set point	Pro	LOC is set to 0
bot		no = no display shown Pro = Process LoL = Low limit set point H iL = High limit set point LoA = Alarm low set point H iA = Alarm high set point	H iL	LOC is set to 0

Setup

Operation Menu

Figure 4.6 - The Operation Menu.

NOTE:

Shaded parameters may not appear, depending on the controller's configuration and model number.

Operation Menu

- `LLO` Low Limit Set Point*
- `LHI` High Limit Set Point*
- `ALO` Alarm Low*
- `AHI` Alarm High*
- `CAL` Calibration Offset

* These parameters may be masked or hidden, depending on the settings of your controller. For an explanation of when the parameters will appear, refer to Table 4.6 below.

Operation Parameters

`LLO`

Low Limit Set Point Sets the low limit set point. Active if `Ot1` is set to `H_L` or `LO`.
Range: `rL` to `LHI`, or `rH` if `LHI` is not active.

`LHI`

High Limit Set Point Sets the high limit set point. Active if `Ot1` is set to `H_L` or `HI`.
Range: `LLO` to `rH`, or `rL` if `LLO` is not active.

`ALO`

Alarm Low: Represents the low process alarm. This parameter will not appear if `Ot2` is set to `no`. This parameter is present if `Ot2` is set to `PrA` or `Pr` and `LOC` is set to `0` or `1`.
Range: `rL` to `AHI`, or `rH` if `AHI` is not active. **Default:** `rL`

`AHI`

Alarm High: Represents the high process alarm. This parameter will not appear if `Ot2` is set to `no`. This parameter is present if `Ot2` is set to `PrA` or `Pr` and `LOC` is set to `0` or `1`.
Range: `ALO` to `rH`, or `rL` if `ALO` is not active. **Default:** `rH`

`CAL`

Calibration Offset: Adds or subtracts degrees from the input signal.
Range: -180°F to 180°F/-100°C to 100°C;
or -18.0°F to 18.0°F/-10.0°C to 10.0°C **Default:** 0

Setup

Table 4.6 - Operation Menu Prompts and Descriptions.

Operation Menu

Document your Series 94 Operation Parameters
Do not enter any values here; make photocopies instead.

Operation Parameters	Value	Range	Factory Default	Appears If
`LLO`		`rL` to `LHI` or `rH` if `LHI` is not active	`rL`	`Ot1` is set to `H_L` or `LO` and `LOC` is not set to `3`.
`LHI`		`LLO` to `rH` or `rL` if `LLO` is not active	`rH`	`Ot1` is set to `H_L` or `HI` and `LOC` is not set to `3`.
`ALO`		`rL` to `AHI` or `rH` if `AHI` is not active	`rL`	`Ot2` is set to `PrA` or `Pr` and `LOC` is set to `0` or `1`.
`AHI`		`ALO` to `rH` or `rL` if `ALO` is not active	`rH`	`Ot2` is set to `PrA` or `Pr` and `LOC` is set to `0` or `1`.
`CAL`		-180°F to 180°F/-100°C to 100°C; or -18.0°F to 18.0°F/-10.0°C to 10.0°C	0	`LOC` is set to `0` or `1`.

5 Alarms and Errors

Using Alarms

NOTE:

When the alarm output is de-energized, the N.O. contact is open in the alarm condition.

The Series 94 has a **process alarm** feature. When the actual temperature exceeds that absolute temperature limit an alarm occurs. The process alarm set points may be independently set high and low. Under the Setup Menu, select the type of alarm output with the [Ot2] Output 2 Parameter. [PrA] sets a Process Alarm with alarm message displayed. [Pr] sets a Process alarm with no alarm message displayed.

Latching: Process alarms can be latching or non-latching. When the alarm condition is removed a **non-latching alarm automatically** clears the alarm output. You must **manually clear a latching alarm** before it will disappear by pressing the RESET key.

Flashing [LO] or [HI] in the lower display indicates an alarm when [Ot2] is set to [PrA]. The lower display alternately shows information from the current parameter and the [LO] or [HI] alarm message at one second intervals. The alarm output is de-energized and the Output 2 indicator light is lit.

To clear an alarm: First correct the alarm condition, then:

- **If the alarm is latching…**
  Clear it manually; press the Reset key once as soon as the process temperature is inside the alarm limits and satisfies the alarm hysteresis [HSA].
- **If the alarm is non-latching…**
  The alarm clears itself automatically as soon as the process temperature is inside the alarm limits and satisfies the alarm hysteresis [HSA].

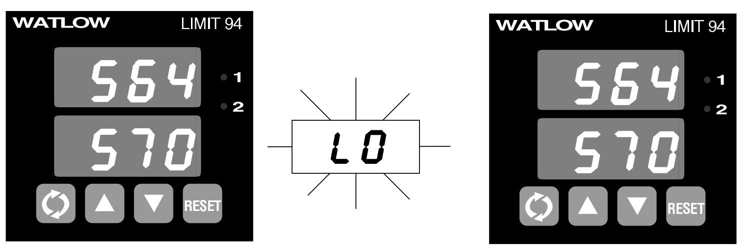


Figure 5.1 - Clearing a latching alarm.

Alarm Silencing is available with the process alarm and has two uses:

When [SIL] is selected as "on," the controller automatically disables the alarm output on initial power up (in either the latching or non-latching mode). Alarm silencing disables the alarm output relay and the Output 2 indicator light. Once the process value crosses into the "safe" region, both a latching or a non-latching alarm is ready. Any future excursion outside of these alarm set points triggers an alarm.

When [SIL] is selected as "on," pressing the Reset Key will disable the alarm output relay and the Output 2 indicator light once an alarm has occurred, but will not eliminate the alarm message if enabled. (If [Ot2] is set to [PrA].) This silences the alarm until the process returns to the "safe" region. Once within this region, the alarm is ready again. Any future excursion outside of the alarm set points triggers an alarm.

Error Code Messages

Three dashes [- - -] in the upper display indicate a Series 94 error. The error code is visible in the lower display.

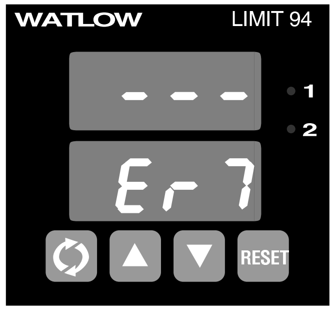


Figure 5.2 - Error Code Message.

[Er2] - Sensor underrange error (applies only to RTD units)
The sensor input generated a value lower than the allowable signal range, or the A/D circuitry malfunctioned. Enter a valid input. Make sure the [In] Input parameter (Setup Menu) and the DIP switch settings both match your sensor. Refer to Table 4.5b on page 4.5 for the appropriate input type and range.

[Er4] - Configuration error
The controller's microprocessor is faulty; call the factory.

[Er5] - Non volatile checksum error
The nonvolatile memory checksum discovered a checksum error. Unless a momentary power interruption occurred while the controller was storing data, the nonvolatile memory is bad. Call the factory.

⚠ CAUTION:
Electrical noise or a noise event, vibration or excess environmental moisture or temperature may cause Series 94 errors to occur. If the cause of an error is not otherwise apparent, check for these.

[Er6] - A/D underflow error
The A/D circuit is underrange. An open or reversed polarity sensor is the most likely cause. Check the sensor; if the connection is good and functions properly, call the factory. The A/D underrange voltage is too low to convert an A/D signal. Make sure the [In] Input parameter matches your sensor and DIP switches are set accordingly.

[Er7] - A/D overflow error
The A/D circuit is overrange. An open or reversed polarity sensor is the most likely cause. Check the sensor; if the connection is good, and the sensor functions properly, call the factory. The A/D overrange voltage is too high to convert an A/D signal. Make sure the [In] Input parameter (Setup Menu) matches your sensor and DIP switches are set accordingly.

Error Code Actions

[Er2], [Er6], [Er7]

To clear a corrected error, press the ⦿Advance key to clear the input error code. Wait for the upper display to change from showing [- - -] to showing the process temperature. The Limit message [Err] will appear. Then press the RESET key to clear/reset the error latched outputs. There may be a 30 second delay from when the ⦿Advance key is pressed.

[Er4] and [Er5] result in these conditions:

- Both outputs will turn off.
- The alarm output, if present, will be in an alarm state (de-energized with the indicator light on).
- The upper display indicates the process value.
- The lower display indicates the error code.
- All keys are inactive.
- All Setup Menu parameters return to default values.
- The above conditions occur regardless of the value of [LOC], or the presence of the Setup or Calibration Menus.

To clear a corrected error cycle power to the controller or press the RESET key.

A Appendix

Noise and Installation Guidelines

For wiring guidelines, refer to the IEEE Standard No. 518-1982, available from IEEE, Inc. 345 East 47th Street, New York, NY 10017.

Noise Sources

- Switches and relay contacts operating inductive loads such as motors, coils, solenoids, and relays, etc.
- Thyristors or other semiconductor devices which are not zero crossover-fired (randomly-fired or phase angle-fired devices).
- All welding machinery and heavy current carrying conductors.
- Fluorescent and neon lights.

Decreasing Noise Sensitivity

- Physical separation and wire routing must be given careful consideration in planning the system layout. For example, ac power supply lines should be bundled together and physically kept separate from input signal lines (sensor lines). A 12" (305 mm) minimum separation is usually effective. Keep all switched output signal lines (high power level) separate from input signal lines (sensor lines). Cross other wiring at 90° angles whenever crossing lines is unavoidable.

- Look at the system layout; identify and locate electrical noise sources such as solenoids, relay contacts, motors, etc. Route the wire bundles and cables as far away as possible from these noise sources. Don't mount relays or switching devices close to a microprocessor control. Don't have phase angle-fired devices in the same electrical enclosure or on the same power line with the control.

- Shielded cables should be used for all low power signal lines to protect from magnetic and electrostatic coupling of noise. Some simple pointers are:
  - ◊ Whenever possible, run low level signal lines unbroken from signal source to the control circuit.
  - ◊ Connect the shield to the control circuit common at the control end only. Never leave the shield unconnected at both ends. Never connect both shield ends to a common or ground.
  - ◊ Maintain shield continuity at daisy chain connection points by reconnecting the broken shield.
  - ◊ Assume no electrostatic shielding when using the shield as a signal return. If you must do this, use triaxial cable (electrostatically shielded coaxial cable).

- Use twisted pair wire any time control circuit signals must travel over two feet, or when you bundle them in parallel with other wires.
- Select the size or gauge of wire by calculating the maximum circuit current and choosing the gauge meeting that requirement. Using greatly larger wire sizes than required generally increases the likelihood of electrostatic (capacitance) coupling of noise.
- Eliminate ground loops in the entire control system. You can spot the obvious loops by studying the “as-built” wiring diagram. There are also not-so-obvious ground loops resulting from connecting internal circuit commons in the manufacturer’s equipment.
- Do not daisy chain ac power (or return) lines, or output signal (or return) lines to multiple control circuits. Use a direct line from the power source to each input requiring ac power. Avoid paralleling L1 (power lead) and L2 (return lead) to load power solenoids, contactors, and control circuits. If an application uses L1 (power lead) to switch a load, L2 (return lead) has the same switched signal and could couple unwanted noise into a control circuit.
- Tie all ground terminals together with one lead (usually green wire) tied to ground at one point. Don’t connect ground to the control case if the control is in a grounded enclosure (preventing ground loops).
- Do not confuse chassis grounds (safety ground) with control circuit commons or with ac supply L2 (return or neutral line). Each return system wiring must be separate. Absolutely never use chassis ground (safety) as a conductor to return circuit current.

Eliminating Noise

- Use “snubbers” (QUENCHARC™ P/N: 0804-0147-0000) to filter out noise generated by relays, relay contacts, solenoids, motors, etc. A snubber is a simple filter device using a 0.1µf, 600 volt, non-polarized capacitor in series with a 100Ω, 1/2 watt resistor. The device can be used on ac or dc circuits to effectively dampen noise at its source. Refer to output wiring in Chapter Two for proper Quencharc installation.
- The ultimate protection is an “uninterruptable” power supply. This “senses” the ac power line; when the line fluctuates, a battery powered 60Hz inverted circuit takes over, supplying power within one-half to one cycle of the ac line; very expensive.

Calibration

Before attempting to calibrate, make sure you read through the procedures carefully and have the proper equipment called for in each procedure. Make sure the DIP switches are in the proper position for the input type. See Chapter 4.

Entering the Calibration Menu

In the Calibration Menu, various input signals must be supplied for the controller to go through its auto calibration. The Calibration Menu can only be entered from the LOC Lock parameter in the Setup Menu. Press the Up-arrow/Down-arrow keys simultaneously for 3 seconds (± 1 second). The CAL Calibration Offset parameter appears in the lower display with "no" in the upper display.

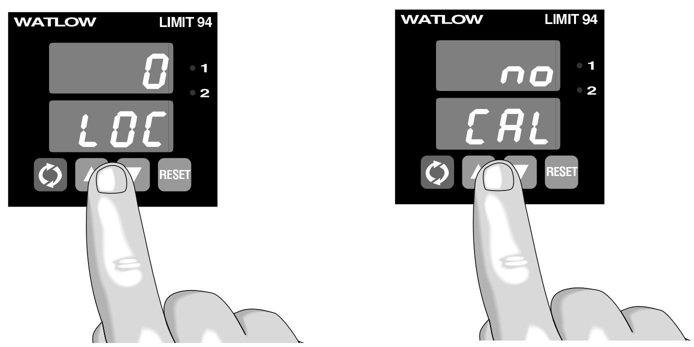


Figure A.3 - Entering the Calibration Menu.

Any inadvertent change in the displayed data, when pressing the Up-arrow/Down-arrow keys, is ignored. Calibration values won't be retained unless Output 2 indicator light is on. To turn Output 2 indicator light on, press the RESET key two times within three seconds. Press the Up-arrow or Down-arrow key to change the upper display to YES. Press Advance to enter the calibration sequence.

Upon entering the calibration menu, the upper display window indicates CAL. It continues to indicate CAL while the operator walks through the entire calibration parameter list. The controller uses the lower display to prompt the user as to what the input should be.

Once the information has been properly established and maintained for at least 5 to 10 seconds, the Advance key may then be used to display the next prompt. After the final input is established, press the Advance key twice to return the controller to the configuration menu at the top of the parameter list.

NOTE:
Calibration values will not be retained unless Output 2 indicator light is on. Do not press the RESET key twice until you are at the correct input parameters.

NOTE:
While in the Calibration Menu, the controller outputs are disabled.

Appendix

Restoring Factory Calibration

The rSt Restore Factory Calibration parameter restores the factory calibration values to the Series 94. If you calibrate your control incorrectly, you have the option to default to the original values. Once you leave the CAL menu, the values are entered.

1. Press the Up-arrow/Down-arrow keys simultaneously for three seconds. The LOC parameter appears in the lower display. Continue holding the Up-arrow/Down-arrow keys simultaneously for three seconds until the lower display reads CAL.
2. Press the Up-arrow key until YES appears in the upper display.
3. Advance through the calibration menu until rSt appears in the lower display.
4. Press the Up-arrow key until YES appears in the upper display.
5. Press the Advance key and the Series 94 advances to test the displays.

This procedure is used only to restore calibration, it does not affect Setup or Operation parameters or values.

Calibration Menu

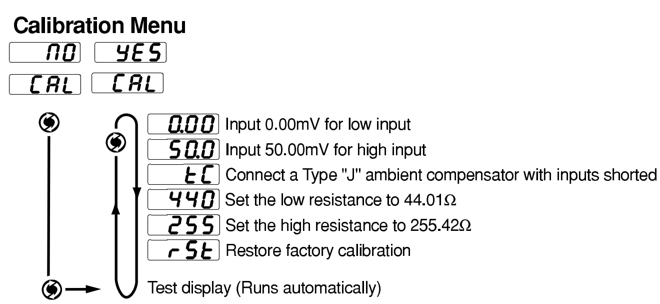


Figure A.4 - Calibration Parameters.

Before attempting to calibrate, make sure you have the proper equipment called for in each procedure.

The Series 94 is calibrated and tested before it leaves the factory.

Thermocouple Field Calibration Procedure

Equipment Required

- Type "J" Reference Compensator with reference junction at 32°F/0°C or Type "J" Thermocouple Calibrator set at 32°F/0°C.
- Precision millivolt source, 0-50mV min. range, 0.01mV resolution

NOTE:
Before calibration on an installed controller, make sure all data and parameters are documented. See the Setup and Operation Tables in Chapter Four.

Setup And Calibration

1. Connect the ac line voltage L1 and L2 to the proper terminals.
2. Connect the millivolt source to Terminal 5 Negative and Terminal 3 Positive on the Series 94 terminal strip. Use regular 20 - 24 gauge wire. Make sure the DIP switch is set for thermocouple input. See Chapter 4.
3. Apply power to the controller and allow it to warm up for 15 minutes. **After warm-up** put the controller in the Calibration Menu. Select [YES].
4. Press the Reset Key twice to turn on Output 2 indicator light. The unit is calibrating when Output 2 indicator light is on. Make sure you are in the correct parameters when Output 2 indicator light is on.
5. Press the ⊛Advance key once to get to the [0.00] prompt. At the 0.00 prompt, enter 0.00mV from the millivolt source to the Series 94. Allow at least 10 seconds to stabilize. Press the ⊛Advance key.
6. At the 50.0 prompt, enter 50.00mV from the millivolt source to the Series 94. Allow at least 10 seconds to stabilize. Press the ⊛Advance key.
7. At the [tC] prompt, disconnect the millivolt source, and connect the reference compensator or thermocouple calibrator to Terminal 5 Negative and Terminal 3 Positive on the Series 94 terminal strip. If using a compensator, turn on and short the input wires. If using "J" calibrator, set to simulate 32°F/0°C. Allow 10 seconds for the control to stabilize, then press the Reset Key twice to turn off Output 2 indicator light. The unit will leave the calibration mode if one minute passes between key activations. To conclude the thermocouple calibration, press the ⊛Advance key to the next prompt or exit the Calibration Menu.

RTD Field Calibration Procedure

Equipment Required

- 1KΩ precision decade resistance box with 0.01Ω resolution.

NOTE:
When the Output 2 indicator light is on, the controller is automatically calibrating. Your sequence is VERY important. Always move to the next parameter before changing the calibration equipment.

Setup And Calibration

1. Connect the ac line voltage L1 and L2 to the proper terminals.
2. Connect the decade resistance box to Terminal 2, 3 and 5 on the terminal strip. Use regular 20 - 24 gauge wire of the same length and type. Make sure the DIP switch is set for RTD input, see Chapter 4.
3. Apply power to the unit and allow it to warm up for 15 minutes. **After warm-up** put the controller in the Calibration Menu. Select [YES]. Press the ⊛Advance key until the [440] prompt is displayed.
4. Press the Reset Key twice to turn on Output 2 indicator light. The controller is calibrating when Output 2 indicator light is on. Make sure you are in the correct parameters when Output 2 indicator light is on.
5. At the [440] prompt, set the decade resistance box to 44.01. Allow at least 10 seconds to stabilize. Press the ⊛Advance key.
6. At the [255] prompt, set the decade resistance box to 255.42. Allow at least 10 seconds to stabilize. Press the Reset Key twice to turn off Output 2 indicator light. The unit will leave the calibration mode if one minute passes between key activations. To conclude the RTD calibration, press the ⊛Advance key to the next prompt or exit the Calibration Menu.

Notes

Glossary

A - B

alarm A signal that indicates that the process has exceeded or fallen below the alarm set point. For example, an alarm may indicate that a process is too hot or too cold.

alarm hysteresis A change in the process variable required to re-energize the alarm output.

alarm silence A feature that disables the alarm relay output.

automatic prompts Data entry points where a microprocessor-based controller asks the operator to enter a control value.

C

calibration offset An adjustment to eliminate the difference between the indicated value and the actual process value.

CE A manufacturer's mark that demonstrates compliance with European Union (EU) laws governing products sold in Europe.

CE-compliant Compliant with the essential requirements of European directives pertaining to safety and/or electromagnetic compatibility.

closed loop A control system that uses a sensor to measure a process variable and makes decisions based on that input.

cold junction See junction, cold.

cold junction compensation Electronic means to compensate for the effective temperature at the cold junction.

compensation, ambient The ability of an instrument to adjust for changes in the temperature of the environment and correct the readings. Sensors are most accurate when maintained at a constant ambient temperature. When temperature changes, output drifts.

control action The response of the control output relative to the error between the process variable and the set point. For reverse action (usually heating), as the process decreases below the set point, the output increases. For direct action (usually cooling), as the process increases above the set point, the output increases.

D - E

default parameters The programmed instructions that are permanently stored in the microprocessor software.

direct action An output control action in which an increase in the process variable causes an increase in the output. Cooling applications usually use direct action.

display capability In an instrument with digital display, the entire possible span of a particular parameter or value.

F - G

Form A A single-pole, single-throw relay that uses only the normally open (NO) and common contacts. These contacts close when the relay coil is energized. They open when power is removed from the coil.

Form C A single-pole, double-throw relay that uses the normally open (NO), normally closed (NC) and common contacts.

H

hysteresis A change in the process variable required to re-energize the control or alarm output. Sometimes called switching differential.

I

isolation Electrical separation of sensor from high voltage circuitry. Allows use of grounded or ungrounded sensing element.

J - K

junction The point where two dissimilar metal conductors join to form a thermocouple.

junction, cold Connection point between thermocouple metals and the electronic instrument. See reference junction.

junction, reference The junction in a thermocouple circuit held at a stable, known temperature (cold junction). Standard reference temperature is 32°F (0°C).

L

limit or limit control A highly reliable, discrete safety device (redundant to the primary controller) that monitors and limits the temperature of the process, or a point in the process. When temperature exceeds or falls below the limit set point, the limit controller interrupts power through the load circuit. A limit control can protect equipment and people when it is correctly installed with its own power supply, power lines, switch and sensor.

M

manual mode A selectable mode that has no automatic control aspects. The operator sets output levels.

N

NEMA 4X A NEMA specification for determining resistance to moisture infiltration and corrosion resistance. This rating certifies the controller as washable and corrosion resistant.

O

on/off A method of control that turns the output full on until set point is reached, and then off until the process error exceeds the hysteresis.

open loop A control system with no sensory feedback.

output Control signal action in response to the difference between set point and process variable.

overshoot The amount by which a process variable exceeds the set point before it stabilizes.

P - Q

parallel circuit A circuit configuration in which the same voltage is applied to all components, with current divided among the components according to their respective resistances or impedances.

parameter A variable that is given a constant value for a specific application or process.

process variable The parameter that is controlled or measured. Typical examples are temperature, relative humidity, pressure, flow, fluid level, events, etc. The high process variable is the highest value of the process range, expressed in engineering units. The low process variable is the lowest value of the process range.

programmed display data Displayed information that gives the operator the intended process information, such as intended set point, intended alarm limit, etc., corresponding to temperature.

prompt A symbol or message displayed by the controller that requests input from the user.

R

reference junction See junction.

resistance temperature detector (RTD) A sensor that uses the resistance temperature characteristic to measure temperature. There are two basic types of RTDs: the wire RTD, which is usually made of platinum, and the thermistor, which is made of a semiconductor material. The wire RTD is a positive temperature coefficient sensor only, while the thermistor can have either a negative or positive temperature coefficient.

reverse action An output control action in which an increase in the process variable causes a decrease in the output. Heating applications usually use reverse action.

RTD See resistance temperature detector.

S

set point The desired value programmed into a controller. For example, the temperature at which a system is to be maintained.

switching sensitivity In on/off control, the temperature change necessary to change the output from full on to full off. See hysteresis.

T - Z

thermal system A regulated environment that consists of a heat source, heat transfer medium or load, sensing device and a control instrument.

thermocouple (t/c) A temperature sensing device made by joining two dissimilar metals. This junction produces an electrical voltage in proportion to the difference in temperature between the hot junction (sensing junction) and the leadwire connection to the instrument (cold junction).

thermocouple break protection The ability of a control to detect a break in the thermocouple circuit and take a predetermined action.

Specifications

(2291)
Control Mode
- Microprocessor-based, user selectable control modes
- Single input, dual output
- 2.5Hz Input Sampling Rate
- 1Hz Display Update Rate
- Automatic reset on power loss

Operator Interface
- Sealed membrane front panel
- Dual, four-digit red or green displays
- Advance, Up-arrow, Down-arrow, and Reset keys
- User selectable screen display

Accuracy
- Calibration accuracy ±0.1% of span ±1°C at standard conditions
  Exceptions:
  Type T; 0.12% of span for -200°C to -50°C,
  Types R and S; 0.15% of span for 0°C to 100°C
  Types B; 0.24% of span for 870°C to 1700°C
- Accuracy span: 1000°F/540°C minimum
- Temperature stability: ±0.1 degree per degree change in ambient

Sensors/Inputs
- Thermocouple, grounded or ungrounded sensors
- RTD 2- or 3-wire, platinum, 100Ω @ 0°C calibration to 0.003850 curve or 0.003916 curve; user selectable
- Sensor break protection de-energizes control output to protect system
- °F or °C, user selectable

Input Range
Specified temperature ranges represent the controller's operational span.

• Thermocouple

Type J	32	to	1382°F
	(0	to	750°C)
Type K	-328	to	2282°F
	(-200	to	1250°C)
Type T	-328	to	662°F
	(-200	to	350°C)
Type N	32	to	2282°F
	(0	to	1250°C)
Type S	32	to	2642°F
	(0	to	1450°C)
Type B	32	to	3308°F
	(0	to	1820°C)

• RTD Resolution

1°	-328	to	1292°F
	(-200	to	700°C)
0.1°	-199.9	to	999.9°F
	(-199.9	to	700.0°C)

Output 1 (Limit)
- Electromechanical relay[1], Form C, 5A @ 120/240V~ maximum, without contact suppression, rated resistive load, 5A @ 30V⎓ (dc)[2]. Minimum contact current: 100mA @5V⎓ (dc).

Output 2 (Alarm)
- Electromechanical relay[1], Form C, 5A @ 120/240V~ maximum, without contact suppression, rated resistive load, 5A @ 30V⎓ (dc)[2]. Minimum contact current: 100mA @5V⎓ (dc).
- Switched dc signal provides a non-isolated minimum turn on voltage of 3V⎓ (dc) into a minimum 500Ω load; maximum on voltage not greater than 12V⎓ (dc) into an infinite load.
- Solid-state relay[2], Form A, 0.5A @ 24V~ min., 264V~ max., opto-isolated burst fire switched, without contact suppression. Off-state output impedance is 31MΩ.
- Alarm output can be latching or non-latching, with separate high and low values. Alarm silencing (inhibit) on power up.

