1031365-001
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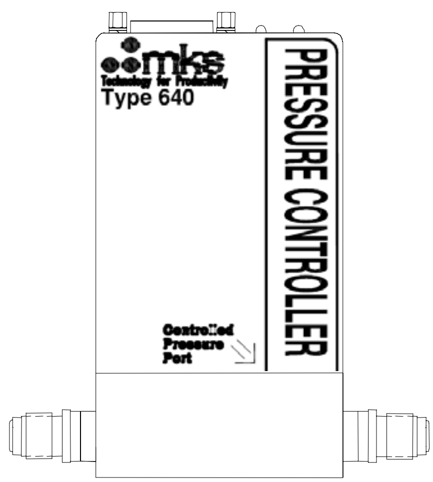
MKS Type 640B/641B (ROHS Compliant) Pressure Controller



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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.

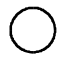
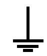
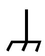
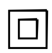
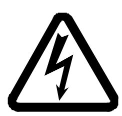
Definition of Symbols Found on the Unit			
On (Supply) IEC 417, No.5007	 Off (Supply) IEC 417, No.5008	 Earth (ground) IEC 417, No.5017	 Protective earth (ground) IEC 417, No.5019
 Frame or chassis IEC 417, No.5020	 Equipotentiality IEC 417, No.5021	 Direct current IEC 417, No.5031	 Alternating current IEC 417, No.5032
 Both direct and alternating current IEC 417, No.5033-a	 Class II 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.

Chapter One: General Information

Introduction

The 640B Series, RoHS-compliant[1] version Pressure Controllers, includes the Type 640B absolute pressure controller and the Type 641B gage pressure controller. The 640 Series Controllers consist of a Baratron® capacitance manometer (either absolute or gage pressure), a normally closed proportional control valve, and closed-loop control electronics. The closed-loop control circuitry enables the unit to function as a proportional-integral (PI) controller. The unit's compact size and small, three-inch footprint reduce space requirements.

The 640B Series offers a variety of options including the seal material, full scale range, and calibration. The seal material is available in an elastomer (Kalrez®, Viton®, Kel-F®, or Chemraz®, refer to *Appendix D: Model Code Explanation*, page 65, for information) or all-metal material. Full scale ranges are available from 10 Torr to 100 psi with a flow capacity of 50 sccm (standard cubic centimeters per minute) to 50 slm (standard liters per minute).

The 640B Series Pressure Controller can be used in either upstream or downstream pressure control applications. The transducer inlet port is identified as the "Controlled Pressure Port" to ensure that you install the 640 Pressure Controller into your system correctly.

The 640B Series Controllers provide two user-settable alarm trip points. The trip points can be set from 1 to 100% of full scale. Each trip point controls an open collector transistor. An LED light located on the top of the unit, indicates the trip point status.

Note	The proportional control valve in the 640 Pressure Controller is *not* a positive shutoff valve. Depending upon your application, you may need to install a separate positive shutoff valve.

[1] The RoHS, "Restriction of Hazardous Substances," directive aims to restrict certain dangerous substances commonly used in electronic and electronic equipment.

How This Manual is Organized

This manual provides instructions on how to set up and install a 640B Series unit.

Before installing your 640B Series unit in a system and/or operating it, familiarize yourself with all precautionary notes in the *Safety Messages and Procedures* section at the front of this manual. Observe and obey all WARNING and CAUTION notes provided in 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 controller with all its functions and features.

Appendix A: Product Specifications, lists the specifications of the instrument.

Appendix B: Valve Orifice Selection, presents the information used to select the appropriate flow range for nitrogen and other gases.

Appendix C: Gas Density Table, lists the standard density of commonly used gases.

Appendix D: Model Code Explanation, explains how the model number of your 640 controller lists the features included in the unit.

Manual Conventions

The following conventions apply throughout this manual:

$\overline{\text{XXXXXX}}$ *For inputs:* Indicates that the line must be pulled low to activate the function.

$\overline{\text{XXXXXX}}$ *For outputs:* Indicates that the output is active low.

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 640 Series 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, and toxic materials.**

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Chapter Two: Installation

How To Unpack the 640 Series Controller

MKS has carefully packed the 640 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, and the like, 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, please refer to the Customer