Output Configurations
• Output 1
• Limit output is latching
• Output 2
User selectable as:
- Latching or non-latching
- Process alarm with flashing alarm message
- Process without alarm message
- Alarm with separate high and low set points
- Hysteresis: 1 to 9999°F, 0.1-999.9°F/1 to 5555°C, 0.1 to 555.5°C switching differential

Line Voltage/Power
- 100-240V~, +10%[3], -15%; (85-264V~) 50/60Hz, ±5%, 12VA max.
- 12-24V≂ (ac/dc), +10%, -15%; (10-26V≂ [ac/dc]) 50/60Hz, ±5%, 7 VA max.
- Data retention upon power failure via non-volatile memory

Operating Environment[3]
- 32 to 149°F (0 to 65°C)
- 0 to 90% RH, non-condensing

Storage Temperature
- -40° to 185°F (-40° to 85°C)

Terminals
- #6 compression universal head screw terminals, accepts 20-14 gauge wire
- Torque to 1.4 Nm (12 in-lb)

Controller Weight
- 0.4 lb (0.2 kg)

Shipping Weight
- 0.75 lb (0.34 kg)

Dimensions
- Compact 1⁄16 DIN size and IP65 (NEMA 4X)[4], front panel makes the Series 94 easy to apply and maintain in a wide variety of applications. Unique mounting bezel, gasket and collar make installation a snap. Use Greenlee punch 60287.

Overall Height:	55 mm	(2.1 inches)
Width:	55 mm	(2.1 inches)
Depth:	120 mm	(4.7 inches)
Bezel Height:	55 mm	(2.1 inches)
Width:	55 mm	(2.1 inches)
Depth:	15 mm	(0.6 inches)
Chassis Height:	45 mm	(1.8 inches)
Width:	45 mm	(1.8 inches)
Depth:	105 mm	(4.1 inches)

Agency Approvals
- FM3545, File #J.I.OD5A1.AF
- IP65, NEMA 4X and NEMA 12[4]
- CE approved (See Declaration of Conformity)

1 Electromechanical relays warranted for 100,000 closures only. Solid-state switching devices recommended for applications requiring fast cycle times or extended service life.
2 Switching inductive loads (relay coils, etc.) requires using an RC suppressor. Quencharc from ITW PAKTRON is recommended, Watlow part number 0804-0147-0000.
3 Operating environment is 0 to 60°C for line voltage exceeding 240V.
4 To effect IP65 (NEMA 4X) rating requires a minimum mounting panel thickness of 1.5 mm (0.06 inch) and surface finish not rougher than 812µ mm (0.32µ inch). Use Greenlee punch 60287.

Series 94 Model Number Information

Ordering Information

(2292)

94 _ _ - 1 _ _ _ - _ _ _ _

Part Number
Microprocessor-based
1/16 DIN, Single Input, Dual Output,
Four Digit Displays

IP65/NEMA 4X[1] Option
A = Without IP65 / NEMA 4X Rating
B = With IP65 / NEMA 4X Rating

CE Option
A = Without CE
B = With CE

Output 1 (Limit)
D = Electromechanical relay, Form C, 5A, without contact suppression[2, 3]

Output 2 (Alarm)
A = None
C = Switched dc output, non-isolated
D = Electromechanical relay, Form C, 5A, without contact suppression[2, 3]
K = Solid-state relay, Form A, 0.5A, without contact suppression[3]

Line Voltage/Power
0 = 100 to 240V~ nominal (high voltage)
1 = 12 to 24V≂ (ac/dc) (low voltage)

Custom Options
00 = Standard
XX = Preset parameters

Display

Upper/Lower	Upper/Lower
RR = Red/Red	AA = Red/Red (without Watlow logo)
RG = Red/Green	AB = Red/Green (without Watlow logo)
GR = Green/Red	AC = Green/Red (without Watlow logo)
GG = Green/Green	AD = Green/Green (without Watlow logo)

[1] To effect IP65 (NEMA 4X) rating requires a minimum mounting panel thickness of 1.5 mm (0.06 inch) and surface finish not rougher than 812μ mm (0.32μ inch). Use Greenlee punch 60287.

[2] Electromechanical relays warranted for 100,000 closures only. Solid-state switching devices recommended for applications requiring fast cycle times or extended service life.

[3] Switching inductive loads (relay coils, etc.) requires using an RC suppressor. Quencharc from ITW PAKTRON is recommended, Watlow part number 0804-0147-0000.

NOTE: User documentation may be available in French, German, Spanish, Italian and Dutch, as well as English. Check Watlow's website (www.watlow.com/) for availability. Specify language at time of order.

Index

Declaration of Conformity
Series 94

WATLOW Winona Inc.
1241 Bundy Boulevard
Winona, Minnesota 55987 USA

Declares that the following product: ***English***

Designation:	Series 94
Model Number(s):	9 4(A or B) (B) -1 D (A, C, D or K) (0 or 1) -(Any four letters or numbers)
Classification:	Safety Component (Temperature Limit Controller), Installation Category II, Pollution Degree 2
Rated Voltage:	100 to 240V~ or 12 to 24V≂
Rated Frequency:	50/60 Hz
Rated Power Consumption:	7VA maximum (12 to 24V≂) or 12VA maximum

Meets the essential requirements of the following European Union Directives by using the relevant standards show below to indicate compliance.

89/336/EEC Electromagnetic Compatibility Directive

EN 61326:1997 With A1:1998 – Electrical equipment for measurement, control and laboratory use – EMC requirements (Industrial Immunity, Class A Emissions).
EN 61000-4-2:1996 With A1, 1998 – Electrostatic Discharge Immunity
EN 61000-4-3:1997 – Radiated Field Immunity
EN 61000-4-4:1995 – Electrical Fast-Transient / Burst Immunity
EN 61000-4-5:1995 With A1, 1996 – Surge Immunity
EN 61000-4-6:1996 – Conducted Immunity
EN 61000-4-11:1994 Voltage Dips, Short Interruptions and Voltage Variations Immunity
EN 61000-3-2:1995 With A1-3:1999 – Harmonic Current Emissions
EN 61000-3-3:1995 With A1:1998 – Voltage Fluctuations and Flicker

73/23/EEC Low-Voltage Directive

EN 61010-1:1993 With A1:1995 Safety Requirements of electrical equipment for measurement, control and laboratory use. Part 1: General requirements

Déclare que le produit suivant: ***Français***

Désignation:	Série 94
Numéro(s) de modèle(s):	9 4 (A ou B) (B) - 1 D (A, C, D ou K) (0 ou 1) - (quatre chiffres ou lettres quelconques)
Classification:	Composant de sécurité (limiteur de température), installation catégorie II, degré de pollution 2
Tension nominale:	100 à 240 V~ ou 24 à 28 V≂
Fréquence nominale:	50/60 Hz
Consommation d'alimentation nominale:	7 VA maximum (12 à 24 V≂) ou 12 VA maximum (100 à 240 V~)

Conforme aux exigences de la (ou des) directive(s) suivante(s) de l'Union Européenne figurant aux sections correspondantes des normes et documents associés ci-dessous :

89/336/EEC Directive de compatibilité électromagnétique

EN 50082-2:	**1995**	**Norme générique d'insensibilité électromagnétique, Partie 2: Environnement industriel**
EN 61000-4-2:	1995	Décharge électrostatique
EN 61000-4-4:	1995	Courants électriques transitoires rapides
EN 61000-4-3:	1994	Insensibilité à l'énergie rayonnée
EN 61000-4-6:	1994	Insensibilité à l'énergie par conduction
ENV 50204:	1995	Téléphone cellulaire
EN 50081-2:	**1994**	**Norme générique sur les émissions électromagnétiques, Partie 2: Environnement industriel**
EN 55011:	1991	Limites et méthodes de mesure des caractéristiques d'interférences du matériel radiofréquence industriel, scientifique et médical (Groupe 1, Classe A)
EN 61000-3-2:	1995	Limites d'émissions d'harmoniques
EN 61000-3-3:	1995	Limites de fluctuations et de vacillement du courant

73/23/EEC Directive liée aux basses tensions

EN 61010-1:	**1993**	**Exigences de sécurité pour le matériel électrique de mesure, de commande et de laboratoire, Partie 1: Exigences générales**

(2293)

Erklärt, daß das folgende Produkt: ***Deutsch***

Beschreibung:	Serie 94
Modellnummer(n):	9 4(A oder B) (B) -1 D (A, C, D oder K) (0 oder 1) -(4 beliebige Buchstaben oder Ziffern)
Klassifikation:	Sicherheitskomponente (Temperaturregelsystem), Installationskategorie II, Emissionsgrad 2
Nennspannung:	100 bis 240 V~ oder 12 bis 24 V≂
Nennfrequenz:	50/60 Hz
Nominaler Stromverbrauch:	Max. 7 VA (12 bis 24 V≂) oder max. 12 VA (100 bis 240 V~)

Erfüllt die wichtigsten Normen der folgenden Anweisung(en) der Europäischen Union unter Verwendung des wichtigsten Abschnitts bzw. der wichtigsten Abschnitte die unten zur Befolgung aufgezeigt werden.

89/336/EEC Elektromagnetische Kompatibilitätsrichtlinie

EN 61326:1997 mit A1:1998 – Elektrisches Gerät für Messung, Kontrolle und Laborgebrauch – EMV-Anforderungen (Störfestigkeit Industriebereich, Klasse A Emissionen)
EN 61000-4-2:1996 mit A1, 1998 – Störfestigkeit gegen elektronische Entladung
EN 61000-4-3:1997 – Störfestigkeit gegen Strahlungsfelder
EN 61000-4-4:1995 – Störfestigkeit gegen schnelle Stöße/Burst
EN 61000-4-5:1995 mit A1, 1996 – Störfestigkeit gegen Überspannung
EN 61000-4-6:1996 – Geleitete Störfestigkeit
EN 61000-4-11:1994 Störfestigkeit gegen Spannungsabfall, kurze Unterbrechungen und Spannungsschwankungen
EN 61000-3-2:1995 mit A1-3:1999 – Harmonische Stromemissionen
EN 61000-3-3:1995 mit A1:1998 – Spannungsfluktationen und Flimmern
EN 61000-3-3: 1995 Grenzen der Spannungsschwankungen und Flimmern

73/23/EEC Niederspannungsrichtlinie

EN 61010-1:1993 mit A1:1995 Sicherheitsanforderungen für elektrische Geräte für Messungen, Kontrolle und Laborgebrauch. Teil 1: Allgemeine Anforderungen

Declara que el producto siguiente: ***Español***

Designación:	Serie 94
Números de modelo:	9 4 (A o B)(B) - 1 D(A, C, D o K)(0 ó 1) - (Cualquier combinación de cuatro números y letras)
Clasificación:	Componente de seguridad (Controlador de límite de temperatura), categoría de instalación II, grado de contaminación ambiental 2
Tensión nominal:	100 a 240V~ o 12 a 24 V≂
Frecuencia nominal:	50/60 Hz
Consumo nominal de energía:	7 VA máximo (12 a 24 V≂) o 12 VA máximo (100 a 240 V~)

Cumple con los requisitos esenciales de las siguientes Directrices de la Unión Europea mediante el uso de las normas aplicables que se muestran a continuación para indicar su conformidad.

89/336/EEC Directriz de compatibilidad electromagnética

EN 61326:1997 CON A1:1998.– Equipo eléctrico para medición, control y uso en laboratorio – Requisitos EMC (Inmunidad industrial, Emisiones Clase A).
EN 61000-4-2:1996 con A1, 1988 – Inmunidad a descarga electrostática
EN 61000-4-3:1997 – Inmunidad a campo radiado
EN 61000-4-4:1995 – Inmunidad a incremento repentino/rápidas fluctuaciones eléctricas transitorias
EN 61000-4-5:1995 con A1, 1996 – Inmunidad a picos de voltaje o corriente
EN 61000-4-6:1996 – Inmunidad por conducción
EN 61000-4-11:1994 Inmunidad a caídas de voltaje, variaciones y pequeñas interrupciones de voltaje
EN 61000-3-2:1995 con A1-3:1999 – Emisiones de corriente armónica
EN 61000-3-3:1995 con A1:1998 – Fluctuaciones de voltaje y centelleo.

73/23/EEC Directriz de bajo voltaje

EN 61010-1:1993 con A1:1995 Requisitos de seguridad de equipo eléctric para medición, control y uso en laboratorio. Parte 1: Requisitos generales

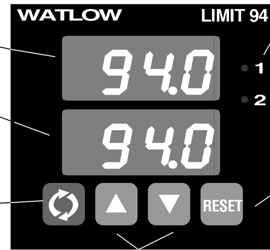
Jim Boigenzahn	Winona, Minnesota, USA
Name of Authorized Representative	Place of Issue
General Manager	August 2001
Title of Authorized Representative	Date of Issue

Signature of Authorized Representative

Appendix

Series 94 Quick Reference

Keys and Displays



Upper Display: Can indicate actual temperature, alarm low, alarm high, limit low set point value, limit high set point value, operating parameter values or an open sensor. When powering up, the upper display will be blank for five seconds.
• To set to blank: set UP to no in the Setup Menu.

Lower Display: Can indicate actual temperature, alarm low, alarm high, limit low set point value, limit high set point value, operating parameter values or an open sensor. When powering up, the lower display will be blank for five seconds.
• To set to blank: set bot to no in the Setup Menu.

Advance Key: Press to step through the Operation, Setup and Calibration Menus.

Output 1 Indicator Light: Lit when limit output is tripped.

Output 2 Indicator Light: Lit when alarm output is tripped.

RESET Key
• Press once to clear any limits or latched alarms.
• Press once to silence alarm output if silencing is enabled.
• Automatic reset on power loss.

Up-arrow and Down-arrow Keys: Increases or decreases the value of the displayed parameter.
• Press lightly to increase or decrease the value by one.
• Press and hold down to increase or decrease the displayed value at a rapid rate. New data will self-enter in five seconds, or can be entered by pressing the Advance Key.
• Press both simultaneously for three seconds to enter the Setup Menu. The LOC parameter appears.
• Continue pressing both keys for three seconds to enter the Calibration Menu.

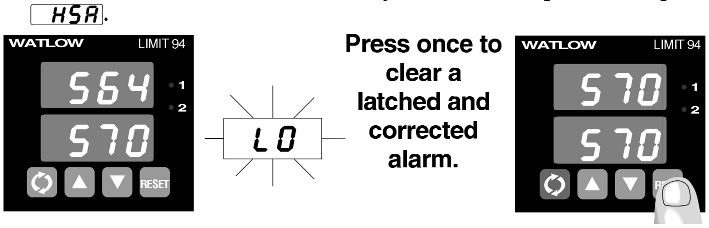
Alarms

The **process alarm** sets an absolute temperature. When the actual temperature exceeds that absolute temperature an alarm occurs. The process alarm set points may be independently set high and low. Under the Setup Menu, select the type of alarm output with the Ot2 Output 2 parameter. PrA sets a Process Alarm with alarm message displayed. Pr sets a Process alarm with no alarm message displayed.

Latching: Alarms can be latching or non-latching. When the alarm condition is removed a **non-latching alarm automatically** clears the alarm output. You must **manually clear a latching alarm** before it will disappear by pressing the Reset key.

To clear an alarm: First correct the alarm condition, then…

- **If the alarm is latching:**
  Clear it manually by pressing the Reset key once as soon as the process temperature is inside the alarm limits and satisfies the alarm hysteresis HSA.
- **If the alarm is non-latching:**
  The alarm clears itself automatically as soon as the process temperature is inside the alarm limits and satisfies the alarm hysteresis HSA.



Flashing LO or HI in the lower display indicates an alarm when Ot2 is set to PrA. The lower display alternately shows information from the current parameter and the LO or HI alarm message at one second intervals. The alarm output is de-energized and the Output 2 indicator light is lit.

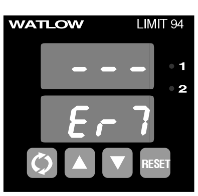
Alarm Silencing is available with the process alarm and has two uses:

When SIL is selected as "on," the controller automatically disables the alarm output on initial power up (in either the latching or non-latching mode). Alarm silencing disables the alarm output relay and the Output 2 indicator light. Once the process value crosses into the "safe" region, both a latching or a non-latching alarm is ready. Any future excursion outside of these alarm set points triggers an alarm.

When SIL is selected as "on," pressing the Reset Key will disable the alarm output relay and the indicator light once an alarm has occurred, but will not eliminate the alarm message if enabled. (If Ot2 is set to PrA.) This silences the alarm until the process returns to the "safe" region. Once within this region, the alarm is ready again. Any future excursion outside of the alarm set points triggers an alarm.

Errors

Three dashes --- in the upper display indicate a Series 94 error. The error code is visible in the lower display.



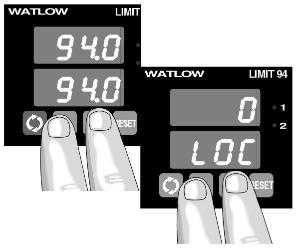
Er2 - Sensor underrange error (applies only to RTD units)
The sensor input generated a value lower than the allowable signal range, or the A/D circuitry malfunctioned. Enter a valid input. Make sure the In Input parameter (Setup Menu) and the DIP switch settings both match your sensor. Refer to the table below for the appropriate input type and range.

Er4 - Configuration error
The controller's microprocessor is faulty; call the factory.

Er5 - Non volatile checksum error
The nonvolatile memory checksum discovered a checksum error. Unless a momentary power interruption occurred while the controller was storing data, the nonvolatile memory is bad. Call the factory.

Er6 - A/D underflow error
The A/D circuit is underrange. An open or reversed polarity sensor is the most likely cause. Check the sensor; if the connection is good and functions properly, call the factory. The A/D underrange voltage is too low to convert an A/D signal. Make sure the In Input parameter (Setup Menu) matches your sensor and DIP switches are set accordingly.

Er7 - A/D overflow error
The A/D circuit is overrange. An open or reversed polarity sensor is the most likely cause. Check the sensor; if the connection is good, and the sensor functions properly, call the factory. The A/D overrange voltage is too high to convert an A/D signal. Make sure the In Input parameter (Setup Menu) matches your sensor and DIP switches are set accordingly.



Setup Menu

Enter the Setup Menu by pressing the Up-arrow and Down-arrow keys simultaneously for three seconds. The lower display shows the LOC Lock parameter, and the upper display shows its current level. All keys are inactive until you release both keys. You can reach the LOC Lock parameter from anywhere. Use the Advance key to move through the menus and the Up-arrow and Down-arrow keys to select data. You will not see all parameters in this menu, depending on the controller's configuration and model number.

Parameter	Value	Range	Factory Default	Appears If:
LOC		0 - 3	0	
In		J, H (K), t, n, S, b, rtd, rt.d	J	DIP switch selectable.
C_F		C or F	F	LOC is set to 0
rL		rL to rh	Input dependent.	LOC is set to 0
rh		rh to rL	Input dependent.	LOC is set to 0
Ot 1		H I, LO, H_L	H_L	LOC is set to 0
HSL		1 - 9999, 0.1 - 999.9°F 1 to 5555, 0.1 to 555.5°C	3, 0.3°F 2, 0.2°C	LOC is set to 0
Ot2		PrA = Process Alarm Pr = Process with no alarm message no = None	no	LOC is set to 0
HSA		1 - 9999, 0.1 - 999.9°F 1 - 5555, 0.1 - 555.5°C	3, 0.3°F 2, 0.2°C	Ot2 is set to Pr or PrA and LOC is set to 0
LAt		LAt or nLA	nLA	Ot2 is set to Pr or PrA and LOC is set to 0
S IL		On or OFF	OFF	Ot2 is set to Pr or PrA and LOC is set to 0
rtd		J IS or d in	d in	In is set to rtd or rt.d and LOC is set to 0
UP		no = no display shown Pro = Process LoL = Low limit set point H iL = High limit set point LoA = Alarm low set point H iA = Alarm high set point	Pro	LOC is set to 0
bot		no = no display shown Pro = Process LoL = Low limit set point H iL = High limit set point	H iL	LOC is set to 0

Setup Menu

Press Up and Down for 3 seconds

- LOC Lock
- In Input
- C_F Celsius - Fahrenheit
- rL Range Low
- rH Range High
- Ot 1 Output 1
- HSL Limit Hysteresis
- Ot2 Output 2*
- HSA Hysteresis Alarm*
- LAt Latching*
- S IL Silencing*
- rtd RTD*
- UP Upper Display
- bot Bottom Display

* These parameters may be masked or hidden, depending on the settings of your controller. For an explanation of when the parameters will appear, refer to Setup Menu table to the right.

Note:
Do not enter any values here; make photocopies instead.

Operation Menu

Operation Parameters	Value	Range	Factory Default	Appears If
LLO		rL to LH I or rH if LH I is not active	rL	Ot 1 is set to H_L or LO and LOC is not set to 3.
LH I		LLO to rH or rL if LLO is not active	rH	Ot 1 is set to H_L or H I and LOC is not set to 3.
ALO		rL to AH I or rH if AH I is not active	rL	Ot2 is set to PrA or Pr and LOC is set to 0 or 1.
AH I		ALO to rH or rL if ALO is not active	rH	Ot2 is set to PrA or Pr and LOC is set to 0 or 1.
CAL		-180°F to 180°F/-100°C to 100°C; or -18.0°F to 18.0°F/-10.0°C to 10.0°C	0	LOC is set to 0 or 1.

Operation Menu

- LLO Low Limit Set Point*
- LH I High Limit Set Point*
- ALO Alarm Low*
- AH I Alarm High*
- CAL Calibration Offset

* These parameters may be masked or hidden, depending on the settings of your controller. For an explanation of when the parameters will appear, refer to the Operation Menu table to the right.

Watlow Winona

Watlow Winona is a division of Watlow Electric Manufacturing Company, St. Louis, Missouri, a manufacturer of industrial electric heating products, since 1922. Watlow begins with a full set of specifications and completes an industrial product that is manufactured totally in-house, in the U.S.A. Watlow products include electric heaters, sensors, controls and switching devices. The Winona operation has been designing solid state electronic control devices since 1962, and has earned the reputation as an excellent supplier to original equipment manufacturers. These OEMs depend upon Watlow Winona to provide compatibly engineered controls which they can incorporate into their products with confidence. Watlow Winona resides in a 100,000 square foot marketing, engineering and manufacturing facility in Winona, Minnesota.

How to Reach Us

TOTAL
CUSTOMER
SATISFACTION
3 Year Warranty

Quality and Mission Statement:

Watlow Winona will be the world's best supplier of industrial temperature control products, services, and systems by exceeding our customers', employees', and shareholders' expectations.

Contact

Your Authorized Watlow Distributor is:

- or Phone: 507/454-5300.
- Fax: 507/452-4507.
- For technical support, ask for an Applications Engineer.
- To place an order, ask for Customer Service.
- To discuss a custom option, ask for a Series 93 Product Manager.

Warranty

The Watlow Series 94 is warranted to be free of defects in material and workmanship for 36 months after delivery to the first purchaser for use, providing that the units have not been misapplied. Since Watlow has no control over their use, and sometimes misuse, we cannot guarantee against failure. Watlow's obligations hereunder, at Watlow's option, are limited to replacement, repair or refund of purchase price, and parts which upon examination prove to be defective within the warranty period specified. This warranty does not apply to damage resulting from transportation, alteration, misuse, or abuse.

Returns

- Call or fax Customer Service for a Return Material Authorization (RMA) number before returning a controller.
- Put the RMA number on the shipping label, and also on a description of the problem.
- 20% of net price restocking charge applies to all standard units returned to stock.

NESLAB

HX Series
Recirculating Chiller
Digital Controller

Thermo NESLAB Manual P/N 002002
Rev. 05/02/01

Installation
Operation
Basic Service

Visit our Web site at:

http://www.thermoneslab.com

Product Service Information, Applications Notes, MSDS Forms, e-mail.

Voice Info: (800) 4-NESLAB

ISO 9001 REGISTERED

NESLAB

Constant Temperature Bath/Circulators
Immersion Coolers
Recirculating Chillers

HX Digital Recirculating Chiller
Installation, Operation, and Maintenance Manual

Table of Contents

SECTION VI
Special Features

SECTION VII
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Troubleshooting

SECTION IX
Diagrams

WARRANTY

Preface

Compliance

Products tested and found to be in compliance with the requirements defined in the EMC standards defined by 89/336/EEC as well as Low Voltage Directive (LVD) 73/23/EEC can be identified by the CE label on the rear of the unit. The testing has demonstrated compliance with the following directives:

LVD, 73/23/EEC	Complies with UL 3101-1:93
EMC, 89/336/EEC	EN 55011, Class A Verification EN 50082-1:1992 IEC 1000-4-2:1995 IEC 1000-4-3:1994 IEC 1000-4-4:1995

For any additional information refer to the Letter of Compliance that shipped with the unit (Declaration of Conformity).

Unpacking

Retain all cartons and packing material until the unit is operated and found to be in good condition.

If the unit shows external or internal damage, or does not operate properly, contact the transportation company and file a damage claim. Under ICC regulations, this is your responsibility.

Warranty

Units have a warranty against defective parts and workmanship for one full year from date of shipment. See back page for more details.

NES-care Extended Warranty Contract

- Extend parts and labor coverage for an additional year.
- Worry-free operation.
- Control service costs.
- Eliminate the need to generate repair orders.
- No unexpected repair costs.

Other contract options are available. Please contact Thermo NESLAB for more information.

After-sale Support

Thermo NESLAB is committed to customer service both during and after the sale. If you have questions concerning the operation of your unit or the information in this manual, contact our Sales Department. If your unit fails to operate properly or if you have questions concerning spare parts or Service Contracts, contact our Service Department.

Before calling, please refer to the serial number label on the rear of the case top to obtain the following information:

- *BOM number* ______________________

- *Serial number* ______________________

Section I Safety

Warnings

Make sure you read and understand all instructions and safety precautions listed in this manual before installing or operating your unit. If you have any questions concerning the operation of your unit or the information in this manual, contact our Sales Department for assistance (see Preface, After-sale Support).

Performance of installation, operation, or maintenance procedures other than those described in this manual may result in a hazardous situation and may void the manufacturer's warranty.

Transport the unit with care. Sudden jolts or drops can damage the refrigeration lines.

Do not attempt to defeat any of the interlock switches or safety features built into the unit.

Observe all warning labels.

Never remove warning label.

Never operate damaged or leaking equipment.

Never operate the unit without cooling fluid in the fluid reservoir.

Make sure the unit is off before connecting or disconnecting the power cord or other cables.

Always turn off the unit and disconnect the power cord from the power source before performing any service or maintenance procedures, or before moving the unit.

Always empty the fluid reservoir before moving the unit.

Never operate equipment with damaged power cords.

Refer service and repairs to a qualified Thermo NESLAB technician.

In addition to the safety warnings listed above, warnings are posted throughout the manual. These warnings are designated by an exclamation mark inside an equilateral triangle with text highlighted in bold. Read and follow these important instructions. Failure to observe these instructions can result in permanent damage to the unit, significant property damage, or personal injury or death.

Section II General Information

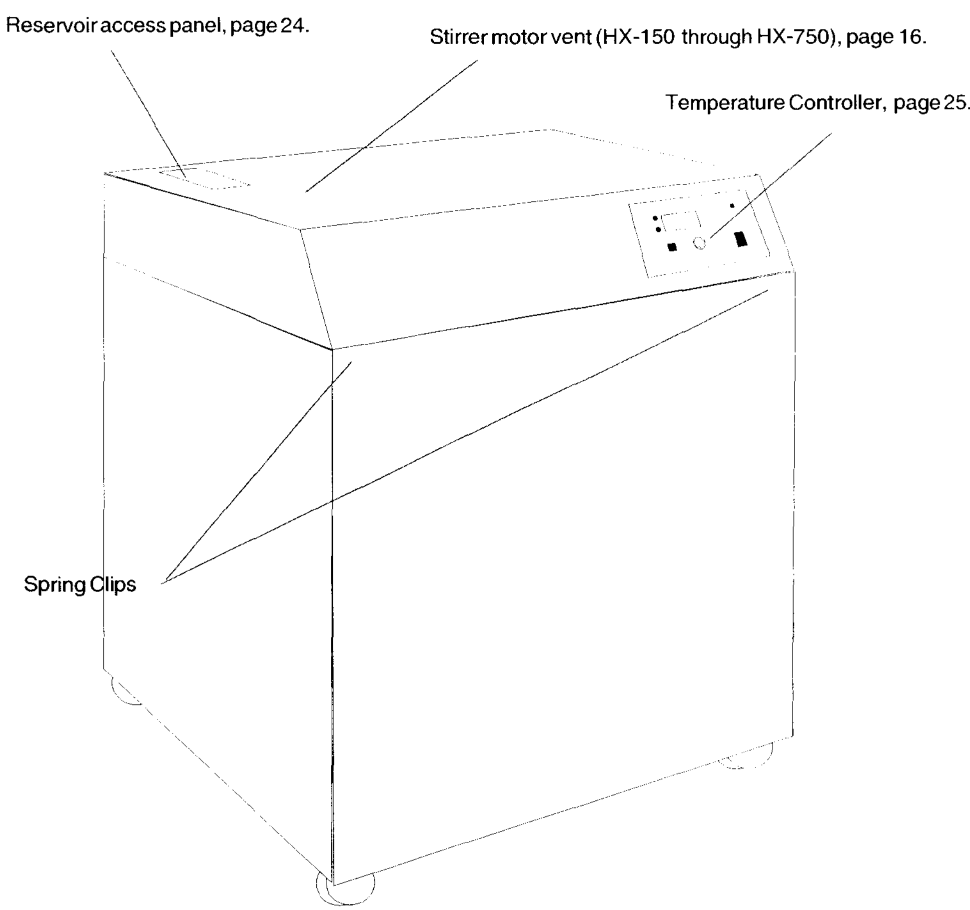
Description

The HX Series Recirculating Chiller is designed to provide a continuous flow of cooling fluid at a constant temperature and volume.

The unit consists of an air-cooled or water-cooled refrigeration system, a fluid reservoir, a fluid recirculation pump, and a digital temperature controller.

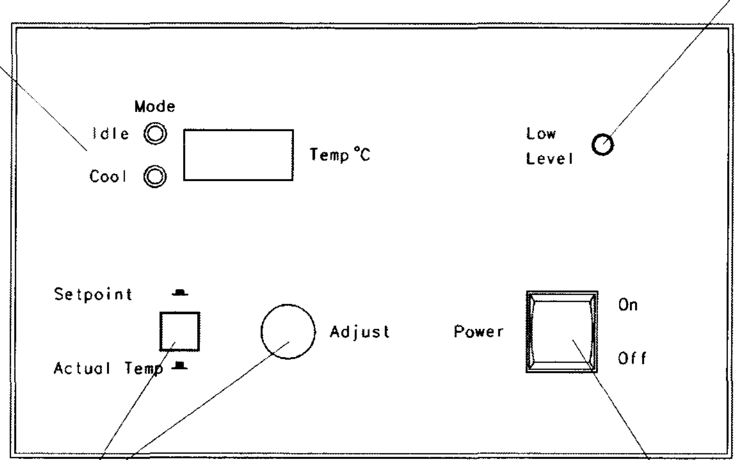
HX units are available with a large number of options. This manual explains how to install, operate, and maintain a "standard" HX unit. This manual also explains some of the available options. Supplemental manuals are supplied with units equipped with options not covered in this manual.

Throughout the manual, you will be asked to consult the unit's serial number label, or the pump identification label, or both, for specific information. The labels are located on the rear of the case top.



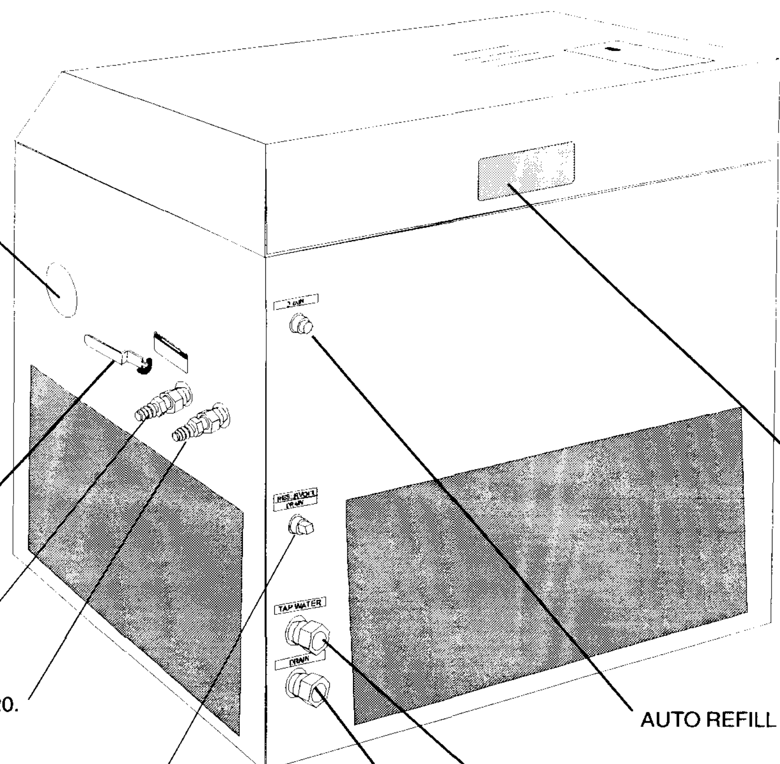
Reservoir fluid Low Level warning, page 25.

Refrigeration Status, page 25.



Setpoint display and adjust, page 26.

Unit On/Off control, page 25.



RECIRCULATING PRESSURE GAUGE, page 30.

RECIRCULATING FLOW CONTROL Handle, page 29.

SUPPLY, page 20.

RETURN, page 20.

RESERVOIR DRAIN, page 20.

Serial Number Label (Typical)

AUTO REFILL (Optional), page 36.

TAP WATER (Water-cooled units), page 21.

DRAIN (Water-cooled units), page 21.

Water-Cooled HX Series Quick Reference Operating Procedures

Installation
Position the unit in a clean environment with easy access to facility cooling water and a drain. The facility water requirements must meet those specified in the instruction or unit performance will be derated.

Ensure the voltage of the power source meets the specified voltage, ±10%.

The plumbing connections are located on the rear of the unit and are labelled TAP WATER, DRAIN, SUPPLY and RETURN. Remove the plastic protective plugs from all the plumbing connections. Connect the TAP WATER fitting to the facility cooling water and the DRAIN fitting to a drain. Connect the SUPPLY fitting to the inlet of your application and the RETURN fitting to the outlet of your application.

To fill the reservoir open the access panel on the left rear corner of the case top and remove the reservoir cover by unscrewing the thumbscrews. Fill the reservoir to within one inch of the top. If the fluid capacity of your application and recirculation lines are significant, have extra fluid on hand.

Thermo NESLAB recommends using distilled/deionized water with a 0.05 to 0.1 megohm-cm reading. If you do not have access to distilled/deionized water we recommend using filtered tap water.

Operation
Before starting the unit, double check all electrical and plumbing connections. Make sure the circulating system has been filled with cooling fluid.

Ensure the facility water is turned on.

On models HX-300 through HX-750, the unit must be connected to the power source for at least 12 hours to allow the oil to be heated and separated from the refrigerant

To start the unit, place the Power Switch to the ON position. The Cool and Idle LEDs on the front panel indicate the status of the refrigeration system. Cool is on when the unit is removing heat from the cooling fluid, Heat is on when the unit is in the hot gas bypass mode. As the operating temperature approaches the setpoint, the LEDs cycle.

When the unit is shut off, wait five minutes before restarting to allow time for the refrigeration pressures to equalize. If the pressures are not allowed to equalize, the compressor will short-cycle and no cooling will occur.

Digital Controller Temperature Adjustment
To display the temperature setpoint, press and hold the DISPLAY switch. To adjust the temperature setpoint, press and hold the DISPLAY switch and turn the ADJUST knob until the desired temperature setpoint is indicated on the digital display. Once the setpoint is adjusted, release the DISPLAY switch. The display will now indicate the temperature of the fluid in the reservoir.

Flow Control
The RECIRCULATING FLOW CONTROL handle controls the flow rate to your application. In the "+" position you receive full flow, the "-" position is no flow.

Periodic Maintenance
Periodically inspect the reservoir fluid. If cleaning is necessary, flush the reservoir with a cleaning fluid compatible with the circulating system and the cooling fluid.

The cooling fluid should be replaced periodically. When operating at low temperatures, the concentration of water in the cooling fluid will increase over time, leading to a loss of cooling capacity.

Periodic vacuuming of the condenser fins is necessary. The frequency of cleaning depends on the operating environment. We recommend avisual inspection of the condenser be made monthly after initial installation. After several months, the cleaning frequency will be established.

Units with PD and TU pumps have a strainer. If debris is in the system, the strainer will prevent the material from being drawn into the pump and damaging the pump vanes.

After initial installation, the strainer may become clogged. The strainer must be cleaned after the first week of installation. After this first cleaning, a monthly visual inspection is recommended. After several months, the frequency of cleaning will be established.

Before cleaning the strainer, disconnect the power cord from the power source and drain the reservoir.

For complete information, including troubleshooting procedures, please refer to this instruction manual.

Air-Cooled HX Series Quick Reference Operating Procedures

Installation

Position the unit so the intake and discharge are not impeded. Inadequate ventilation will cause a reduction in cooling capacity and, in extreme cases, compressor failure.

Avoid excessively dusty areas and institute a periodic cleaning schedule. For proper operation, the unit needs to pull substantial amounts of air through a condenser. A build up of dust or debris on the fins of the condenser will lead to a loss of cooling capacity.

The unit will retain its full rated capacity in ambient temperatures up to approximately +24°C.

Ensure the voltage of the power source meets the specified voltage, ±10%.

The plumbing connections are located on the rear of the unit and are labelled SUPPLY and RETURN. Remove the plastic protective plugs from both plumbing connections. Connect the SUPPLY fitting to the inlet of your application. Connect the RETURN fitting to the outlet of your application.

To fill the reservoir open the access panel on the left rear corner of the case top and remove the reservoir cover by unscrewing the thumbscrews. Fill the reservoir to within one inch of the top. If the fluid capacity of your application and recirculation lines are significant, have extra fluid on hand.

Thermo NESLAB recommends using distilled/ deionized water with a 0.05 to 0.1 megohm-cm reading. If you do not have access to distilled/ deionized water we recommend using filtered tap water.

Operation

Before starting the unit, double check all electrical and plumbing connections. Make sure the circulating system has been filled with cooling fluid.

On models HX-300 through HX-750, the unit must be connected to the power source for at least 12 hours to allow the oil to be heated and separated from the refrigerant

To start the unit, place the Power Switch to the ON position. The Cool and Idle LEDs on the front panel indicate the status of the refrigeration system. Cool is on when the unit is removing heat from the cooling fluid, Heat is on when the unit is in the hot gas bypass mode. As the operating temperature approaches the setpoint, the LEDs cycle.

When the unit is shut off, wait five minutes before restarting to allow time for the refrigeration pressures to equalize. If the pressures are not allowed to equalize, the compressor will short-cycle and no cooling will occur.

Digital Controller Temperature Adjustment

To display the temperature setpoint, press and hold the DISPLAY switch. To adjust the temperature setpoint, press and hold the DISPLAY switch and turn the ADJUST knob until the desired temperature setpoint is indicated on the digital display. Once the setpoint is adjusted, release the DISPLAY switch. The display will now indicate the temperature of the fluid in the reservoir.

Flow Control

The RECIRCULATING FLOW CONTROL handle controls the flow rate to your application. In the "+" position you receive full flow, the "-" position is no flow.

Periodic Maintenance

Periodically inspect the reservoir fluid. If cleaning is necessary, flush the reservoir with a cleaning fluid compatible with the circulating system and the cooling fluid.

The cooling fluid should be replaced periodically. When operating at low temperatures, the concentration of water in the cooling fluid will increase over time, leading to a loss of cooling capacity.

Periodic vacuuming of the condenser fins is necessary. The frequency of cleaning depends on the operating environment. We recommend a visual inspection of the condenser be made monthly after initial installation. After several months, the cleaning frequency will be established.

Units with PD and TU pumps have a strainer. If debris is in the system, the strainer will prevent the material from being drawn into the pump and damaging the pump vanes.

After initial installation, the strainer may become clogged. The strainer must be cleaned after the first week of installation. After this first cleaning, a monthly visual inspection is recommended. After several months, the frequency of cleaning will be established.

Before cleaning the strainer, disconnect the power cord from the power source and drain the reservoir.

For complete information, including troubleshooting procedures, please refer to this instruction manual.

General Information

Specifications

	HX-75	HX-150	HX-300
Temperature Range[1,2]	+5°C to +35°C		
Temperature Stability	±0.1°C		
Unit Dimensions (H x W x D)			
Inches	35 ¾ x 23 ¼ x 18 ¾	39 5/8 x 26 ¼ x 21 1/8	45 7/8 x 33 ¾ x 25 ¼
Centimeters	90.8 x 59.0 x 47.6	100.6 x 66.7 x 53.7	116.5 x 85.7 x 64.1
Reservoir Volume			
Gallons	5.0	8.0	15.0
Liters	18.9	30.3	56.8
Shipping Weight			
Pounds	261	320	477
Kilograms	118	145	216

	HX-500	HX-750
Temperature Range	+5°C to +35°C	
Temperature Stability	±0.1°C	
Unit Dimensions[3] (H x W x D)		
Inches	50 5/8 x 46 x 28 ¾	63 ¾ x 46 x 29
Centimeters	128.3 x 116.8 x 73.0	161.9 x 116.8 x 73.7
Reservoir Volume		
Gallons	28.0	40.0
Liters	106.0	151.0
Shipping Weight		
Pounds	746	971
Kilograms	338	440

1. Modified temperature ranges from -15°C to +90°C are available.
2. For additional dimensions see page 47.
3. HX-750 with a water-cooled refrigeration system has the same dimensions as the HX-500.

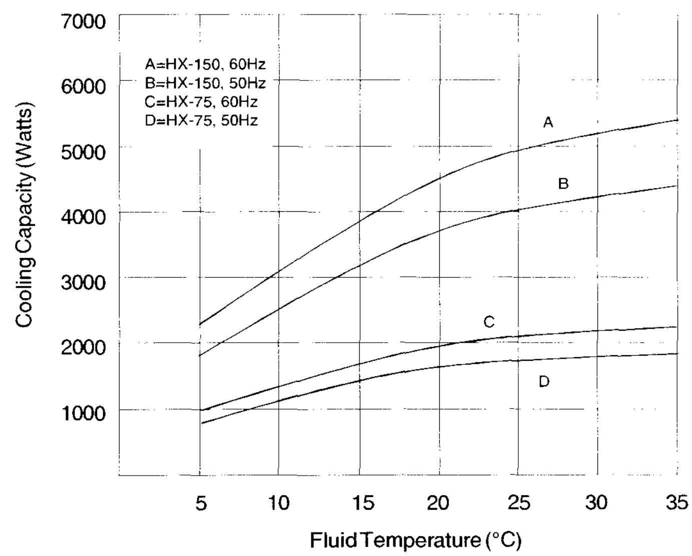
Cooling Capacity

Cooling capacity will vary depending on fluid temperature, ambient temperature, and cooling fluid.

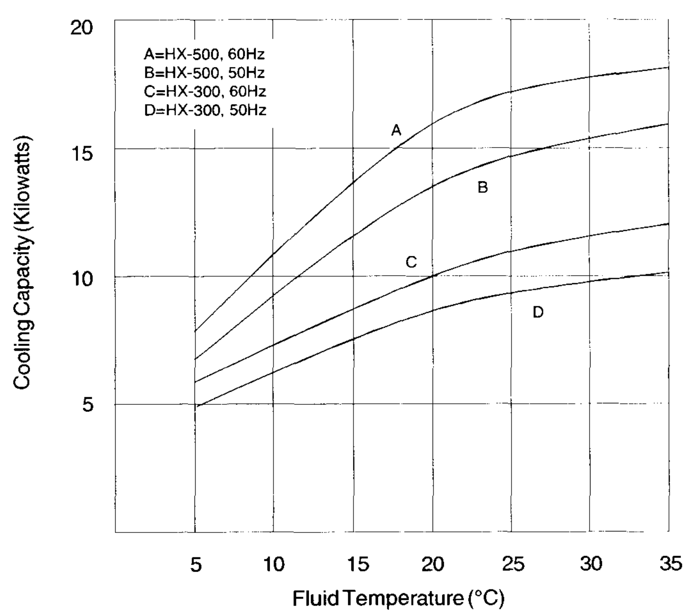
Cooling capacities were obtained under the following conditions:

1. *air-cooled unit operating at +20°C (+68°F) ambient temperature*
2. *cooling fluid with specific heat of 1.0 was used for fluid temperatures from +5°C to +35°C.*

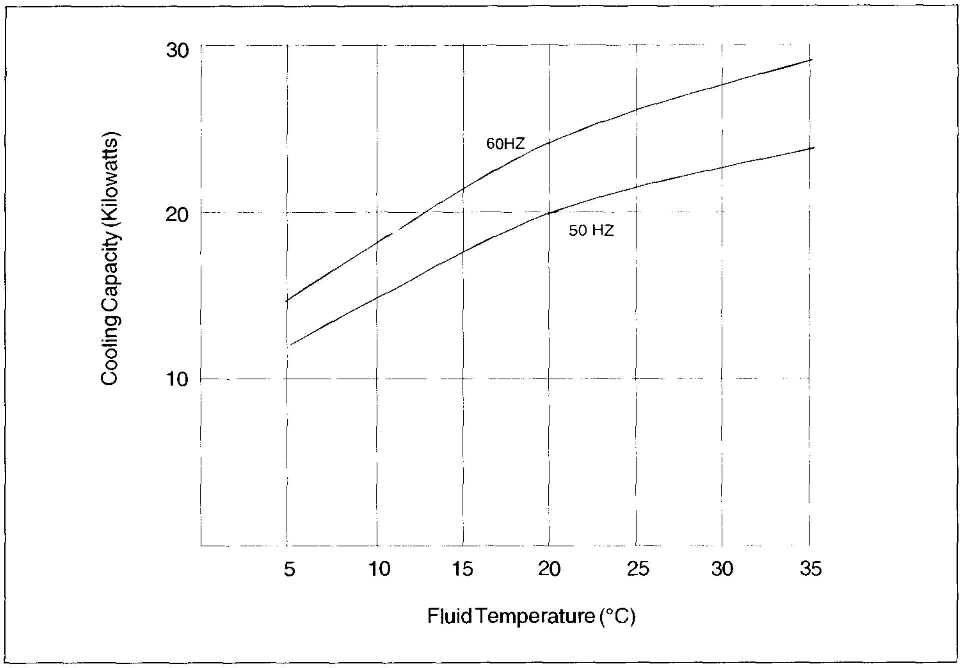
HX-75 & HX-150



HX-300 & HX-500



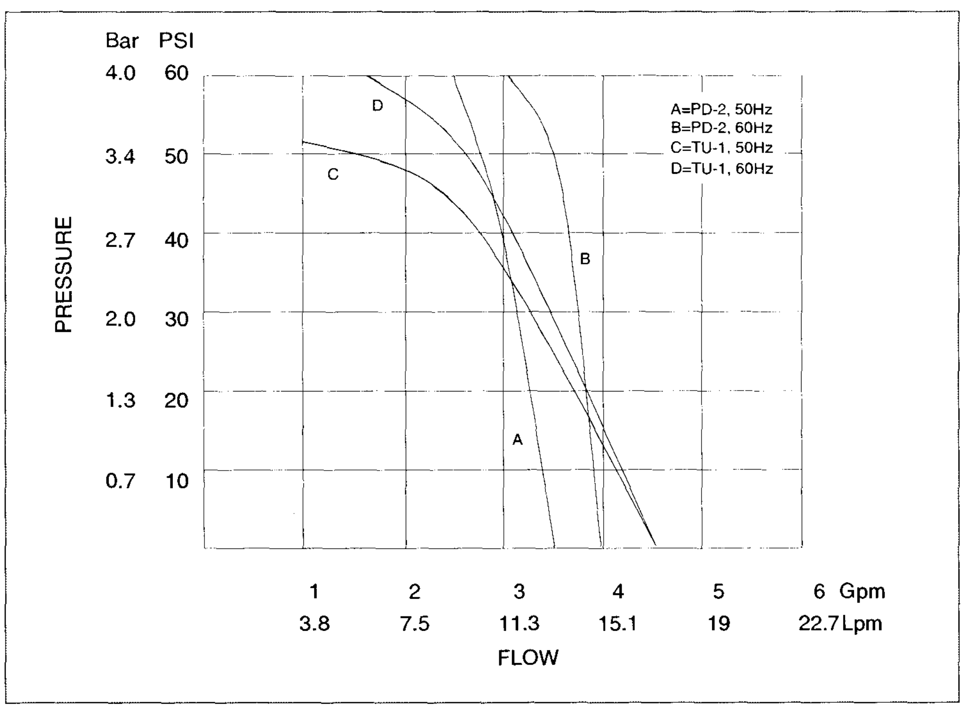
HX-750



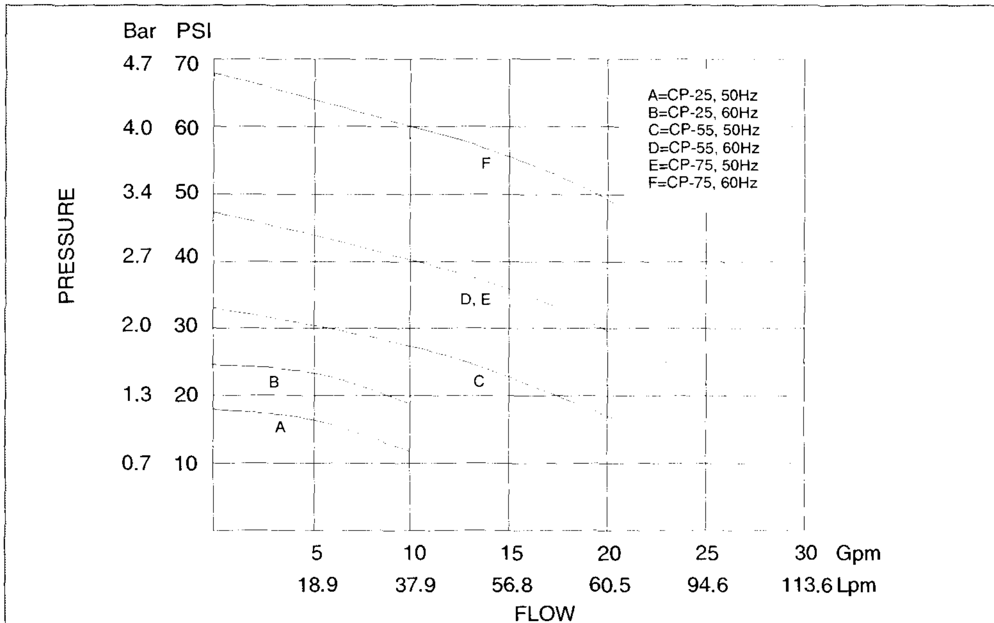
Pump Capacity

HX units are available with one of three standard pump types: positive displacement (PD), centrifugal (CP), and turbine (TU). Refer to the pump identification label on the rear of the case top to identify the specific pump in your unit.

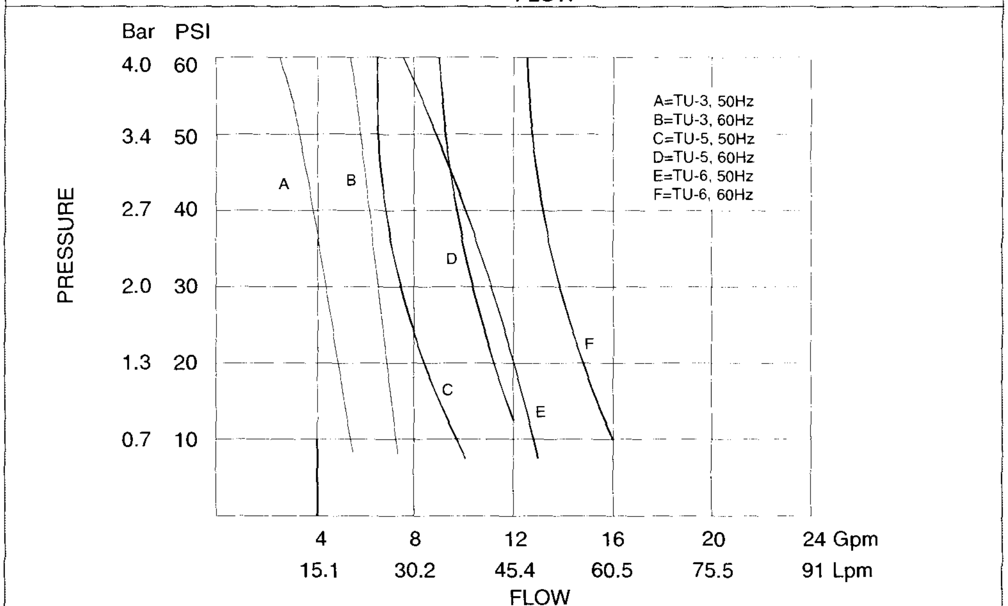
PD-2 & TU-1



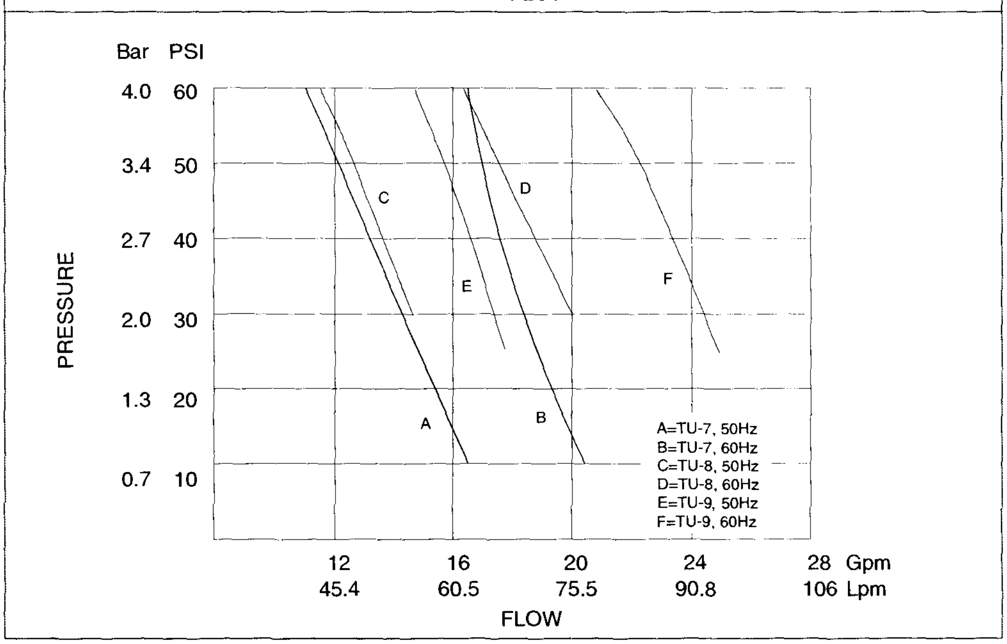
CP



TU-3, 5 & 6



TU-7, 8 & 9



Section III Installation

Site (Air-cooled Units)

The unit should be located in a laboratory or clean industrial environment where ambient temperatures are inside the range of +55°F to +95°F (+13°C to +35°C).

The unit will retain its full rated capacity in ambient temperatures to approximately +75°F (+24°C). Reduce the cooling capacity 1% for every 1°F above +75°F, to a maximum ambient temperature of +95°F. In °C, reduce the cooling capacity 1% for every 0.5°C above +24°C, to a maximum ambient temperature of +35°C.

Never place the unit in a location where excessive heat, moisture, or corrosive materials are present.

The unit has an air-cooled refrigeration system. It must be positioned so the air intake and discharge are not impeded.

On models HX-75 and HX-150, air is drawn through the left side of the unit and discharged through the right and rear. A minimum clearance of 2 feet (0.6 meter) on these three sides is necessary for adequate ventilation.

On models HX-300 through HX-750, air is drawn through the front of the unit and discharged through the side and rear. A minimum of 5 feet (1.5 meters) on all four sides of the unit is necessary for adequate ventilation.

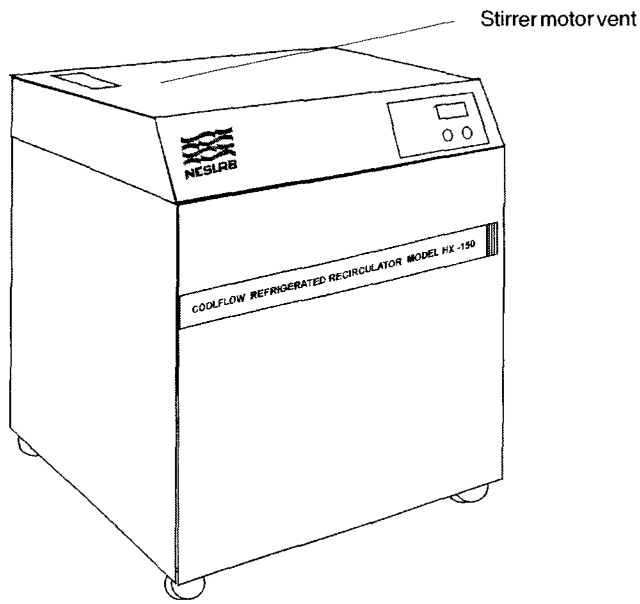
In some applications where space is at a premium, the minimum ventilation clearance can be compromised. However, consult our Sales Department before positioning the unit in a location with less minimum clearance than listed above. Inadequate ventilation will cause a reduction in cooling capacity and, in extreme cases, compressor failure.

Excessively dusty areas should be avoided and a periodic cleaning schedule should be instituted (see Section VII, Condenser Cleaning).

Avoid excessively dusty areas and institute a periodic cleaning schedule (see Section VII, Condenser Cleaning). If the compressor is allowed to overheat the unit's High Pressure Cutout (HPC) will cycle the unit on and off until cleaning is done and proper airflow is restored. This cycling will eventually damage the unit's compressor.

Models HX-150 through HX-750 have a stirrer motor located under the case top. (Models HX-500 and HX-750 have two stirrer motors.) Heat generated by the stirrer motor is discharged through vents in the case top. Do not block the vents. A minimum clearance of 2 inches (5 centimeters) is necessary for adequate ventilation.

NOTE: Units with plate heat exchangers do not have stirrer motors.



NOTE: The HX-750 380/480V model contains a three phase condenser fan motor. It is possible to connect the main power and have the motor turn in the wrong direction resulting in incorrect airflow over the condenser. Proper airflow is achieved by exchanging any two main power connectors so air is drawn into the fan.

Refer to the table below to determine the approximate amount of air intake required for the unit to retain its full rated capacity. If the air intake does not meet these standards, cooling capacity will be reduced.

Air Intake	**HX-75**	**HX-150**	**HX-300**
Cubic feet per minute	600	1050	1900
Liters per minute	17000	29730	53800

Air Intake	**HX-500**	**HX-750**
Cubic feet per minute	5000	5600
Liters per minute	141750	158800

Site (Water-cooled units)

The unit should be located in a laboratory or clean industrial environment with easy access to a facility cooling water supply and a drain.

All units are equipped with castors for easy movement. This allows the unit to be placed in a small area, as long as there is ample space for the unit to be moved for access on all four sides. A minimum access clearance of 3 feet (1 meter) on two adjacent sides is recommended.

The facility cooling water supply must meet or exceed the requirements listed in the table shown on the next page for the unit to operate at its full rated capacity. If the facility cooling water does not meet these standards, the cooling capacity will be reduced.

As the temperature of the cooling water supply increases, the required flow rate and pressure of the cooling water supply increases.

For example, with a model HX-150, if the temperature of the cooling water supply is +65°F, the flow rate must be at least 1.5 gallons per minute, with a pressure differential of at least 3.5 PSI. However, if the temperature of the cooling water supply is +85°F, the flow rate must be at least 4.0 gallons per minute, with a pressure differential of at least 10 PSI.

If the unit is being used with a building water supply, the back pressure of the drain must be less than the supply pressure.

A water regulating valve, located in the TAP WATER line, regulates the flow rate of the cooling water supply as it enters the unit. The valve regulates the flow rate based on the heat load. Flow through the unit stops automatically when the unit is shut off.

Models HX-150 through HX-750 have a stirrer motor is located under the case top. (Models HX-500 and HX-750 have two stirrer motors.) Heat generated by the stirrer motor is discharged through vents in the case top. Do not block the vents. A minimum clearance of 2 inches (5 centimeters) is necessary for adequate ventilation. See illustration on previous page.

NOTE: Units with plate heat exchangers do not have stirrer motors.

Installation

	Temperature of cooling water supply			
	+55°F (+13°C)	**+65°F (+18°C)**	**+75°F (+24°C)**	**+85°F (+29°C)**
HX-75				
Flow Rate				
Gallons per minute	0.75*	1.0	1.5	3.0
Liters per minute	2.8*	3.7	5.7	11.4
Pressure Drop				
PSI	1.5*	2.0	3.5	8.0
Bar	0.10*	0.13	0.24	0.55
HX-150				
Flow Rate				
Gallons per minute	1.0*	1.5	2.0	3.5
Liters per minute	3.8*	5.7	7.6	13.2
Pressure Drop				
PSI	2.0*	3.5	5.0	10.0
Bar	0.13*	0.24	0.34	0.69
HX-300				
Flow Rate				
Gallons per minute	2.5*	4.0	6.5	11.0
Liters per minute	9.5*	15.1	24.6	41.6
Pressure Drop				
PSI	6.0*	8.0	13.5	25.0
Bar	0.41*	0.55	0.93	1.72
HX-500				
Flow Rate				
Gallons per minute	3.5	5.0	8.0	16.0
Liters per minute	13.2	18.9	30.3	60.6
Pressure Drop				
PSI	13.0	17.0	23.0	57.0
Bar	0.89	1.17	1.58	3.93
HX-750				
Flow Rate				
Gallons per minute	6.0	8.0	12.5	16.6
Liters per minute	22.7	30.3	47.3	62.8
Pressure Drop				
PSI	14.0	20.0	28.5	40.0
Bar	0.96	1.38	1.96	2.76

*Estimated Value

Electrical Requirements

Refer to the table below to determine electrical requirements of your unit. Verify the requirements by reviewing the ratings listed on the serial number label on the rear of the case top.

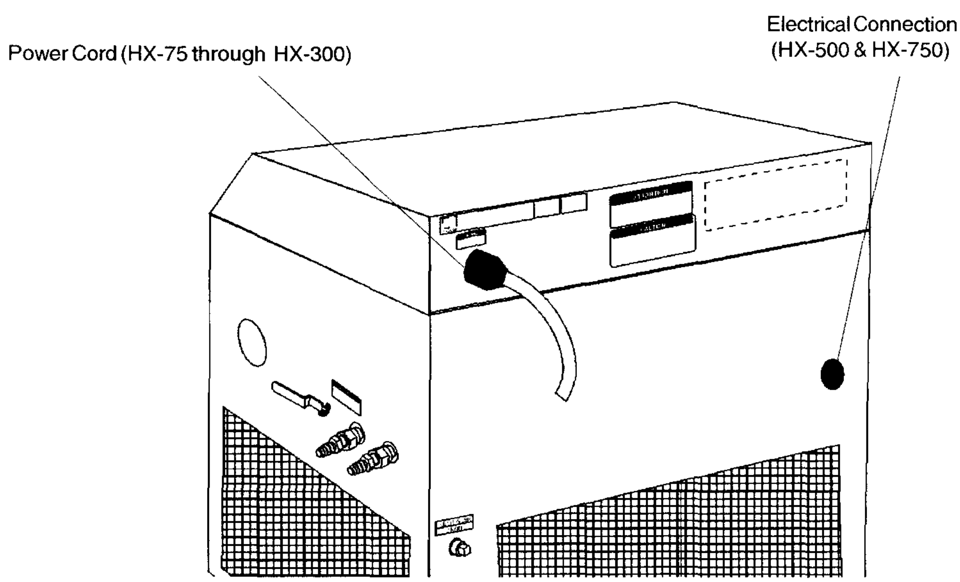
	HX-75 & HX-150		HX-300		
Volts	208-230	220-240	208-230	200-220	380-420
Hertz	60	50	60	50	50
Phase	1	1	3	3	3
Plug	NEMA L6-30P or L6-20P		NEMA L15-30P or L16-20P		

	HX-500 & HX-750	
Volts	208-230	380-420
Hertz	60	50
Phase	3	3
Plug	N/A	

Make sure the voltage of the power source agrees with the unit's voltage and frequency rating. The unit is designed to tolerate deviations of ±10% from the rated line voltage.

Models HX-75 through HX-300 have an 8 foot (2.4 meter) power cord installed on the unit at the time of shipment.

NOTE: Custom units equipped with heaters may not have a power cord. See Section VI, Special Features.



The unit construction provides extra protection against the risk of electric shock by grounding appropriate metal parts. The extra protection may not function unless the power cord is connected to a properly grounded outlet. It is the user's responsibility to assure a proper ground connection is provided.

Models HX-500 and HX-750 are not equipped with a power cable. Installation of the cable is the user's responsibility. Wire the unit in conformance to local, state, and federal electrical codes. Double check all wiring to make sure it is properly connected and protected from the elements.

Models HX-300 through HX-750 are equipped with a compressor crankcase heater. The crankcase heater warms the oil in the compressor and prevents refrigerant from mixing with the oil. Before start up, the unit must be connected to its power source for at least 12 hours. This allows time for the oil to be heated and separate from the refrigerant.

Plumbing Requirements

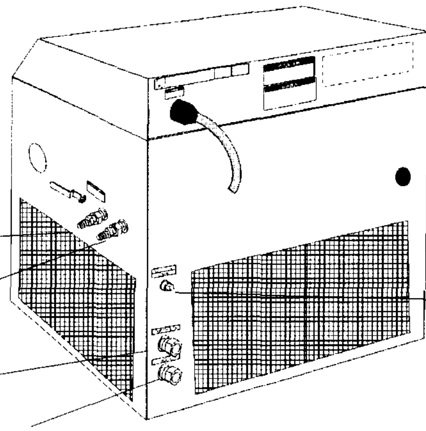
Air-cooled and water-cooled units

Before installing the unit to an instrument that previously used tap water as a cooling fluid, flush the instrument several times to remove any rust or scale that has built up. Consult the manufacturer of the instrument for a cleaning fluid recommendation.

The plumbing fittings used to connect the HX to the instrument being cooled are located on the right side of the unit (labelled SUPPLY and RETURN). These connections are ¾ inch FPT, 1 inch FPT for units with CP-75 and TU-9 pumps.

Remove the protective plugs from the SUPPLY and RETURN connections. Connect the SUPPLY fitting to the inlet of the instrument being cooled. Connect the RETURN fitting to the outlet of the instrument being cooled.

The RESERVOIR DRAIN connection on the rear of the unit is a ½ inch FPT fitting connected internally to the unit's fluid reservoir. This fitting provides a means for draining the reservoir. The unit is shipped with a ½ inch MPT plug installed in this fitting. Remove the plug to drain the reservoir.



Two plumbing adapters (¾ inch MPT x 5/8 inch hose) are included with the unit. If the unit is being plumbed to the instrument being cooled using flexible tubing, install the adapters in the SUPPLY and RETURN plumbing ports. To prevent leaking, wrap the threads of the adapters with Teflon® sealing tape before installing them in the plumbing ports. The adapters will accept ½ or 5/8 inch ID flexible tubing.

If the unit is "hard plumbed" to the instrument being cooled or to the cooling water supply, damage can occur if the unit is bumped or jolted from its site. Provisions should be made to prevent the unit from being moved after installation. Once the unit is plumbed, secure the locking castors on the unit's base. If the unit is located in a heavy traffic area where the possibility of collision is imminent, it may be necessary to secure the unit to the site using blocks or mounting brackets.

Flexible tubing, if used, should be heavy wall or reinforced construction. All tubing should be rated to withstand 110 psi at the highest operating temperatures. Make sure all tubing connections are securely clamped. Avoid running tubing near radiators, hot water pipes, etc. If substantial lengths of tubing are necessary, insulation may be required to prevent loss of cooling capacity.

Tubing and insulation are available from Thermo NESLAB. Contact our Sales Department for more information (see Preface, After-sale Support).

It is important to keep the distance between the unit and the instrument being cooled as short as possible, and to use the largest diameter tubing practical. Tubing should be straight and without bends. If diameter reductions must be made, they should be made at the inlet and outlet of the instrument being cooled, not at the HX.

If substantial lengths of connecting tubing are required, they should be pre-filled with cooling fluid before connecting them to the unit.

Installation

Water-cooled units

The plumbing connections used to connect the water-cooled condenser in the HX to the facility cooling water supply are located at the rear of the unit (labelled TAP WATER and DRAIN). On models HX-75 through HX-300, these fittings are ½ inch FPT. On models HX-500 and HX-750, these fittings are 1 inch FPT.

Remove the plastic protective plugs from the TAP WATER and DRAIN connections. Connect the TAP WATER fitting to the facility cooling water supply. Connect the DRAIN fitting to a drain.

Fluids

Never use flammable or corrosive fluids with this unit. Do not use automotive antifreeze. Commercial antifreeze contains silicates that can damage the pump seals. Use of automotive antifreeze will void the manufacturer's warranty.

Thermo NESLAB recommends using distilled/deionized water with a 0.05 to 0.1 megohm-cm reading.

Highly distilled/deionized water, above the 3 megohm-cm region, may become aggressive and is not recommended for use with units with wetted parts other than stainless steel. Distilled/deionized water in the 15 megohm-cm region is definitely aggressive and should not be used. Units operating in these regions should be closely monitored. See Water Quality Standards and Recommendations in this section.

If you do not have access to distilled/deionized water we recommend using filtered tap water. Thermo NESLAB cannot recommend any custom fluids, these fluids are too dependent on your particular application.

If your unit is equipped with a plate heat exchanger do not use 100% water as a recirculating fluid. Due to the physical nature of a plate heat exchanger, and its response to temperature changes, using 100% water may cause the plate heat exchanger to rupture.

Below +8°C, a non-freezing solution is required. A 50/50 mixture, by volume, of distilled/deionized water and laboratory grade ethylene glycol is suggested. The selected cooling fluid must have a viscosity of 50 centistokes or less.

For units with extended temperature ranges above +35°C, we recommend distilled/deionized water up to +80°C. Above +80°C, you are responsible for the fluid(s) used.

Water Quality Recommendations

Unfavorably high total ionized solids (TIS) can accelerate the rate of galvanic corrosion. These contaminants can function as electrolytes which increase the potential for galvanic cell corrosion and lead to localized corrosion such as pitting which can be observed at the studs and on the outside surface of cooling coils. Eventually, the pitting will become so extensive that the coil will leak refrigerant into the water reservoir.

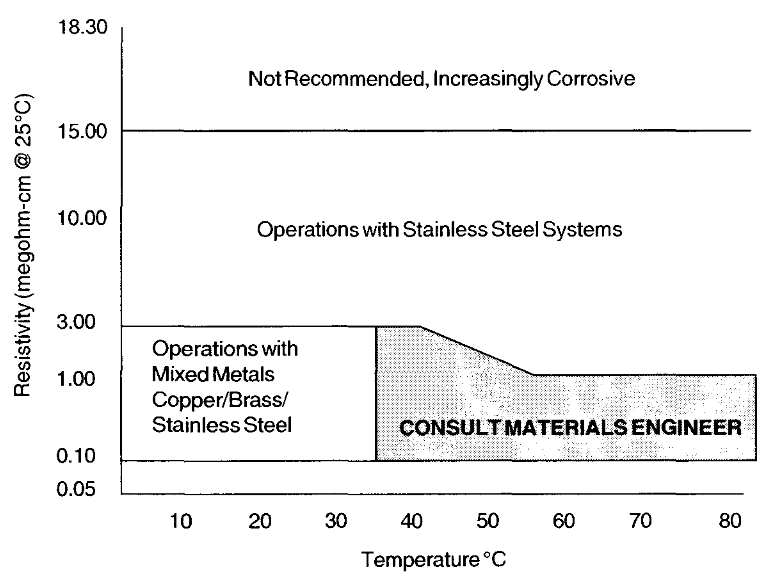
Installation

As an example, raw water in the United States averages 171 ppm (of NaCl). The recommended level for use in a water system is between 0.5 to 5.0 ppm (of NaCl).

Recommendation: Initially fill the tank with distilled/deionized water. Do not use untreated tap water as the total ionized solids level may be too high.

Maintain this water quality at a resistivity of between 1 to 10 megohm-cm (compensated to 25°C) by using a purification system. Although the initial fill may be as high as 10 megohm-cm (compensated to 25°C), the desired level for long time usage is 1 to 3 megohm-cm (compensated to 25°C).

The above two recommendations will reduce the electrolytic potential of the water and prevent or reduce the galvanic corrosion observed.



Water Quality Considerations

Installation

Filling Requirements

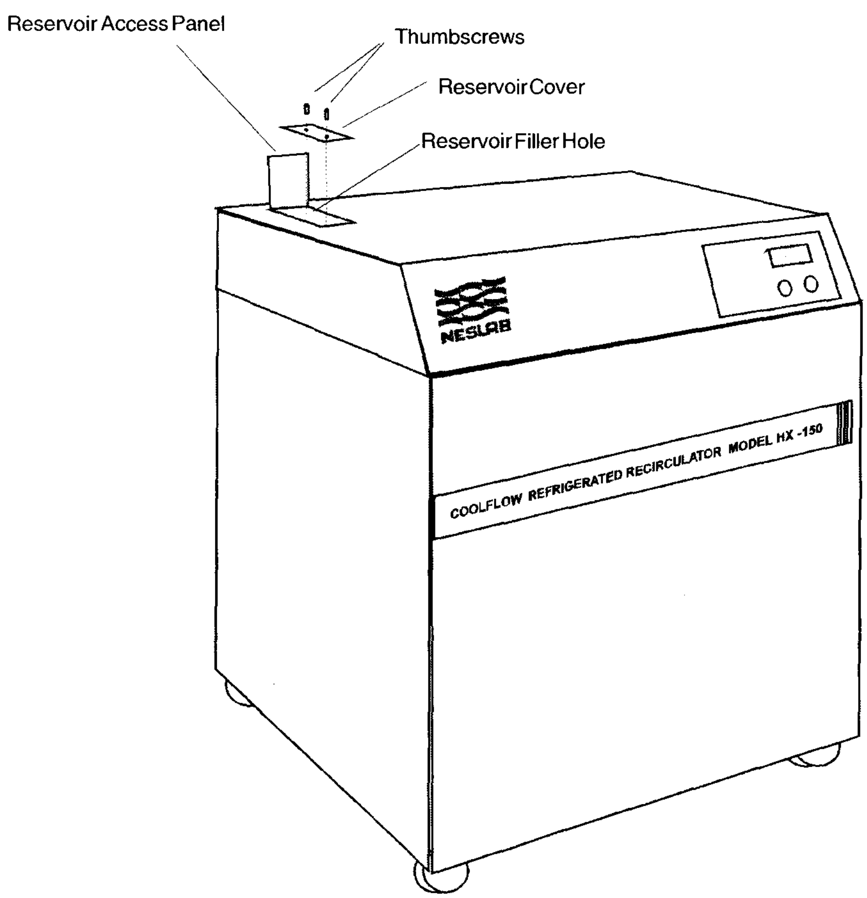
The reservoir access panel is located at the left rear corner of the case top, below an access panel. To open the access panel, slide the latch back (towards the rear of the unit) and lift.

Loosen the thumbscrews and remove the reservoir cover.

Fill the fluid reservoir with cooling fluid to within 1 inch of the top.

The fluid capacity of the instrument being cooled and the recirculation lines may be significant. To prevent the lowering of the fluid level in the reservoir below the operating level, have extra cooling fluid on hand to keep the reservoir filled to within 1 inch of the top.

When the recirculating system is full, replace the reservoir cover. Close the access panel.



Section IV Temperature Controllers

Temperature Controllers

The standard temperature controllers available with HX units are: Digital and Digital with Interlock. This section explains the controller's operation.

Refrigeration Control

On “standard” units, the refrigeration compressor runs continuously, unless the fluid temperature exceeds +40°C. However, on some “custom” units equipped with an extended temperature range, the compressor may operate at higher temperatures. A refrigerant hot gas bypass system, designed to eliminate compressor cycling and premature wear, is used to maintain constant temperature in all units.

The Idle and Cool indicators indicate the status of the refrigeration system. See next page. The Idle indicator is lit when the unit is in the hot gas bypass mode. The Cool indicator is lit when the refrigeration system is removing heat from the cooling fluid. As the fluid temperature approaches the temperature setpoint, the indicators cycle on and off to indicate the duty cycle of the system. The unit can be in Cool or Idle, but never both at the same time. A balance between Cool and Idle controls the temperature.

Start Up

Before starting, check all electrical and plumbing connections and make sure the recirculating system (the HX, your application, and the recirculation lines) has been properly filled with cooling fluid. Also, make sure the flow control valve is fully closed (see Section V, Flow Control). For CE Mark units ensure the circuit breaker on the right hand side of the unit is on.

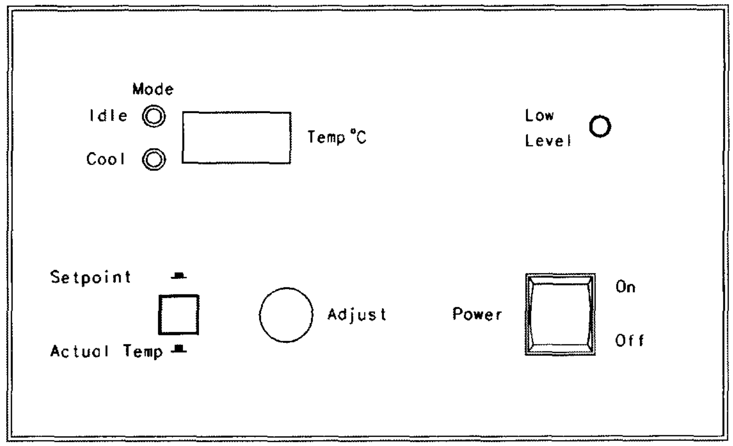
For water-cooled units — ensure that the facility water is turned on.

Models HX-300 through HX-750 are equipped with a compressor crankcase heater. The crankcase heater warms the oil in the compressor and prevents refrigerant from mixing with the oil. Before start up, the unit must be connected to its power source for at least 12 hours. This allows time for the oil to be heated and separate from the refrigerant.

To start the unit, place the Power On/Off switch in the On position. The pump and refrigeration system will start. The Temp°C display will indicate the reservoir fluid temperature. After starting recheck the fluid level, a "top off" may be needed. To shut the unit off, place the Power On/Off switch in the Off position.

When the unit is shut off, wait approximately five minutes before restarting. This allows time for the refrigeration pressures to equalize. If the pressures are not allowed to equalize, the compressor will short-cycle (clicking sound) and no cooling will occur.

Digital



Digital Temperature Controller

Temperature Adjustment

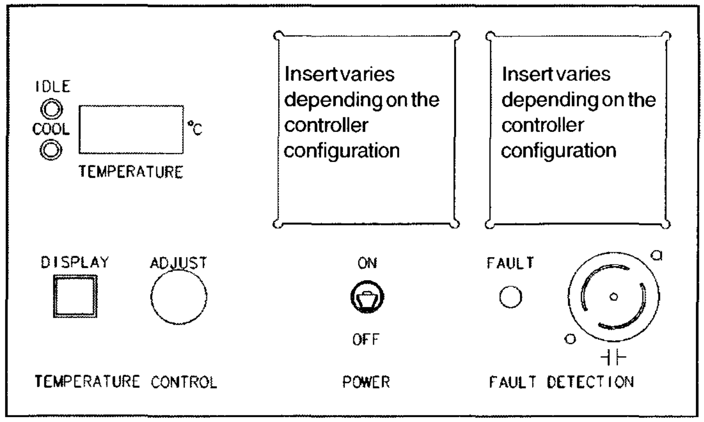
To display the temperature setpoint, press and hold the Setpoint/Actual Temp button. To adjust the setpoint, press and hold the Setpoint/Actual Temp button and turn the Adjust dial until the desired temperature setpoint is indicated on the Temp°C LED display. Once the setpoint is adjusted, release the Setpoint/Actual Temp button. The Temp°C LED display will indicate the temperature of the fluid in the reservoir.

NOTE: Inadvertent movement of the Adjust dial will result in a change in the setpoint. The change will not be immediately reflected on the Temp°C display unless the Setpoint/Actual Temp button is pressed. The display will eventually change as the unit responds to the new setpoint

Low Level Warning

The Low Level indicator is connected to a float switch in the reservoir. The indicator warns the user of a low cooling fluid level in the reservoir. A low fluid level condition occurs when the cooling fluid in the reservoir drops below the operating level. The indicator serves only as a warning. The unit will not shut down as a result of a low fluid level condition.

Digital with Interlock



Digital with Interlock Temperature Controller

Description

The Digital with Interlock temperature controller is a Digital temperature controller with up to four monitoring options: low temperature, high temperature, low fluid level, and low flow. The controller can be built with any combination of these four monitors.

Temperature Adjustment

To display the temperature setpoint, press and hold the DISPLAY button. To adjust the temperature setpoint, press and hold the DISPLAY button and turn the ADJUST dial until the desired temperature setpoint is indicated on the TEMPERATURE °C LED display. Once the setpoint is adjusted, release the DISPLAY button. The TEMPERATURE °C display will indicate the temperature of the fluid in the reservoir.

NOTE: Inadvertent movement of the ADJUST dial will result in a change in the setpoint. The change will not be immediately reflected on the TEMPERATURE °C display unless the DISPLAY button is pressed. The display will eventually change as the unit responds to the new setpoint.

Fault Response

Controllers with a START switch are configured to shut off in the event that a fault occurs. Controllers NOT equipped with a START switch will allow the unit to continue to operate if a fault occurs. This option is available for customers who are willing to accept the risk of damage to the unit in order to continue to provide cooling fluid to the instrument being cooled.

With either controller configuration, the relay contacts connected to the controller receptacle will open and the FAULT indicator will light if a fault occurs. The cause of the fault must be identified and corrected before the unit can be restarted.

START Switch

If the controller is equipped with a START switch, a fault will cause the unit to shut down. Press the START switch to restart the unit after the fault has been corrected. If the fault has not been corrected, the unit will not start and the FAULT indicator will light when the START switch is pressed.

Temperature Monitors

The optional high and low temperature monitors are connected to sensors that monitor the temperature of the cooling fluid as it exits the reservoir. The monitors protect the system from exposure to excessively hot or cold cooling fluid. A temperature fault occurs when the fluid temperature exceeds the set temperature limit.

To adjust either temperature monitor, turn the appropriate calibrated dial to the desired temperature limit.

Low Fluid Level Monitor

The low fluid level monitor is connected to a float switch in the reservoir. If the controller is equipped with a LOW LEVEL indicator, the low level monitor is not connected to the interlock circuit. The indicator will light if the reservoir cooling fluid drops below the operating level. Unit response depends on its configuration, see Fault Response on previous page.

If the controller is NOT equipped with a LOW LEVEL indicator, the low level monitor is connected to the interlock circuit. Unit response depends on its configuration, see Fault Response on previous page.

Low Flow Monitor

The optional low flow monitor is connected to a flow switch in the RETURN line. A low flow fault occurs when the flow rate of the returning cooling fluid drops below 0.3 gallons per minute (1.0 liters per minute).

When starting a unit with a controller equipped with both a low flow monitor and a START switch, the START switch must be held in the ON position until the flow switch “closes” (2 or 3 seconds). If time is not allowed for the flow switch to close, the unit will stop when the START switch is released.

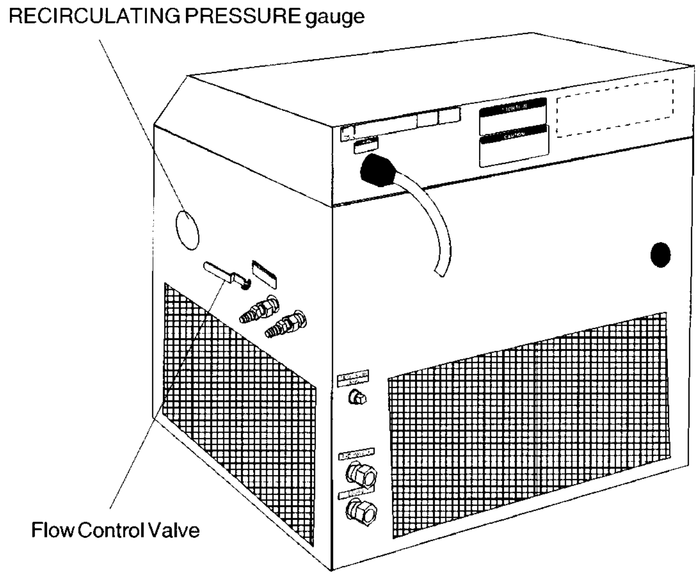
Interlock Relay Contacts

A set of contacts are connected to a receptacle on the operator panel. The contacts are rated 15A, 125V. This is not a power inlet or outlet. The receptacle is isolated from the circuitry. Its ground pin is connected to the chassis. The contacts are normally open: they are closed when the unit is running normally (no faults present), and they are open when the unit is off or when a fault occurs.

Section V Operation

Flow Control

The flow control handle is connected to a valve that controls the flow rate of the cooling fluid to the instrument being cooled. The handle is located on the right side of the unit and is labelled RECIRCULATING FLOW CONTROL.



When the handle is in the "+" position, the valve is open and all possible cooling fluid is supplied to the instrument being cooled. When the handle is in the "-" position, the valve is closed and no cooling fluid is supplied to the instrument being cooled. When the handle is between these two positions, the flow rate of the cooling fluid is between full flow and no flow. Use a flow meter on the SUPPLY line to adjust the desired flow rate.

Make sure the flow control handle is closed before starting the unit. Once the unit is running, use the handle to slowly open the valve until the desired flow rate is adjusted.

On units equipped to detect a low flow condition (Digital with Interlock temperature controllers equipped with a low flow monitor), the flow control valve must be opened slightly to allow fluid to circulate through the flow switch that monitors the flow rate. A flow rate of more than 0.3 gallons per minute (1.0 liters per minute) is necessary. If the flow is completely shut off, or if flow is not adequate, a low flow fault will occur and the unit will not start.

Never rapidly turn the valve wide open from the closed or slightly open position.

Pressure Gauge

The RECIRCULATING PRESSURE gauge is located next to the flow control handle. The gauge indicates the operating pressure of the system.

Pressure Relief Valve

(PD-2 and TU Pumps Only)

Units with a PD-2 or any TU type pump have an adjustable pressure relief valve. Refer to the pump identification label on the rear of the case top to identify the specific pump in your unit.

The pressure relief valve establishes the maximum operating pressure of the unit. If the pressure of the fluid leaving the pump exceeds the valve setting, the relief valve will bypass the fluid within the unit to relieve the pressure. The valve does not determine the actual operating pressure; the operating pressure of the system is determined by the back pressure of the connected equipment and the setting of the flow control valve. If adjustment seems necessary, consult our Service Department for assistance.

Before calling, refer to the serial number label to obtain the following:

- *unit part number*
- *unit serial number*

Operation

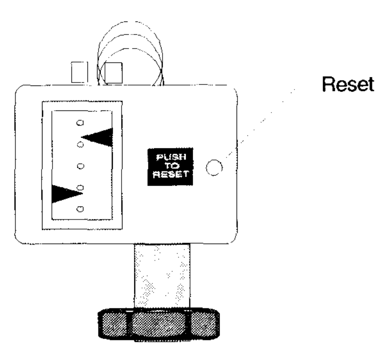
High Pressure Cutout

(Water-Cooled Units Only)

Should the unit's refrigeration discharge pressure become too high the high pressure cutout will activate and shut down the unit. High pressures can be caused by a lack of cooling water to the compressor or debris in the refrigeration lines.

Once the cause of the problem has been identified and corrected you must manually reset the cutout. The cutout location depends on the size of your unit. On the HX-75, it is normally behind the right side panel, on the HX-150 it is behind the left side panel, and on the HX-300 through HX-750 it is normally behind the rear panel.

Locate the white reset switch on the high pressure cutout. Press in on the switch until a "click" is heard. If the reset does not "click" the cutout was not activated and the unit shut down occurred for another reason.



HPC (Typical)

Section VI Special Features

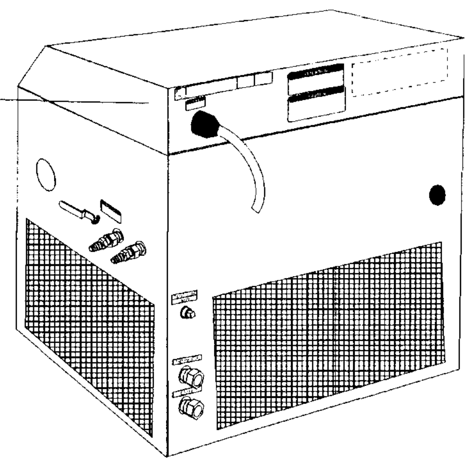
Pump Motor Overload Protector

Refer to the serial number label for the specific electrical requirements of your unit; specifically, identify the phase requirements of your unit.

The pump motor overload protector prevents the pump motor from exposure to excessive current. If an overload fault occurs, due, for example, to excessive pressure or flow, or excessive ambient temperature, the overload protector will shut off the pump motor. The overload protector will automatically reset after approximately one to two minutes.

If a fault occurs, a red lamp on the protector enclosure will light while the pump motor is off. The lamp goes out once the protector resets.

The pump motor overload protector is located under the bonnet, inside the electrical enclosure.



The unit's fault response also varies depending on the unit's configuration.

If the unit has Digital temperature controller and a single phase pump motor, the unit will continue to run if an overload fault occurs. The pump will restart as soon as the protector resets.

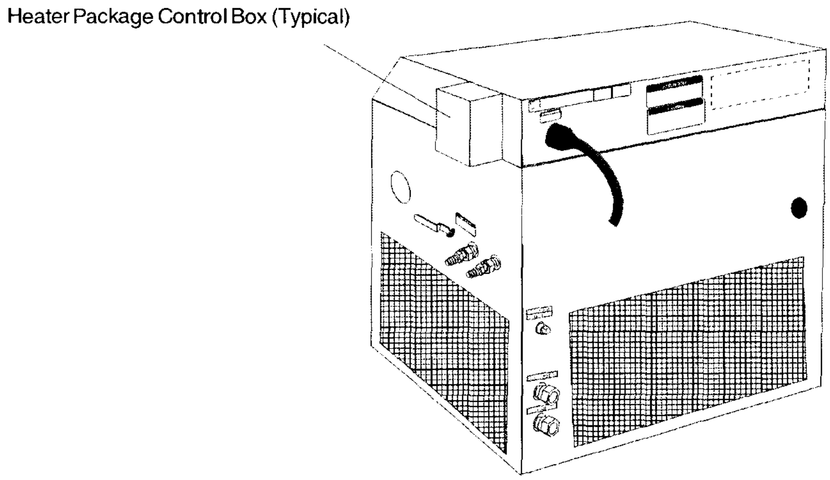
If the unit has Digital temperature controller and a three phase pump motor, the pump and refrigeration system will both shut down until the protector resets.

If the unit has a Digital with Interlock temperature controller with a low flow monitor, the unit will shut down due to a low flow fault. The unit must be manually restarted after the protector resets.

The overload protector can be adjusted to require manual resetting after an overload fault. If you are unsure of the phase of the pump motor in your unit, contact our Service Department (see Preface, After-sale Support).

Heater Package (Optional)

The heater package option consists of an immersion heater in the unit's fluid reservoir, a high temperature limit device, a solid state zero-crossing relay, a heater ENABLE/DISABLE switch and a FAULT indicator. The ENABLE/ DISABLE switch and the FAULT indicator are located on a small control box appended to the right side of the case top. The FAULT indicator will light if the high temperature limit device is tripped. The high temperature limit device will disconnect power to the heater if the heater surface temperature exceeds a preset limit.



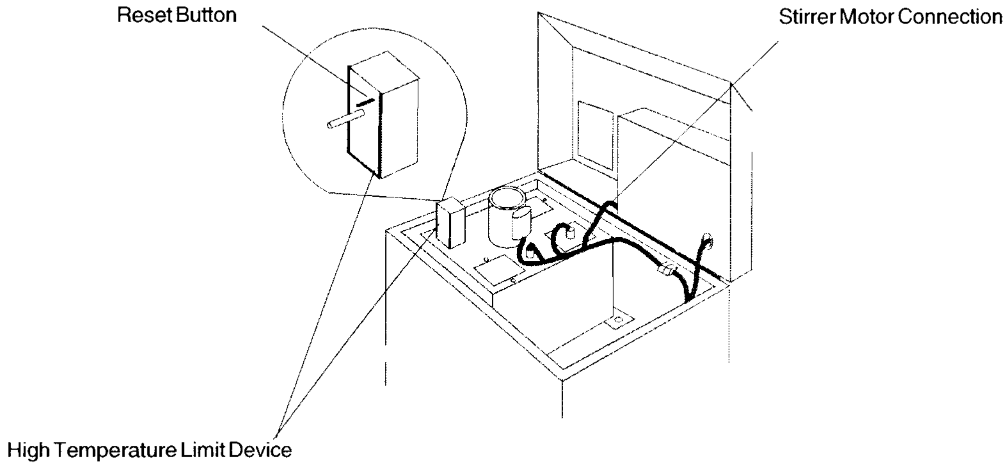
With the ENABLE/DISABLE switch set to ENABLE, the heater will cycle on and off under the control of the temperature controller. With the switch in the DISABLE position, the heater will remain off.

The heater high temperature limit device senses the surface temperature of the heater. If the heater temperature becomes too high, the limit device opens a mechanical relay to remove power from the heater.

The heater surface temperature may operate several degrees higher than the reservoir fluid. The limit device is factory set to a temperature above the upper limit of the temperature controller's range.

⚠ **For personal safety and equipment reliability, the following procedure must only be performed by a qualified technician. Contact our Service Department for assistance (see Preface, After-sale Support).**

To reset a tripped temperature limit device, lift and open the case top. The case top is secured to the unit base by a hinge between the case top and the base (along the rear of the unit), and by two spring clips located at the front corners, see page 6. To gain access to the temperature limit device, disengage the spring clips with a flat bladed screw driver and lift the front of the case top and tilt it back. A support brace, located on the right side of the inner case, will stop and support the case top.



You must identify and correct the fault before restarting the unit.

The protection device and the heater power connections are located in a small stainless steel box on top of the fluid reservoir. The protection device has a reset button and a temperature limit adjustment shaft. Press the reset button to restore operation. **NOTE:** On units without a reset button, cycle the unit's power switch.

Some units equipped with heaters do not have a power cable. Installation of the cable is your responsibility. Wire the unit in conformance to local, state and federal electrical codes. Double check all wiring to make sure it is properly connected and protected from the elements.

Special Features

The unit construction provides extra protection against the risk of electric shock by grounding appropriate metal parts. The extra protection may not function unless the power cord is connected to a properly grounded outlet. It is your responsibility to assure a proper ground connection is provided. For personal safety and equipment reliability, the following procedure should only be performed by a qualified technician.

To access the power cable connection box and install the cable:

- Lift the unit's bonnet.
- Remove the panel under the right half of the bonnet by removing the screws and the stirrer motor connection. (The stirrer motor connection is located at the lower left corner of the bonnet, see illustration above.)
- Remove the plastic plug on the rear of the bonnet. We recommend that you install an electrical conduit in place of the plastic plug.
- Insert your cable through the conduit.
- Locate the connection box and connect your cable to L1 and L2 (both connections are labeled) and to the ground stud (not labeled).
- Replace the panel and stirrer motor connection.

Remote Condenser (Optional)

Units with the optional remote air-cooled condenser are equipped with high and low refrigeration pressure monitors. The monitors are connected internally to a pressure gauge that monitors refrigeration pressure at the suction side of the compressor. The monitors protect the refrigeration system from operating under excessively high and low refrigeration pressures. A pressure fault occurs when the refrigeration pressure exceeds the set pressure limit.

The status of the monitors is indicated by the COMPRESSOR LOW PRESSURE and COMPRESSOR HIGH PRESSURE indicators located on the operator panel.

In the event of either a low or high refrigeration pressure fault, the unit will shut down. The unit must be manually restarted after the cause of the fault has been identified and corrected. If both indicators are lit simultaneously, an interruption in the main power supply has occurred.

Nitrogen Purge (Optional)

Units equipped with nitrogen purge valves are designed to accept a constant flow of dry nitrogen into the reservoir. The nitrogen blankets the cooling fluid reducing fluid evaporation.

Remove the reservoir cover by removing the screws. Fill the reservoir with fluid. Replace the reservoir cover and screws. Connect the nitrogen line to the valve on the reservoir cover.

A pressure regulator, set to 0.5 psig (0.35 kg/cm^3) or lower, should be used to prevent fluid overflow.

Particulate Filters (Optional)

Some custom units are fitted with particulate filter assemblies attached to the supply side of the recirculation water. The frequency for cleaning/ changing the filter depends on your usage. Should the unit's performance be degraded, check the filter.

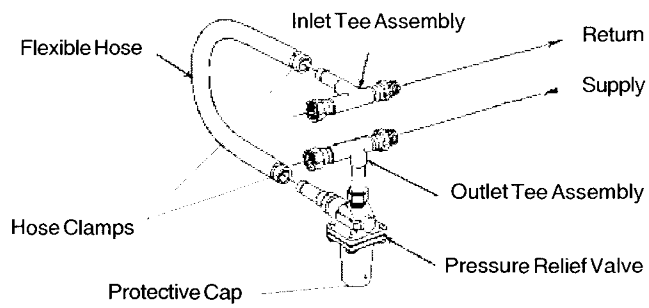
Filters are available from Thermo NESLAB, contact our Customer Service Center. Before calling refer to the serial number label on the rear of the unit to obtain the following information:

-unit serial number
-unit part number

External Pressure Reducer (Optional)

For applications requiring a maximum pressure less than 55 psi, an External Pressure Reducer (EPR) is available. An EPR allows an adjustable operating pressure of 10 to 50 psi. If the pressure of the fluid leaving the unit exceeds the valve setting the relief valve will bypass the fluid back into the unit to relieve the pressure. The pressure of the system is determined by the back pressure of the connected equipment and the flow rate of the recirculating fluid to your application.

Connect the EPR assembly as shown below. Tighten the hose clamps tight enough to prevent leakage. Do not overtighten or the clamps will "bite" into the flexible tubing and can cause excessive wear.



Connect the outlet tee assembly to the inlet of your application. Connect the inlet tee assembly to the outlet of your application.

Adjustment

When adjusting the relief valve some leaking may occur, place a container under the valve during adjustment.

Remove the protective cap and locate a threaded fitting with a slot for a large screwdriver. Hold the threaded fitting in place and loosen the lock nut on the valve body until it is almost flush with the threaded fitting. Unscrew the threaded fitting three to four turns. (If the threaded fitting unscrews completely from the valve housing, screw it back in two to three turns.)

To simulate blockage, close (or pinch off) the hose between the EPR outlet tee assembly and your application. Monitor the operating pressure of the HX unit. Turn the threaded fitting until the desired relief pressure is set (the EPR valve cannot be set lower than the total back pressure of your instrument, or flow will not be received).

Tighten the locknut to secure the position of the threaded fitting. Open the hose between the EPR outlet tee assembly and your application.

Special Features

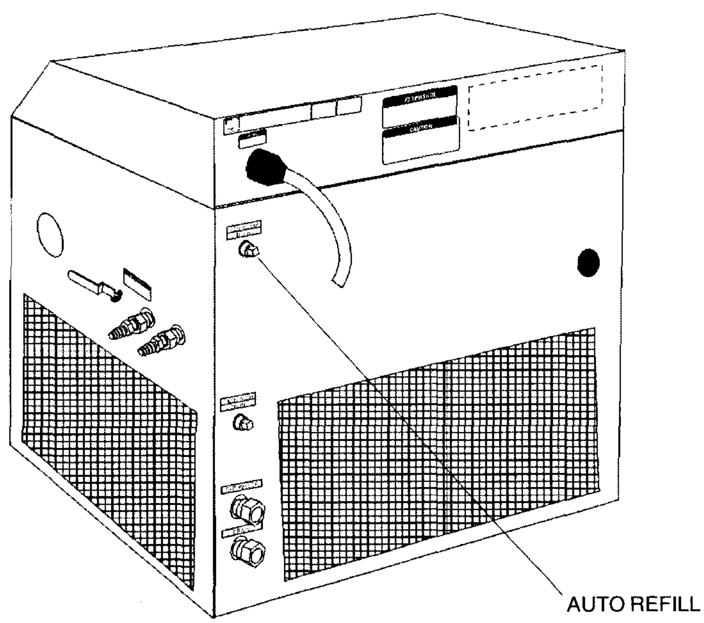
Automatic Refill Device (Optional)

The automatic refill device is designed to maintain the correct level of cooling fluid in the reservoir. The device consists of a float switch in the reservoir and a solenoid valve on top of the reservoir. If the cooling fluid level falls, the float switch will drop, opening the solenoid valve and allowing makeup fluid to fill the reservoir. Once the cooling fluid level reaches the proper level, the float switch will rise and the solenoid valve will close.

The plumbing connection for the refill device is located at the right rear corner of the unit and is labelled AUTO REFILL. This connection is a $^{3}/_{8}$ inch OD stainless steel barbed fitting.

Connect this fitting to a makeup fluid source using $^{5}/_{16}$ or $^{3}/_{8}$ inch ID flexible tubing. Make sure all tubing connections are securely clamped.

Tubing is available from Thermo NESLAB. Contact our Sales Department for more information (see Preface, After-sale Support).



Section VII Maintenance & Service

For personal safety and equipment reliability, the following procedure should only be performed by a qualified technician. Contact our Service Department for assistance (see Preface, After-sale Support).

Service Contracts

Thermo NESLAB offers on-site Service Contracts that are designed to provide extended life and minimal downtime for your unit. For more information, contact our Service Department (see Preface, After-sale Support).

Condenser Cleaning (Air-cooled units only)

For proper operation, the unit needs to pull substantial amounts of air through a finned condenser. A build up of dust or debris on the fins of the condenser will lead to a loss of cooling capacity.

If the compressor is allowed to overheat the unit's High Pressure Cutout (HPC) will cycle the unit on and off until cleaning is done and proper airflow is restored. This cycling will eventually damage the unit's compressor.

The frequency of cleaning depends on the operating environment. Thermo NESLAB recommends a monthly visual inspection of the condenser after initial installation. After several months, the cleaning frequency will be established.

For "standard" air-cooled units, periodic vacuuming of the fins on the condenser is necessary.

For units with the optional remote air-cooled condenser, remove any debris from around the condenser site. If a visible accumulation of dust or dirt is found on the condenser fins, the condenser should be cleaned with a condenser cleaning solvent and rinsed with water.

Exercise caution not to damage the condenser fins or coil. Condenser fin or coil damage can result in a loss of performance and, in extreme cases, refrigeration system failure.

Algae

To restrict the growth of algae in the fluid reservoir, it is recommended that the reservoir cover be kept in place and that all recirculation lines be opaque. This will eliminate the entrance of light which is required for the growth of most common algae.

Thermo NESLAB recommends the use of Chloramine-T, 1 gram per 3.5 liters. Other algicides can be harmful to the unit's internal components. Contact Thermo NESLAB for additional information.

Hoses

The unit's internal and external hoses and clamps should be inspected and tightened on at least a semiannual basis.

Configuration

Case Top

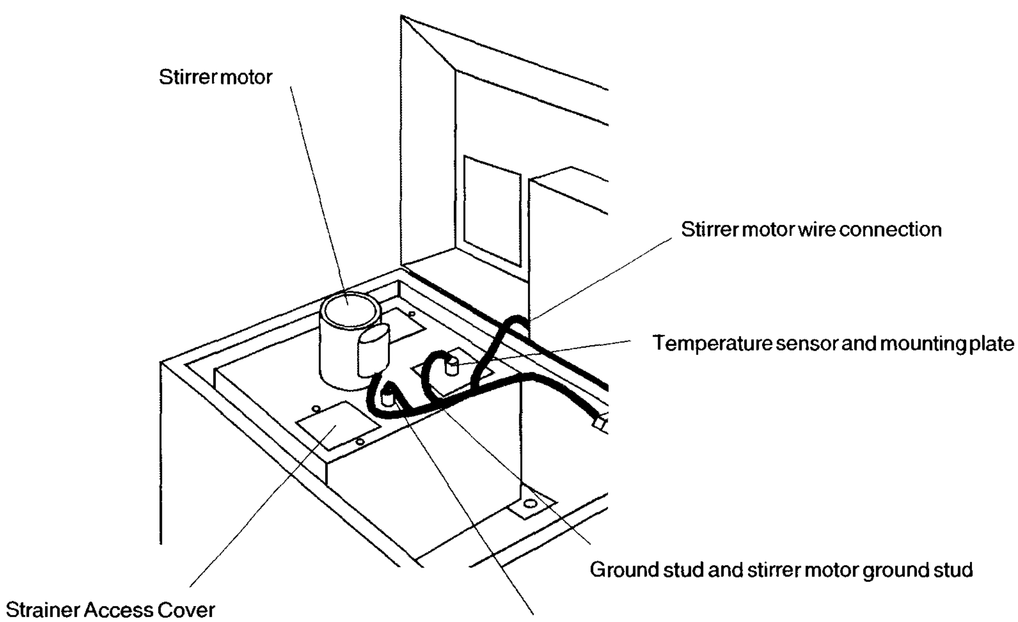
The unit has a hinged case top to allow service access. The case top is secured to the top of the unit base by a hinge between the case top and base (along the rear of the unit), and by two spring clips located at the front corners, see illustration on page 6. To gain access to the pump assembly or the reservoir area, disengage the spring clips with a flat bladed screw driver and lift the front of the top cover and tilt it back. A support brace, located on the right side of the inner base, will stop and support the case top. Ensure the spring clips engage when the top is lowered back into position.

Reservoir Cover

Access to the inside of the fluid reservoir is necessary to clean the reservoir. The figure on the next page illustrates a typical layout of the components mounted on top of the reservoir cover. The component layout varies depending on the unit size. If you are unable to identify the components on your unit's reservoir cover, contact our Service Department for assistance (see Preface, After-sale Support).

Disconnect the unit from its power source before removing the reservoir cover.

Locate the reservoir stirrer motor (units with plate heat exchangers and HX-75s do not have a stirrer motor; HX-500s and HX-750s have two stirrer motors). Disconnect the motor wires at the plug located on the side of the



Maintenance & Service

electrical box cover. Also disconnect the green ground wire that connects the ground stud on the reservoir cover to the unit's grounding bar.

Locate the float switch mounting bracket. Remove the two stainless steel screws that secure the bracket to the reservoir cover. Carefully remove the mounting bracket and place the assembly in an area adjacent to the reservoir. Make sure not to strain the connecting wires.

Locate the temperature sensor mounting plate. Remove the two stainless steel screws that secure the bracket to the reservoir. Carefully remove the sensor mounting plate with the sensor(s) attached and place the assembly in a protected area adjacent to the reservoir. Make sure not to damage the sensor(s) or strain the connecting wires.

Remove the stainless steel screws that secure the reservoir cover to the reservoir. Remove the cover and place it to one side in a manner that protects the stirrer motor blades from being bent.

Service Access Panels

Service panels on your unit allow easy access to the pump and refrigeration assemblies. Panel location varies with the size and type of unit. The panels are designed to allow removal without disconnecting the HX from the instrument being cooled.

Disconnect the unit from its power source before removing any of the access panels.

Reservoir Cleaning

Periodic reservoir cleaning is necessary. It is recommended that a visual inspection of the reservoir be made monthly after initial installation. After several months, the frequency of cleaning will be established.

Disconnect the unit from its power source and drain the reservoir before cleaning the reservoir.

Lift the top cover to access the reservoir. Remove the reservoir cover as described in Configuration.

Clean the reservoir with a cleaning fluid compatible with the recirculating system and the cooling fluid.

Do not use steel wool or other abrasive materials. They can scratch the stainless steel surface and initiate rusting.

When the reservoir is clean, reassemble the cover assembly and close the case top.

Refer to Section III, Filling Requirements for instructions on replacing the cooling fluid.

Pump Strainer

(PD and TU Pumps Only)

If debris is drawn into the recirculating system, the strainer will prevent the material from being sucked into the pump and damaging the pump vanes.

After initial installation, the strainer may become clogged with debris and scale. Therefore, the strainer must be cleaned after the first week of use. After this first cleaning, a monthly visual inspection is recommended. After several months, the cleaning frequency will be established.

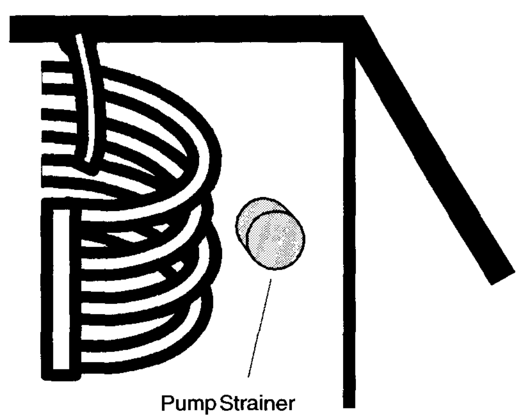
Disconnect the power cord from the power source and drain the fluid reservoir before cleaning the strainer. Do not operate the unit with the strainer removed.

PD-2 and TU Pumps

The wire mesh pump strainer is located in the reservoir on the pump suction line. Remove the strainer access panel located on top of the reservoir cover to access the strainer.

Cover the strainer with a plastic bag to help catch any debris which may become free.

Unscrew the strainer and rinse it with water. Replace the strainer. Refer to Section III, Filling Requirements for instructions on replacing fluid.



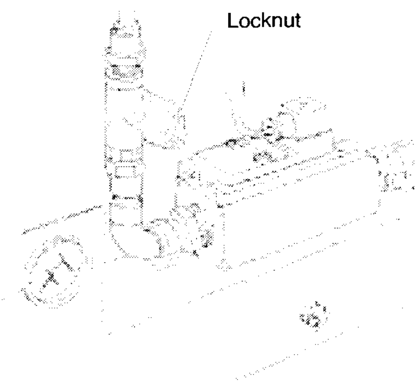
Reservoir cover deleted for clarity

Flow Filter Strainer (Optional)

Unit's equipped with flow switches have flow filter strainers located behind the top right access panel on the inlet side of the flow switch.

Unscrew the locknut and remove the screen. Clean the screen by rinsing it with water.

Replace the strainer and locknut. Refer to Section III, Filling Requirements for instructions on replacing the cooling fluid.



Phase Rotation

Refer to the serial number label on the rear of the case top for the specific electrical requirements of your unit; specifically, identify the phase requirements of your unit.

Three phase units with three phase pump motors have a phase rotation interlock. The interlock prevents the unit from starting if the phase rotation is wrong. If the unit will not start, see Section VIII, Checklist. If the options in the checklist are not applicable, the problem may be phase rotation.

Disconnect the unit from its power source, remove the rear panel and the junction box cover (if so equipped). Reverse any two line conductors on the line side of the relay.

Never remove the green ground wire.

Replace the junction box and the rear panel. Reconnect the unit to its power source. If the unit will not start, contact our Service Department.

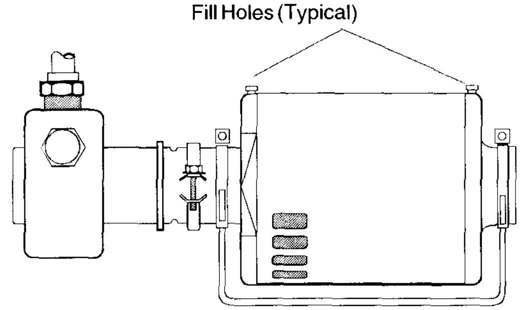
If you are unsure whether your three phase unit has a three phase pump motor, contact our Service Department (see Preface, After-sale Support).

Pump Lubrication

Units with PD-2 pumps require pump motor lubrication. Refer to the pump identification label on the rear of the case top to identify the specific pump in your unit.

Motors used to drive the pump are manufactured by several companies. These motors use sleeve type bearings with large oil reservoirs. Oiling instructions are generally posted on each motor. In the absence of instructions, add approximately 30 to 35 drops of SAE 20 non-detergent oil in each fill hole on the following schedule (SAE 20 = 142 CS viscosity):

Duty Cycle	Oiling Frequency
Continuous	Once every year
Intermittent	Once every 2 years
Occasional	Once every 5 years



Maintenance & Service

Refrigeration Data (R-22)

This information does not apply to units with remote condensers.

Air-Cooled Standard and High-Temperature Units (All Pump Types)[1]

Unit	Amount	Hot Gas Valve(psi/kPa)	Suction(psi/kPa)	Discharge(psi/kPa)	Speed Check(°F/°C per Minute)
HX-75	22 ounces/625 grams	25/172	77 - 84/530 - 580	225 - 250/1550 - 1725	2.7 - 3.1/1.5 - 1.7
HX-150	28 ounces/794 grams	25/172	70 - 73/483 - 500	240 - 270/1655 - 1860	3.6 - 4.5/2.0 - 2.5
HX-300	9 pounds/4 kilograms	25/172	84 - 105/580 - 725	270 - 305/ 1860 - 2100	4.3 - 4.92.4 - 2.7
HX-500	13.5 pounds/6.1 kilograms	25/172	80 - 90/550 - 620	215 - 235/1485 - 1620	3.6 - 4.3/2.0 - 2.4
HX-750	20 pounds/9 kilograms	40/275	65 - 75/450 - 517	185 - 215/1275 - 1480	Unspecified

Water-Cooled Standard and High-Temperature Units (All Pump Types)[2]

Unit	Amount	Hot Gas Valve (psi/kPa)	Suction(psi/kPa)	Discharge(psi/kPa)	Speed Check(°F/°C per Minute)
HX-75	20 ounces/567 grams	25/172	72/500	170/1172	2.7 - 3.1/1.5 - 1.7
HX-150	24 ounces/680 grams	25/172	65/450	175/1205	3.6 - 4.5/2.0 - 2.5
HX-300	7 pounds/3.2 kilograms	25/172	73 - 78/500 - 540	180/1240	Unspecified
HX-500	10 pounds/4.5 kilograms	40/275	75 - 82/517 - 565	180/1240	Unspecified
HX-750	18 pounds/8.2 kilograms	40/275	50 - 60/345 - 413	180/1240	Unspecified

On HX-75 and HX-150 set the high pressure control to cut out at 300 PSI, cut in at 200 PSI. For other sizes use the following:

	cut in	cut out
high pressure control	200 PSI	300 PSI
low pressure control if cut in/cut out type	35-37 PSI	3-5 PSI
low pressure control if cut in/differential	37-40 PSI	diff = 35 PSI

NOTE: For all low-temperature units please call Thermo NESLAB.

1. 27°C unit temperature, water in reservoir, access panel removed. Hot Gas setting is observed on the suction gauge when the unit is in the heat/idle cycle. Measure pressures with unit in cool cycle, as it crosses 20°C. The speed check is measured as the unit cools past 20°C, using water as a fluid, with no heat applied. Thermo NESLAB recommends a short loop of hose between the inlet and outlet fittings.

2. 25°C unit temperature, water in reservoir. Hot Gas setting is observed on the suction gauge when the unit is in the heat/idle cycle. Measure pressures with unit in cool cycle, as it crosses 25°C. The speed check is measured as the unit cools past 20°C, with no heat applied. Thermo NESLAB recommends a short loop of hose between the inlet and outlet fittings.

Section VIII Troubleshooting

Checklist

Unit will not start
For CE Mark units, check the position of the circuit breaker on the right side of the unit.

For units equipped with an EMO button, check the position of the button.

Check power source for correct voltage output. Refer to the serial number label on the rear of the unit for the specific electrical requirements of your unit. Power source must be specified voltage, ±10%.

Check house circuit breaker.

On three phase units with three phase pump motors, the phase rotation may be reversed (see Section VII, Phase Rotation).

On water-cooled units, make sure the cooling water supply is connected to the TAP WATER connection, not the DRAIN connection. Ensure the facility water is turned on.

Check the High Pressure Cutout, it may need to be reset (see Section V, Operation).

Unit will not circulate fluid
Check the tubing between the unit and your application for obstructions.

The pump strainer may require cleaning (PD and TU pumps only). Refer to the pump identification label on the rear of the case top to identify the specific pump in your unit. For instructions on cleaning the pump strainer, see Section VII, Pump Strainer.

On units with CP type pumps, if the back pressure of the instrument being cooled is greater than the maximum pressure of the pump, adequate flow may not be obtained. Check for obstructions in the tubing.

Inadequate temperature control
Make sure the installation of the unit is in compliance with the conditions described in Section III.

Make sure the heat load of the instrument being cooled is not greater than the cooling capacity of the unit.

When the unit is shut off, wait approximately five minutes before restarting. This allows time for the refrigeration pressures to equalize. If the pressures are not allowed to equalize, the compressor will short-cycle (clicking sound) and no cooling will occur.

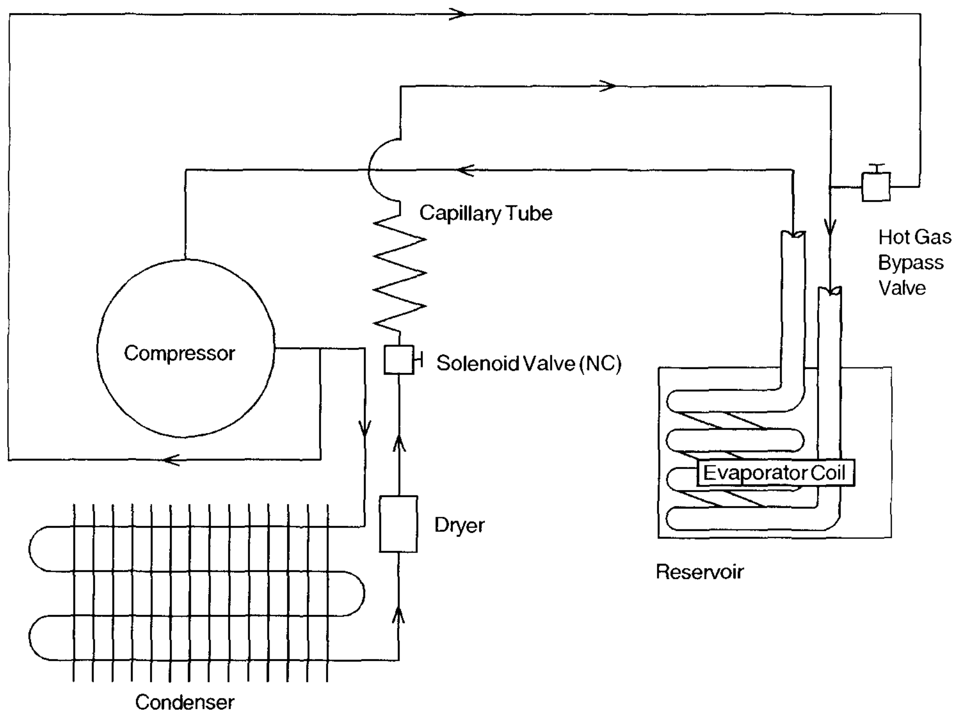
Service Assistance

If, after following these troubleshooting steps, your unit fails to operate properly, contact our Service Department for assistance (see Preface, After-sale Support). Before calling, please obtain the following information:

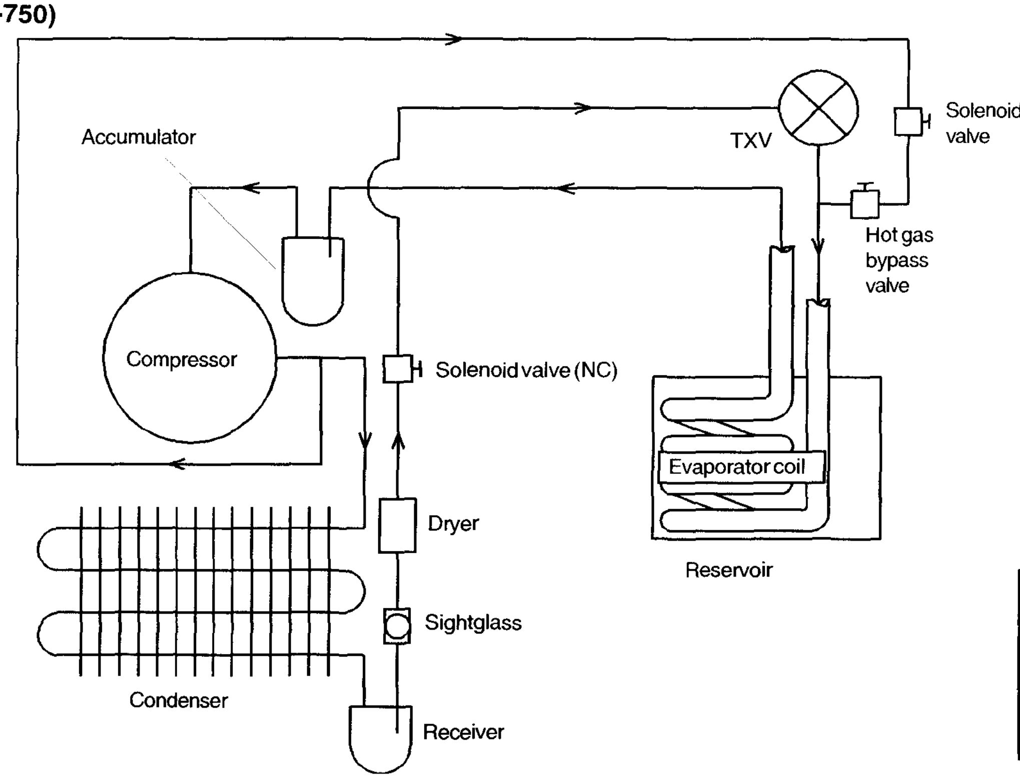
- *unit part number*
- *unit serial number*

Section IX Diagrams

Refrigeration Flow Diagram
(HX-75 and HX-150)

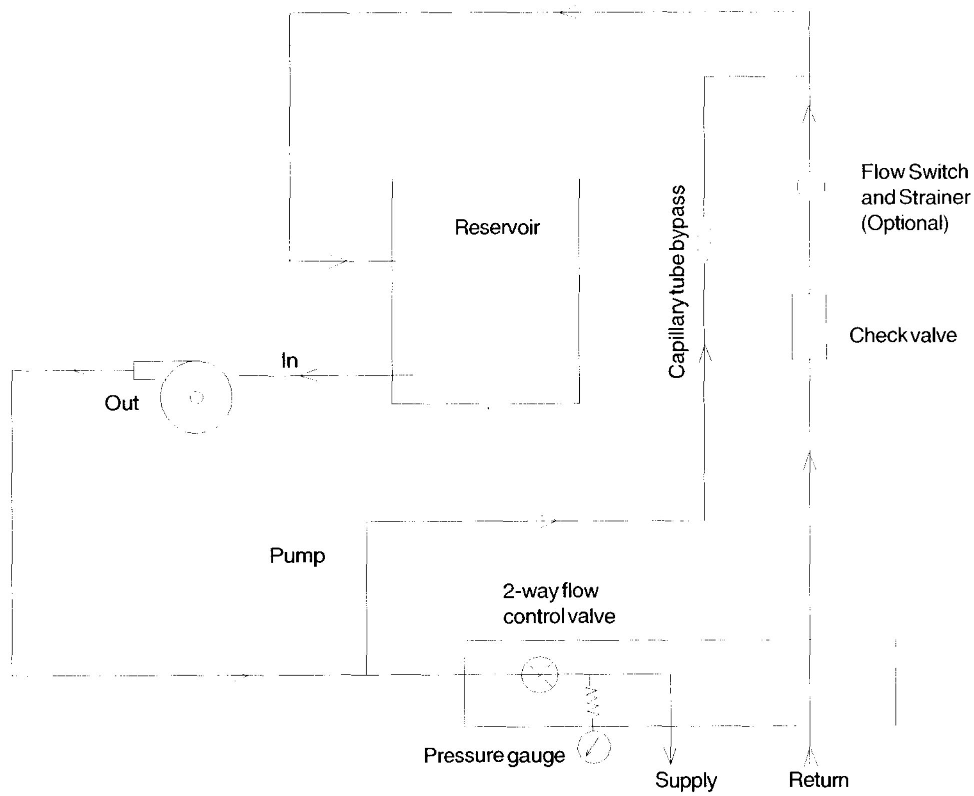


Refrigeration Flow Diagram
(HX-300 through HX-750)

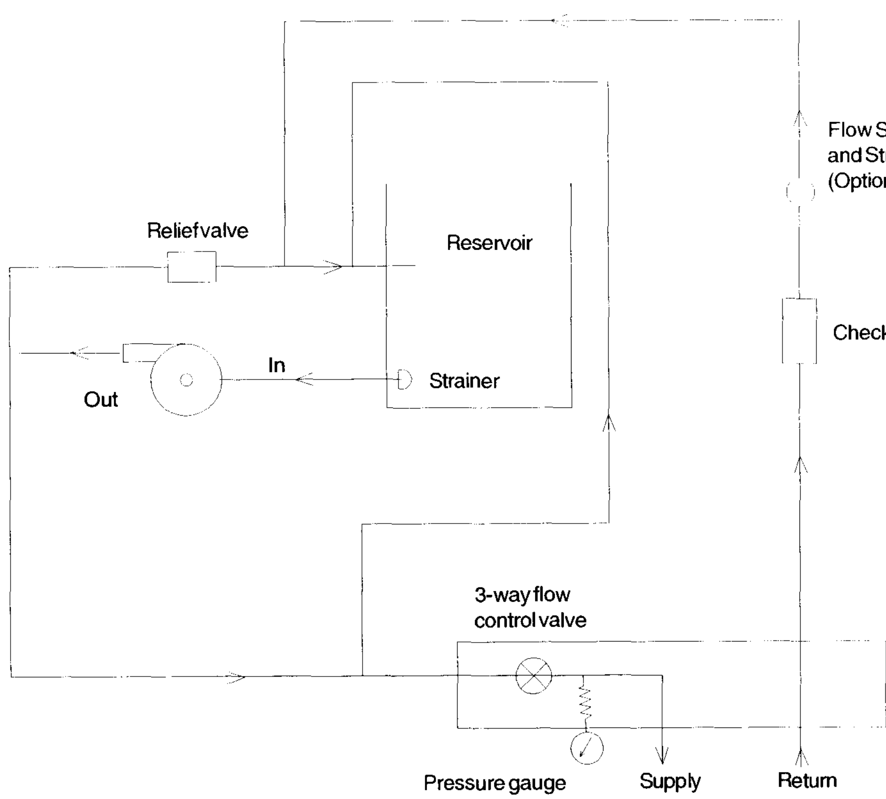


Diagrams

Pump Flow Diagram (CP Pumps)

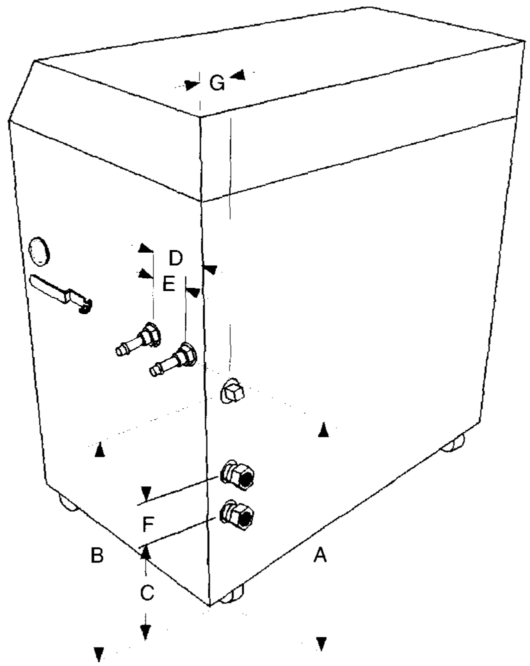


Pump Flow Diagram (PD and TU Pumps)



Diagrams

Dimensions



Unit Dimensions	HX-75	HX-150	HX-300	HX-500	HX-750AC*
Height	35¾	$39\frac{5}{8}$	$45\frac{7}{8}$	$50\frac{5}{8}$	63¾
Width	23¼	26¼	33¾	46	46
Depth	18¾	$21\frac{1}{8}$	25¼	28¾	29
Dimension A	16	20	$25\frac{3}{8}$	25¼	41
Dimension B	15¼	19¼	23½	$21\frac{1}{8}$	33¾
Dimension C	8¼	9¼	$8\frac{3}{8}$	5½	NA
Dimension D	7¼	7¼	7½	9½	9½
Dimension E	3	3	3	3	3
Dimension F	3	3	3	5½	NA
Dimension G	$1\frac{3}{8}$	$1\frac{3}{8}$	1½	2¼	NA
Dimension H	2½	2½	$2\frac{3}{8}$	2¼	2¼
Dimension I	$24\frac{7}{8}$	27½	31½	$35\frac{1}{8}$	35
Dimension J	48½	54	$64\frac{7}{8}$	73½	86¼
Crate Dimensions (H x W x D)	46x30x27	49x33x29	55x40x33	61x54x36	74x54x36

* Air-cooled units. Water-cooled units are the same size as the HX-500 units.

1. Dimensions are given in inches, ±1/8 inch.
2. Model HX-750 with a water-cooled condenser has the same dimensions as an HX-500.
3. Dimension A is the distance from the floor to the center of the SUPPLY and RETURN connections.
4. Dimension B is the distance from the floor to the center of the DRAIN connection.
5. Dimension C is the distance from the floor to the center of the tap water outlet connection.
6. Dimension D is the distance from the center of the SUPPLY connection to the rear of the unit case.
7. Dimension E is the distance between the SUPPLY and RETURN connections
8. Dimension F is the distance between the center of the TAP WATER connections (upper inlet and lower outlet).
9. Dimension G is the distance from the edge of the unit case to the center of the three plumbing connections.
10. Dimension H is the distance from the floor to the bottom of the case, height of the castors (not shown).
11. Dimension I is the depth of the unit with the case top open (not shown).
12. Dimension J is the height of the unit with the case top open (not shown).

WARRANTY

Thermo NESLAB Instruments, Inc. warrants for 12 months from date of shipment any Thermo NESLAB unit according to the following terms.

Any part of the unit manufactured or supplied by Thermo NESLAB and found in the reasonable judgment of Thermo NESLAB to be defective in material or workmanship will be repaired at an authorized Thermo NESLAB Repair Depot without charge for parts or labor. The unit, including any defective part must be returned to an authorized Thermo NESLAB Repair Depot within the warranty period. The expense of returning the unit to the authorized Thermo NESLAB Repair Depot for warranty service will be paid for by the buyer. NESLAB's responsibility in respect to warranty claims is limited to performing the required repairs or replacements, and no claim of breach of warranty shall be cause for cancellation or recision of the contract of sales of any unit.

With respect to units that qualify for field service repairs, NESLAB's responsibility is limited to the component parts necessary for the repair and the labor that is required on site to perform the repair. Any travel labor or mileage charges are the financial responsibility of the buyer.

The buyer shall be responsible for any evaluation or warranty service call (including labor charges) if no defects are found with the Thermo NESLAB product.

This warranty does not cover any unit that has been subject to misuse, neglect, or accident. This warranty does not apply to any damage to the unit that is the result of improper installation or maintenance, or to any unit that has been operated or maintained in any way contrary to the operating or maintenance instructions specified in NESLAB's Instruction and Operation Manual. This warranty does not cover any unit that has been altered or modified so as to change its intended use.

In addition, this warranty does not extend to repairs made by the use of parts, accessories, or fluids which are either incompatible with the unit or adversely affect its operation, performance, or durability.

Thermo NESLAB reserves the right to change or improve the design of any unit without assuming any obligation to modify any unit previously manufactured.

THE FOREGOING EXPRESS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO WARRANTIES OR MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

NESLAB'S OBLIGATION UNDER THIS WARRANTY IS STRICTLY AND EXCLUSIVELY LIMITED TO THE REPAIR OR REPLACEMENT OF DEFECTIVE COMPONENT PARTS AND Thermo NESLAB DOES NOT ASSUME OR AUTHORIZE ANYONE TO ASSUME FOR IT ANY OTHER OBLIGATION.

Thermo NESLAB ASSUMES NO RESPONSIBILITY FOR INCIDENTAL, CONSEQUENTIAL, OR OTHER DAMAGES INCLUDING, BUT NOT LIMITED TO LOSS OR DAMAGE TO PROPERTY, LOSS OF PROFITS OR REVENUE, LOSS OF THE UNIT, LOSS OF TIME, OR INCONVENIENCE.

This warranty applies to units sold in the United States. Any units sold elsewhere are warranted by the affiliated marketing company of Thermo NESLAB Instruments, Inc. This warranty and all matters arising pursuant to it shall be governed by the law of the State of New Hampshire, United States. All legal actions brought in relation hereto shall be filed in the appropriate state or federal courts in New Hampshire, unless waived by Thermo NESLAB.

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Thermo NESLAB

System V
Liquid to Liquid
Heat Exchanger

Thermo NESLAB Manual P/N U00202
Rev. 06/03/03

Installation
Operation
Basic Maintenance

Visit our Web site at:

http://www.thermo.com

Product Service Information, Applications Notes, MSDS Forms, e-mail.

Voice Info: (800) 258-0830

Constant Temperature Bath/Circulators
Immersion Coolers
Recirculating Chillers

System V Liquid to Liquid Heat Exchanger Instruction and Operation Manual

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Maintenance

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SECTION IX
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Preface

Compliance

Products tested and found to be in compliance with the requirements defined in the EMC standards defined by 89/336/EEC as well as Low Voltage Directive (LVD) 73/23/EEC can be identified by the CE label on the rear of the unit. The testing has demonstrated compliance with the following directives:

LVD, 73/23/EEC	Complies with UL 3101-1:93
EMC, 89/336/EEC	EN 55011, Class A Verification EN 50082-1:1992 IEC 1000-4-2:1995 IEC 1000-4-3:1994 IEC 1000-4-4:1995

For any additional information refer to the Letter of Compliance that shipped with the unit (Declaration of Conformity).

After-sale Support

Thermo Electron Corporation is committed to customer service both during and after the sale. If you have questions concerning the operation of your unit, contact our Sales Department. If your unit fails to operate properly, or if you have questions concerning spare parts or Service Contracts, contact our Service Department. Before calling, please obtain the following information from the unit's serial number label on the rear of the unit:

- *BOM number* ____________________

- *Serial number* ____________________

- *Software version (see page 18)* ________

Warranty

Units have a warranty against defective parts and workmanship for one full year from date of shipment. See back page for more details.

Unpacking

Retain all cartons and packing material until the unit is operated and found to be in good condition. If the unit shows external or internal damage contact the transportation company and file a damage claim. Under ICC regulations, this is your responsibility.

Section I Safety

Warnings

Make sure you read and understand all instructions and safety precautions listed in this manual before installing or operating your unit. If you have any questions concerning the operation of your unit or the information in this manual, contact our Sales Department (see After-sale Support).

Performance of installation, operation, or maintenance procedures other than those described in this manual may result in a hazardous situation and may void the manufacturer's warranty.

Observe all warning labels.

Never remove warning labels.

Never operate damaged or leaking equipment.

Never operate the unit without cooling fluid in the reservoir.

Always turn off the unit and disconnect the line cord from the power source before performing any service or maintenance procedures, or before moving the unit.

Always empty the reservoir before moving the unit.

Never operate equipment with damaged line cords.

Refer service and repairs to a qualified technician.

In addition to the safety warnings listed above, warnings are posted throughout the manual. These warnings are designated by an exclamation mark inside an equilateral triangle with text highlighted in bold print. Read and follow these important instructions. Failure to observe these instruction can result in permanent damage to the unit, significant property damage, or personal injury or death.

Section II General Information

Description

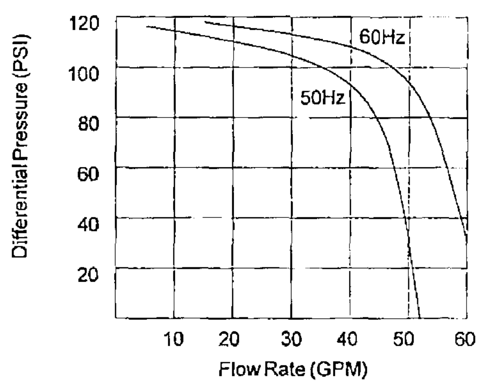
The System V Liquid to Liquid Heat Exchanger is designed to remove heat from water-cooled instruments.

The unit consists of a heat exchanger, recirculation pump, stainless steel reservoir and a microprocessor temperature controller.

Specifications

Temperature Range	+5°C to +40°C
Temperature Stability	±1.0°C

Pumping Capacity[1]



Cooling Capacity[2]	150 KW
Reservoir Volume	
Gallons	5.0
Liters	18.9
Unit Dimensions	
(H x W x D)	
Inches	55½ x 28 x 37
Centimeters	141.0 x 71.1 x 94.0

1. Relief valve open.
2. Cooling capacity is based on a 10°C difference between the temperature of the cooling water supply and the process fluid leaving the System V to the instrument being cooled and a 34 gpm facility water flow rate.

Section III Installation

Site

The unit should be placed in a laboratory or clean industrial environment with easy access to a facility cooling water and a drain.

Facility Water Requirements

A control valve, located in the FACILITY WATER SUPPLY line, regulates the flow rate of the cooling water supply as it enters the unit. The valve regulates the flow rate based on the heat load. Flow through the unit stops automatically when the unit is shut off.

The flow display on the controller measures the flow rate of the cooling fluid to the instrument being cooled.

Electrical Requirements

Refer to the serial number label on the rear of the unit to identify the specific electrical requirements of your unit.

Make sure the voltage of the power source meets the specified voltage, ±10%.

⚠ **The unit construction provides protection against the risk of electric shock by grounding appropriate metal parts. The protection may not function unless the power cord is connected to a properly grounded outlet. It is the user's responsibility to assure a proper ground connection is provided.**

NOTE: To reduce the large inrush current normally required for pump start up, units are equipped with a starting torque controller.

Fluids

Filtered tap water is the recommended cooling fluid. See Fluid Standards and Recommendations on the next page.

Filling Requirements

Open the reservoir access panel on the rear left corner on the top of the unit. Remove the fill hole cover. Fill the reservoir with cooling fluid.

Water Quality Standards and Recommendations

	Permissible (PPM)	Desirable (PPM)
Microbiologicals		
(algae, bacteria, fungi)	0	0
Inorganic Chemicals		
Calcium	<40	<0.6
Chloride	250	<25
Copper	<1.3	<1.0
Iron	<0.3	<0.1
Lead	<0.015	0
Magnesium	<12	<0.1
Manganese	<0.05	<0.03
Nitrates\Nitrites	<10 as N	0
Potassium	<20	<0.3
Silicate	<25	<1.0
Sodium	<20	<0.3
Sulfate	<250	<50
Hardness	<17	<0.05
Total Dissolved Solids	<50	<10
Other Parameters		
pH	6.5-8.5	7-8
Resistivity	0.01*	0.05-0.1*

* Megohm-Cm (Compensated to 25°C)

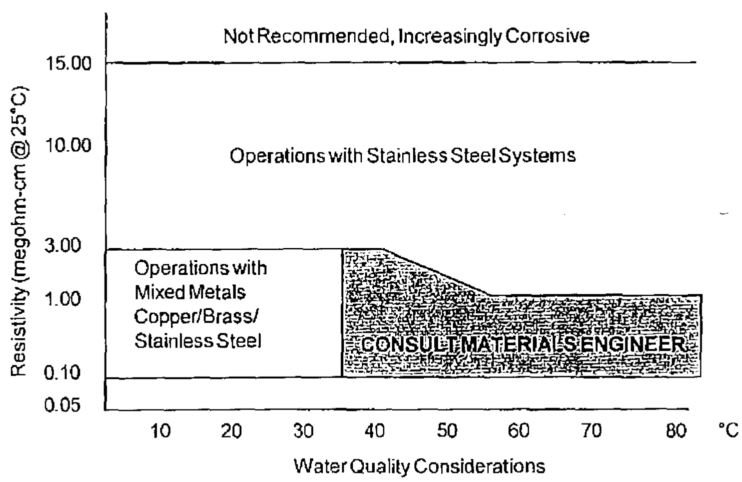
Unfavorably high total ionized solids (TIS) can accelerate the rate of galvanic corrosion. These contaminants can function as electrolytes which increase the potential for galvanic cell corrosion and lead to localized corrosion such as pitting. Eventually, the pitting could become so extensive that leaking will occur between the process water and facility water diminishing the System's heat transfer capability.

High water hardness (Calcium and Maganese) can also produce scaling. Scaling will inhibit heat transfer between the process and facility side by building up a deposit layer on metal surfaces. As an example, raw water in the United States averages 171 ppm (of NaCl). The recommended level for use in a water system is between 0.5 to 5.0 ppm (of NaCl).

Recommendation: Initially fill the tank with distilled/deionized water. Do not use untreated tap water as the total ionized solids level may be too high.

Maintain this water quality at a resistivity of between 1 to 10 megohm-cm (compensated to 25°C) by using a purification system. Although the initial fill may be as high as 10 megohm-cm (compensated to 25°C), the desired level for long time usage is 1 to 3 megohm-cm (compensated to 25°C).

The above two recommendations will reduce the electrolytic potential of the water and prevent or reduce the galvanic corrosion observed.



Plumbing Requirements

The plumbing connections are located on the rear of the unit. They are labelled FACILITY WATER and RECIRCULATING WATER. The FACILITY WATER connections and the RECIRCULATING WATER connections are 1½ inch female pipe thread.

Before installing the unit to an instrument that previously used tap water as a cooling fluid, flush the instrument several times to remove any rust or scale that has built up. The manufacturer of the instrument should be able to recommend a cleaning fluid for their equipment.

Connect the FACILITY WATER SUPPLY to the cooling water source. Connect the FACILITY WATER RETURN to the drain.

Limit the facility water inlet pressure to less than 80 psi (5,5 Bar) and limit the facility water inlet pressure to outlet pressure differential across the System V to less than 35 psid (2,4 Bar).

Connect the RECIRCULATING WATER SUPPLY to the inlet of the instrument being cooled. Connect the RECIRCULATING WATER RETURN to the outlet of the instrument being cooled.

Connect the auto refill line to a house water supply.

Flexible tubing, if used, should be of heavy wall or reinforced construction. All tubing should be rated to withstand 135 psi at +40°C. Make sure all tubing connections are securely clamped. Avoid running tubing near radiators, hot water pipes, etc. If substantial lengths of tubing are necessary, insulation may be required to prevent loss of cooling capacity.

Tubing and insulation are available from Thermo. Contact our Sales Department for more information (see Preface, After-sale Support).

It is important to keep the distance between the unit and the instrument being cooled as short as possible, and to use the largest diameter tubing practical. Tubing should be straight and without bends. If reductions must be made, they should be made at the inlet and outlet of the instrument being cooled, not at the unit.

If substantial lengths of cooling lines are required, they should be pre-filled with cooling fluid before connecting them to the unit.

Section IV Operation

Start Up

Before starting the unit, double check all electrical and plumbing connections and make sure the circulating system (the System V, the instrument being cooled, and the tubing that connects them) has been properly filled with cooling fluid.

Turn the RECIRCULATING FLOW CONTROL handle to the vertical position (full closed). To start the unit press the controller's START.

The low fluid level monitor in the reservoir prevents the unit from operating if the fluid in the reservoir is below the safe operating level. By slightly and/or intermittently opening the RECIRCULATING FLOW CONTROL toward the horizontal position (full open) and using extra cooling fluid to keep the unit topped off, the system can be filled without repeated tripping of the low fluid level monitor.

If the unit shuts down, top off the reservoir and restart the unit. When the system is full, the reservoir level will no longer drop when the RECIRCULATING FLOW CONTROL valve is opened.

Temperature Adjustment

The temperature is set in the controller's Setup Loop, see page 14. The temperature control system actuates a control valve in the FACILITY WATER SUPPLY line. The control valve adjusts the flow of the cooling water supply to produce the desired operating temperature.

The cooling fluid temperature can be monitored on the controller's display.

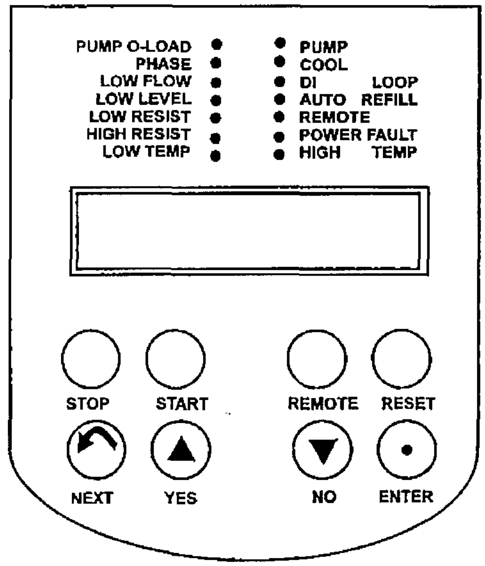
When selecting an operating temperature, remember that the lowest achievable temperature is a function of the available flow rate, the temperature of the cooling water supply and the heat load.

The green COOL light on the controller provides an indication of the control valves status. When the temperature control valve is wide open (for maximum cooling), the COOL light is on steady. When the control valve is closed, the COOL light is off. As the control valve moves between these extremes, the light will flash with varying on-time to indicate the approximate position of the control valve.

Flow Control

The unit's RECIRCULATING FLOW CONTROL handle controls the flow of the cooling fluid to the instrument being cooled. When the handle is in the full horizontal position all available fluid is being supplied. When the handle is in the full vertical position no cooling fluid is being supplied. Read the controller to read and adjust the desired flow rate.

Controller Keypad



START
Depressing **START** energizes the channel contactor which starts the circulating pump and brings the reservoir temperature to the current setpoint.

STOP
Depressing de-energizes the channel contactors and stops the pump.

REMOTE
Enables remote operation. **NOTE:** Pins 11 and 12 on the INTERFACE (J25) connector are used for remote start/stop. See Wiring Diagram.

RESET
Clears alarm indications after fault condition has been corrected. Alarm LEDs will remain lit after problem is eliminated to provide indication of problem cause for operator. RESET clears these indicators.

NEXT
Scrolls forward through the menus.

YES, ▲
Answers Yes to Y/N questions, increments numerical values upward for setting numeric values.

NO, ▼
Answers NO to Y/N questions, increments numerical values downward for setting numeric values.

ENTER
Confirms entry of numeric values.

Status Indicators

Status indicators are provided to show the state of various functions.

PUMP O-LOAD
Indicates a pump overload.

PHASE
Indicates improper phase to the unit.

LOW FLOW
Indicates low process flow.

LOW LEVEL
Indicates that the reservoir level is too low.

LOW RESIST
Indicates resistivity is below setpoint.

HIGH RESIST
Indicates resistivity is above setpoint.

LOW TEMP
Indicates temperature is below setpoint.

PUMP
Indicates pump is running.

COOL
Illuminates when the heat exchanger is removing heat from the fluid in the reservoir. Flashes when the channel is operating in the cool proportional band.

DI LOOP
Indicates flow through the resistivity cartridge.

AUTO REFILL
Indicates auto refill is in operation.

REMOTE
Indicates unit is in REMOTE mode of operation.

POWER FAULT
Indicates a system fault.

HIGH TEMP
Indicates temperature is above setpoint.

Changing a Value

The **YES** key increments the value. The **NO** key decrements the value.

The display will flash as soon as either key is depressed, and will continue to flash until the **ENTER** key is pressed to accept the new value.

The new value will not be used by the controller until the **ENTER** key is depressed and the display stops flashing.

If the **NEXT** key is pressed while the value is flashing, the new value will not be accepted. The display will stop flashing and the original value will be displayed. In this case the **NEXT** key can be used to abort data entry. The display will not sequence unless the **NEXT** key is depress again.

For large values the display can be changed by manipulating the individual digits. Press the **YES** key and the **NO** key at the same time. The most significant digit will start to flash. The **YES** key increments or the **NO** key decrements the digit. Press the **ENTER** key to accept the digit and to move to the next most significant digit. Repeat until all digits are entered. Pressing the **NEXT** key before all digit are entered will abort the procedure and return the display to the original value.

The controller will not allow you to enter a value above the maximum (+40°C) or below the minimum (+5°C). If you try to enter an illegal value outside the operating range, the display will revert to its original value.

Controller Displays

An alphanumeric display presents numeric readings of various operating conditions within the chiller. Display function is selected by pressing the appropriate keys to move through a menu of available information.

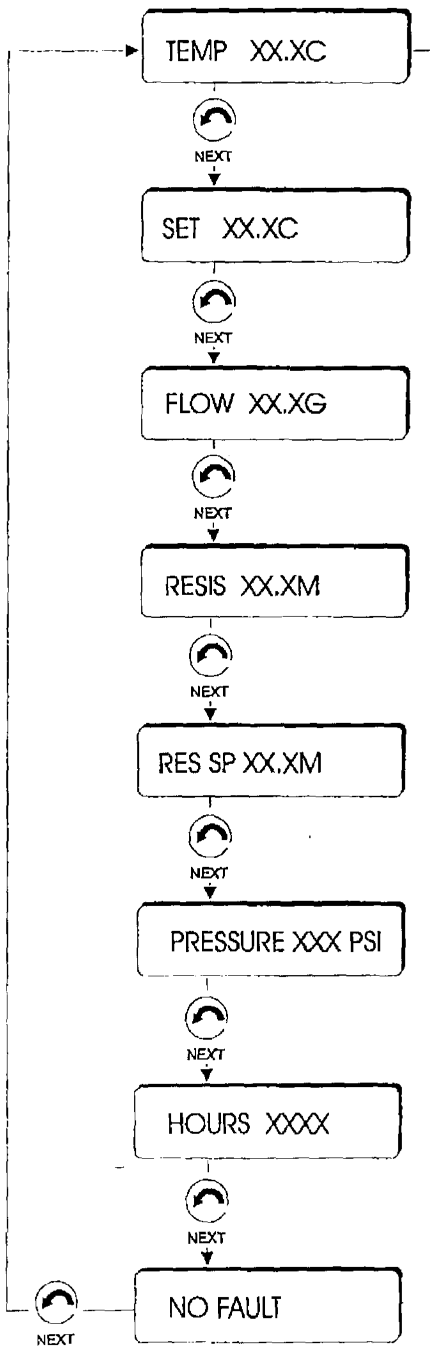
Various controller loops allow the operator to display and/or alter different parameters of the controller. The various controller loops can be accessed from the temperature display by pressing and holding the key combinations shown on Figure 1 on the next page.

When the controller is first powered up it goes through a short self test and then enters the Operator's Loop, displaying the reservoir fluid temperature.

Operators Loop

When the controller is first powered it goes through a short self test and then enters the Operator's Loop, displaying the temperature of coolant leaving the chiller at the SUPPLY port.

By pressing the NEXT key the controller will step through the menu shown below.



TEMPERATURE xxxC
This displays the temperature of coolant leaving the chiller at the SUPPLY port.

SET xxxC
This displays the setpoint for temperature control. The chiller's temperature controller causes the supply temperature to be equal to this temperature.

FLOW xxxG
This displays the flowrate at the RETURN port in gallons per minute.

RESIS xx.xM
This displays the DI resistivity.

RES SP xx.xM
This displays the DI resistivity setpopint.

PRESSURE xxx PSI
This displays the system back pressure.

HOURS xxxx
This displays the unit's hours of operation.

NO FAULT
This displays the fault status. If a fault is present, the display is listed from highest to lowest priority.

RTD1 FAIL
REV PHASE
PUMP OLOAD
LOW LEVEL
LOW FLOW
LOW RESIST
HI RESIST
LOW TEMP
HIGH TEMP
PWR FAULT

Figure 1 Operator's Loop

Setup Loop

The Setup Loop allows the operator to change the flow alarm setting, low and high temperature limits, and the resistivity alarm limits. Use this loop to determine if the unit will cutout or not with a fault condition.

To enter this loop you must be in the Operator's Loop and displaying the temperature. Depress and hold the ENTER key while pressing the NEXT key.

Adjust values with the UP and DOWN arrows. Press ENTER for the controller to accept each new entry.

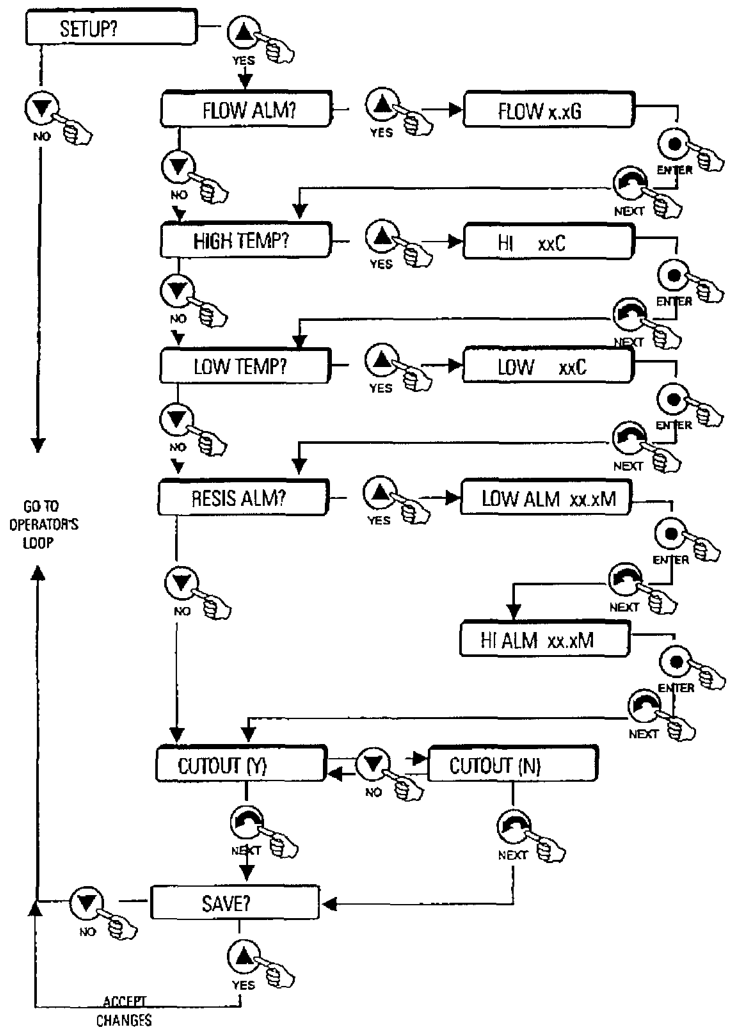


Figure 2 Setup Loop

NOTE: Should you desire to return to the temperature display and abort *all* changes, keep pressing the **NEXT** until the display reads **SAVE?** Press **NO.**

Section V Special Features

Emergency Motor Off (EMO)

When the EMO is depressed power is disconnected from the unit, with the exception of the control board. The EMO is also routed to 2RECP for connection to a remote EMO. In order for the unit's EMO to be effective, 2RECP should be connected in series with the remote EMO.

High Temperature Safeties

In the event of a high temperature fault, the POWER FAULT lamp will light and the unit will shut down. The cause of the fault must be identified and corrected before the unit can be restarted.

Low Liquid Level Safety

The low liquid level safety is connected to a float switch in the reservoir. A low liquid level fault occurs when the cooling fluid in the reservoir drops below the operating level.

In the event of a low liquid level fault, the amber LOW LEVEL lamp will light and the unit will shut down. The cause of the fault must be identified and corrected before the unit can be restarted.

Pump Motor Overload Protector

The unit has a pump motor overload protector. The overload protector prevents the pump motor from exposure to excessively high current. If an overload fault occurs, due, for example, to a heavy work load, the amber PUMP O-LOAD light will light and the unit will shut down. The overload protector will automatically reset after about two minutes. The unit must be manually restarted by pressing the reset on the controller.

Resistivity Monitor

The monitor is factory preset at 2.7 megohm-cm. See Controller IV Setup Loop for instructions on changing this value and setting low and high alarms.

NOTE: The controller IV RESISTIVITY MONITOR energizes a solenoid coil, allowing water to flow through the cartridges. The monitor has +0.20 megohm, -0.30 megohm hysteresis. When the resistivity drops to 0.30 megohms below the setpoint the solenoid is energized. It stays energized until the resistivity reaches 0.20 megohms above the setpoint.

Fault Response Modes

In the event of a low fluid level or high temperature fault, two modes of response to a fault are possible: SHUTOFF and ALARM ONLY.

In the SHUTOFF mode, if either fault occurs, the FAULT light will light and the unit will shut down.

In the ALARM ONLY mode the FAULT light will light, but the unit will continue to operate. This mode is available for users who prefer to accept the risk of damage to the System in order to continue to provide all available cooling fluid to thir application in the event of a failure.

The unit is shipped from the factory with the ALARM mode selected.

Section VI Maintenance

Service Contracts

Thermo offers on-site Service Contracts that are designed to provide extended life and minimal down-time for your unit. For more information, contact our Service Department (see Preface, After-sale Support).

Pump Strainer

A wire mesh pump strainer is located in the unit. If debris is drawn into the system, the strainer will prevent the material from being drawn into the pump and damaging the pump vanes.

After initial installation, the strainer may become clogged with debris and scale within the first week. Therefore, the strainer must be cleaned after the first week of installation. After this first cleaning, the frequency of cleaning depends on the purity of the cooling water. It is recommended that a visual inspection of the reservoir be made monthly after the initial cleaning. After several months, the cleaning frequency will be established.

If the strainer is visibly clogged, cleaning is required.

Disconnect the power cord from the power source and drain the reservoir before cleaning the strainer.

Remove the strainer by unscrewing it.

Clean the strainer by rinsing it with water.

Refer to Section III, Filling Requirements for instructions on replacing the cooling fluid.

Never operate the unit with the strainer removed.

Particulate Filter

To change the filter open the front access door. Turn the valve on the inlet (right) side of the filter perpendicular to the plumbing. Grip the cannister and turn counterclockwise. Replace the used filter.

Replace the cannister and hand tighten. Return valve to the original position.

Algae

To restrict the growth of algae in the reservoir, it is recommended that the reservoir fill plug be kept in place and that all circulation lines be opaque. This will eliminate the entrance of light which is required for the growth of most common algae.

We recommend the use of Chloramine-T, 1 gram per 3.8 liters.

Section VII Service

For personal safety and equipment reliability, the following procedure should only be performed by a qualified technician. Contact our Service Department for assistance (see Preface, After-sale Support).

Pressure Relief Valve

A pressure relief valve is located on the pump discharge line. The relief valve establishes the maximum operating pressure of the unit. If the pressure of the fluid leaving the pump exceeds the valve setting, the relief valve will bypass the fluid within the unit to relieve the pressure. The relief valve does not determine the actual operating pressure; the actual operating pressure is determined by the flow control valve setting and pressure drop through the instrument being cooled.

The valve is factory preset at 135 psi. If adjustment is necessary, call our Customer Service Department (see Preface, After-sale Support).

Phase Rotation

Three phase units with three phase pump motors are equipped with a phase rotation interlock. The amber PHASE light on the controller will illuminate if there is an error.

This interlock prevents the unit from starting if the phase rotation is wrong. If the phasing is wrong, the PHASE light will light and the unit will not start.

Unplug the unit. Reverse any two power cord wires in the power cord plug.

Never remove the green ground wire.

Plug in the unit. The PHASE light should be off and the unit should start.

Displaying Software Version

To display the software version ensure the controller is in the Operator's Loop and displaying the reservoir fluid temperature. Depress and hold the enter key •. Press the YES NO YES keys and the display will indicate CALIBRATE? While continuing to hold the enter key press the YES NO YES keys again. The display will now indicate the software version, for example 000550.36h.

Section VIII Troubleshooting

Checklist

Unit does not start, FAULT light does not come on when START button is pushed.

- Check the position of the EMO.
- Check the voltage of the power source. Refer to the serial number on the rear of the unit for the specific electrical requirements of your unit. Make sure the voltage of the power source meets the specified voltage, ±10%.
- Check the fuses (see Section VII, Fuses).

When START switch is pushed, unit does not run, FAULT light comes on (SHUTOFF mode)

- Check the position of the EMO.
- Check fluid level in the reservoir. The low fluid level monitor prevents the unit from starting if the fluid level is below the safe operating level.
- Make sure the TEMPERATURE CONTROL setting is less than the HIGH TEMPERATURE LIMIT setting.

Unit runs, but FAULT light is on (ALARM ONLY mode)

- Check fluid level in the reservoir. The low fluid level monitor indicates a fault if the fluid level is below the safe operating level.
- Make sure the TEMPERATURE CONTROL settings are less than the HIGH TEMPERATURE LIMIT settings.

Unit continues to run for a short period and then stops

- Check fluid level in the reservoir. If low, check the system for leaks.
- Make sure the heat load is not greater than the cooling capacity (see Section II, Cooling Capacity).
- Make sure the cooling water supply meets the requirements outlined in Section III, Facility Water Requirements.
- Possible power interruption has occurred causing "latch" relay to unlatch. Attempt to restart.

COOL light always on, temperature is not dropping

- Make sure the heat load is not greater than the cooling capacity (see Section II, Specifications).
- Make sure the cooling water supply meets the requirements outlined in Section III, Facility Water Requirements.
- Clean the pump strainer.

Spare Parts List

Part #	Description
008700	VALVE, SOLENOID, 1.5" SLOW, 208VAC
008899	VALVE, CHECK, ½" SWT, BRZ, WTR
008995	TRANSDUCER, PRESSURE, 0-200 PSI
013057	CASTER, 3", W/MOUNT BRAKE
013058	CASTER, 3", W/BRAKE, W/MOUNTING PLATE
014744	VALVE, MTR, NC, 1" FPT, BRZ 6-9V
024677	FLOW TRANS, 1", BRASS, 10-60 GPM
051737	COIL ASSY, OMKC1, 120VAC, HXII
052860	OUTLET, DEI FLOW METER
003282	VALVE RELIEF, 40-125 PSI, ¾" BR
009217	GAUGE, PRESSURE, 0-160 PSI, STEM
053937	TANK ASSY, SYS 5
003224	SCREEN, SUCTION, 20 MESH, 1¼"
008342	VALVE, CHECK, 1" FPT, BRZ, SWING, Y
008415	VALVE, RELIEF, 60-150 PSI
008899	VALVE, CHECK, ½" SWT, BRZ, WTR
009856	VALVE, CHECK, BRZ, 1.5", SWING
014530	VALVE, 3WAY BALL, 1-1/2 FPT
024928	PUMP, TU RGTC9, 208/60, 200/50/3
000239	DIODE, BIPOLAR ARC SUP, 48VDC
000241	SWITCH, CONT BLOCK, 2NC, 800E
000410	LAMP, 24V POWER IND, 800E
000500	SENSOR, 3/16" X 6" X 10FT LD SHLD
000545	RELAY SOCKET, SCREW TERM G2R
000546	RELAY, SPDT, 24VDC, 21MA W/DIOD
000689	RECEPTACLE, 50A, PANEL INLET
000940	CONT, 3P+1NO, 24VAC, 20A, FUJI
001696	SWITCH, MUSHROOM, 2NC, P-P, RED, 800T
005599	SWITCH, FLOAT, HORIZ 5/8" SHIELD
005663	LAMP, PILOT, AMBER STD AB800E
005807	CKT BRKR, 30A RT 3P
005808	CKT BRKR, 20A RT 3P
006520	RELAY, BIMETAL O-LOAD, 10-16A
010187	PLUG, 250V, 15A, 3P, PANL, ML-3P
010188	RECPT, 250V, 15A, 3P, CORD, ML-3R
010855	FUSE, 1.0A, 250V, FNM, SLO, 35AI
010881	FUSE, 0.5A, 250V, FNM, SLO, 34AI
010882	FUSE, 2.0A, 250V, FNM SLO, 100AI
014517	TRANSFORMER, 208V, 24/24V, 8/158VA
014692	SWITCH, SELECT, 2POS, BLK, 800E
059909	KEYPAD ASSY, SYS4 D4
009242	VALVE, BALL, ½" FPT, SS BALL & STEM
006056	RELAY, DPDT, 24DC, 10A/240V, FLMT
009114	COIL, SOLV, 115VAC, MKC1, 26" CON

009013	VALVE, SOLENOID, W6P1, NC MKC-1
026521	PROBE, RESISTIVITY SS FTG
026714	CARTRIDGE, DEI, 14", ¼" NPT
009116	COIL, SOLV, 220VAC, MKC1, 26" JBOX
009725	VALVE, SOLENOID, ¼ FPT MKC1
013006	RUBBER BUMPER, .50 SQ X .25 H STICK
U00202	INSTRUCTION MANUAL
008634	FILTER, CARTRIDGE, 1", 40 MIC

Service Assistance

If, after following these troubleshooting steps, your units fails to operate properly, contact our Service Department for assistance (see Preface, After-sale Support). Before calling please obtain the following information:

Part number

Serial number

Voltage of unit

Voltage of power source

Technical Support

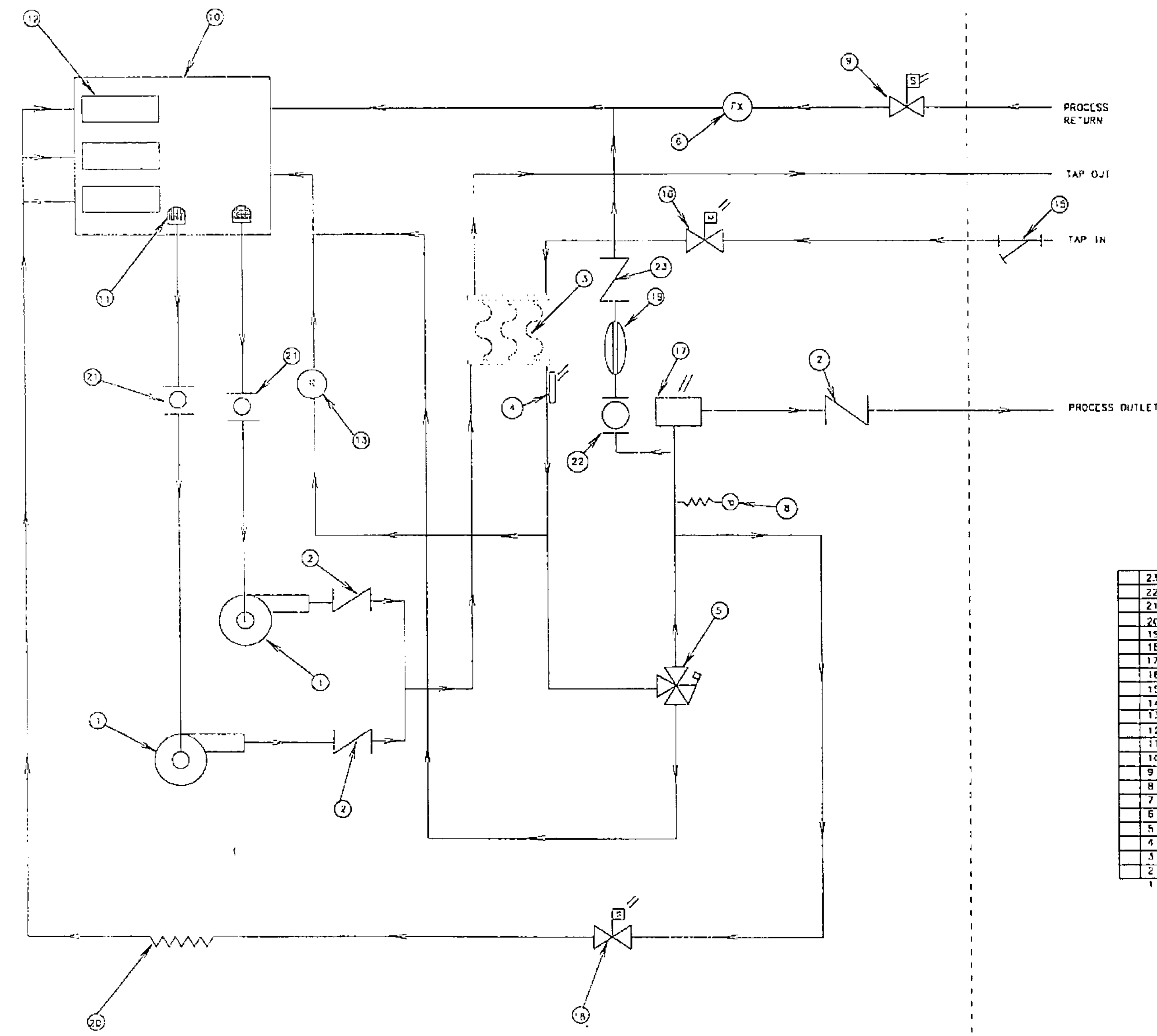
Our Service Department can provide you with a complete list of spare parts for your unit (see Preface, After-sale Support). Before calling, please obtain the following information:

Part number

Serial number

Pump Flow Diagram

	A	ADDED ITEMS 22&23. ITEM 4 WAS HTC 6 WAS FLOWMETER. MOVED 2,7,&8. ITEMS 2,7,&8 ARE MOVED.(PCO 6626)	2-11-97	JCH	AK	LTU
B3	B	CHANGED: SYM #19 P/L SPEC WAS 50 MICRONS. DELETED: SYM #7 (THERMOMETER) AND SYM #14 (HTC) WERE BETWEEN SYM #4 AND #5. ECO 14012	3-8-00	BAJ		



	23	1	FILTER CHECK VALVE		
	22	1	FILTER BALL VALVE		
	21	2	BALL VALVE		
	20	1	DEI CAP TUBE		
	19	1	FILTER		40 MICRON
	18	1	DEI SOLENOID VALVE		
	17	1	DEI SENSOR		
	16	1	MODULATING VALVE		
	15	1	BASKET STRAINER		
	14	–	DELETED		
	13	1	RELIEF VALVE		
	12	1	DEI CARTRIDGE		
	11	2	SUCTION SCREEN		
	10	1	TANK		
	9	1	SOLENOID VALVE		
	8	1	PRESSURE GAUGE		
	7	–	DELETED		
	6	1	FLOW TANSDUCER		1/8"NPT
	5	1	BALL VALVE, 3-WAY		
	4	1	HTC BULB		
	3	1	PLATE EXCHANGER		
	2	3	CHECK VALVE		
	1	2	PUMP		

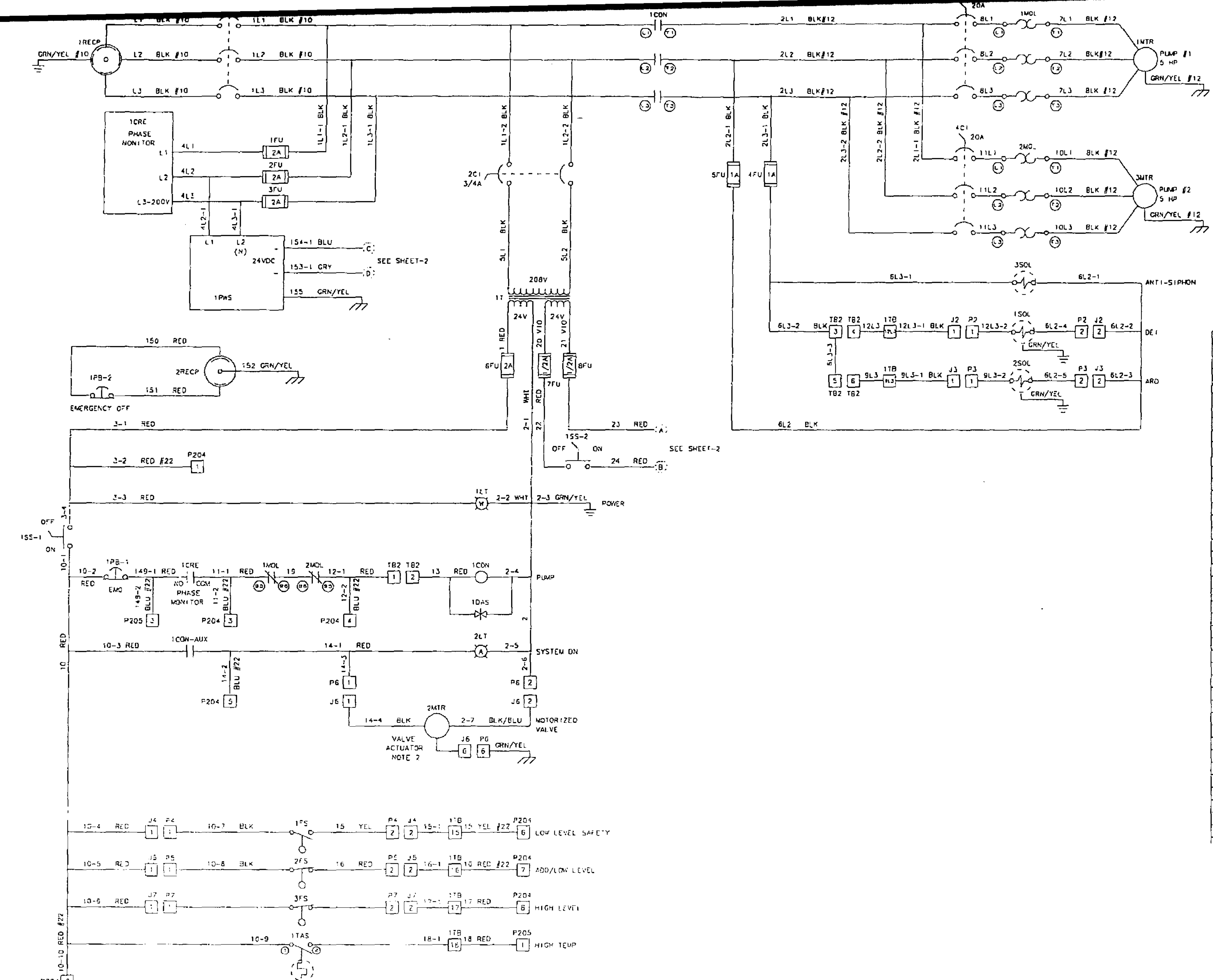
J HOLWAY 1-14-97
K LILLY 1-14-97
BECARD 1-14-97

FLOW DIAGRAM
SYSTEM V

AS SHOWN

C F00691 B

FCCSE7 NTS 1 OF 1



C7D8 D8 A8 C4A7 C4	A	ADDED: GND TO 1PWS AND 2MTR; VARIOUS WIRE NOS., COLORS AND GAGES: P/J8-1,2; P/J5-1. CHANGED: TB2 WAS 2TB; P/J8-2 WAS P/J4-3; 11L1,2,3 WAS 8L3,2,1; 12L3 WAS 1L3. PCO 10863	3-18-98	BAJ	DS	D9
A7 C7 B8 D4	B	ADDED: GROUND TO 1TAS; WIRE NUMBERS TO 1PWS L1 AND L2 WIRES. CHANGED: "SYSTEM ON" WAS "PUMP STATUS"; WIRE NUMBER 2L1-1 WAS 2L1-2; NOTE-3 WAS "LAST WIRE NUMBER IS 152". PCO 11652	6-5-98	BAJ	AK	LC
	C	CHANGED: 2CI P/N WAS 014087; J25 WAS 000869. ECO 13743	7-15-99	BAJ	CLC	CAD
	D	NO CHANGE. SEE SHEET-2 FOR REVISION. ECO 13871	9-7-99	BAJ	—	CAD
A6,8 A7 A7,8	E	ADDED: 1,2CBL, P/J4-6, P/J8,9 TO P/L; P/J7-1,2 TO WIRING OF 3FS, 1TAS CONN. POINT NUMBERS. CHANGED: 1LT P/N WAS 003083; 2LT WAS 000411; 1RS 005504; WIRE #10-9 WAS TO 3FS WIRE #10-6 RED. ECO 14056	11-5-99	BAJ	JCM	CWC
A7 C3 D8 B7	F	CHANGED: 1TAS WAS SHOWN "OPEN ON RISE". DELETED: 3SOL GROUND WIRE ECO 15741 CHANGED: 1CRE PART NUMBER WAS 010783; 1CRE CONNECTION POINT "NO" WAS "3" AND "COM" WAS "4". ECO 15617	1-30-01	BAJ	RBL	APC
C4A6 D3-5 B7C8	G	ADDED: 1TB TO WIRE #9L3, 12L3, 15-18; CONNECTION POINT TEXT TO 1CON, 1,2MOL; VARIOUS WIRE NUMBERS AND COLORS. ECO 17082	8-02-02	BAJ		

NOTES:

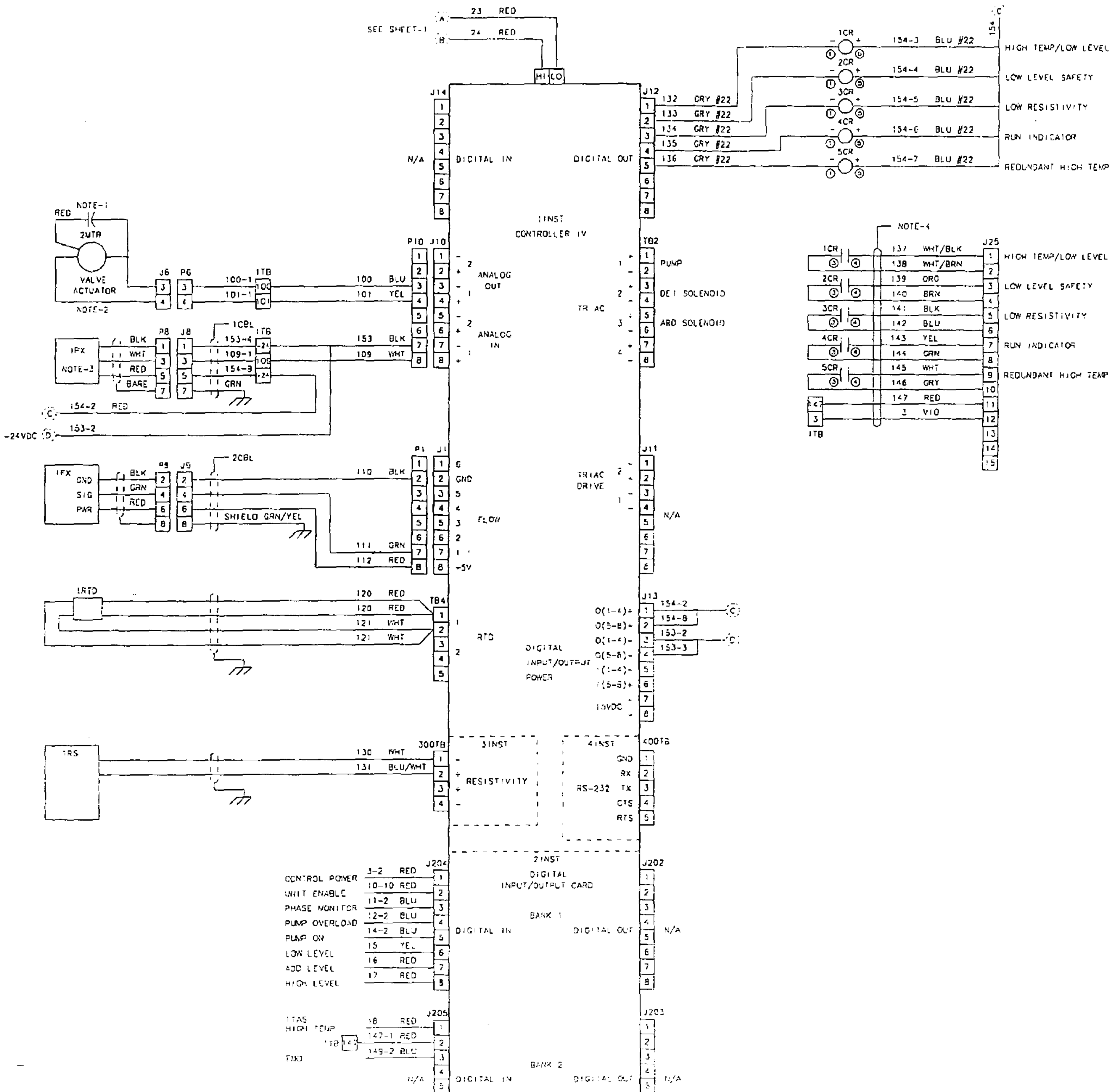
1. ALL WIRES ARE #16 AWG UNLESS OTHERWISE SPECIFIED.
2. SHOWN IN TWO PLACES, SHEETS 1 AND 2.
3. LAST WIRE NUMBER USED IS 155.
4. DIAGRAM PARTS LIST USED AS REFERENCE ONLY.

P8,9	CONNECTOR, PLUG	001565	9 PIN, CPC
P4-6	CONNECTOR, PLUG	005101	2 PIN, M & L
J25	CONNECTOR, JACK	006555	15 PIN, D
J8,9	CONNECTOR, JACK	024130	9 PIN, CPC
J4-6	CONNECTOR, JACK	006100	2 PIN, M & L
1TAS	TEMPERATURE ACTUATED SWITCH	006440	
1T	TRANSFORMER, CONTROL	014517	208/24/24, 8/15BVA
1SS	SELECTOR SWITCH, ON/OFF	000241	
3SOL	SOLENOID VALVE, ANTI-SIPHON	008700	
1,2SOL	SOLENOID	009116	208VAC, MKC1
1RTD	RESISTIVE TEMPERATURE DEVICE	000500	100 OHM
1RS	RESISTIVITY SENSOR	026521	K=0.1
2RECP	RECEPTACLE, ITLK EXTERNAL END	010187	
1RECP	RECEPTACLE	000689	250V, 50A
1PX	PRESSURE TRANSDUCER	038995	
1PWS	POWER SUPPLY	001185	24V DC
1PB	PUSH BUTTON, EMERGENCY OFF	001696	
3MTR	MOTOR, PUMP #2	024928	5 HP
2MTR	MOTOR, VALVE ACTUATOR	014744	1", 6-9V
1MTR	MOTOR, PUMP #1	024928	5 HP
1,2MOL	MOTOR OVERLOAD	006520	10-16A
2LT	PILOT LIGHT, AMBER	005663	24VAC
1LT	PILOT LIGHT, WHITE	000411	24VAC
4INST	INSTRUMENT, RS-232 CARD	000242.1B	
3INST	INSTRUMENT, RESISTIVITY CARD	005844.2A	
2INST	INSTRUMENT, DIGITAL I/O CARD	005845.2B	
1INST	INSTRUMENT, CONTROLLER IV	005843.2E	
1FX	FLOW TRANSDUCER	024677	10-60 GPM, 1"
1-3FS	FLOAT SWITCH	005599	POLY-PRO
7,8FU	FUSE, CONTROLLER IV	010881	1/2A, 250V, FNM
6FU	FUSE	010882	2A, 250V, FNM
4,5FU	FUSE, SOLENOID VALVES	010855	1A, 250V, FNM
1-3FU	FUSE, PHASE MONITOR	000353	2A, 600V, NTD
1DAS	DIODE ARC SUPPRESSOR	000239	48V
1CRE	CONTROL RELAY ELECTRONIC	062512	PHASE MONITOR, 230V
1-5CR	CONTROL RELAY	000546	
1CON	CONTACTOR, PUMP	000940	3P+1, 24VAC, 20A
3,4CI	CIRCUIT INTERUPTER, PUMP	005808	20A
2CI	CIRCUIT INTERUPTER	024768	3/4A
1CI	CIRCUIT INTERUPTER, MAIN	005807	30A
1,2CBL	CABLE	006528	22AWG, 4C

JOLIN 1-23-98
GRANT 1-26-98
GRANT 1-26-98

AS LISTED

SYSTEM V
CONTROL (DIGITAL)



C0 C5 C8	A	ADDED: VARIOUS WIRE NOS., COLORS AND GAGES: NOTE-4; P/J6 BETWEEN P10 AND 2MTR. CHANGED: TB4 WAS 4TB; TB2 WAS 2TB; 111 GRN WAS 111 CLR. PCO 10053	3-18-98	BAJ	LG	LG
	B	ADDED: NOTE-5. PCO 11652	6-5-98	BAJ	AH	LG
	C	NO CHANGES. SEE SHEET-1 FOR REVISION. ECO 13743	7-15-99	BAJ	CLC	CAD
D3	D	DELETED. NOTE-5 WAS "J25 IS AN IDC MALE CONNECTOR". ECO 13971	9-7-99	BAJ	--	CAD
C0 B8	E	ADDED: P/J8; P/J9; "22AWG, 15C" TO NOTE-4 CHANGED: WIRE NO. 131 WAS BLK. ECO 14056	11-3-99	BAJ	JCH	CWC
	F	NO CHANGES. SEE SHEET-1 FOR REVISION. ECO 15741 & ECO 16617	1-30-01	BAJ	RDL	APC
C8 C4 A6 B4	G	ADDED: 1TB TO WIRE #100,101,109,153, 154-8 CHANGED 1TB-147 WAS J205-2; 1TB-3 WAS J204-1; 1TB-147 WAS J25-11, WIRE NUMBERS TO 1INST-J13. ECO 17052	8-02-02	BAJ		

NOTES:

1. CAPACITOR KIT INCLUDED WITH MOTORIZED VALVE.
2. SHOWN IN TWO PLACES, SHEETS 1 AND 2.
3. SHIELDED CABLE USED.
4. CABLE USED IS P/N 006697, 22 AWG, 15C.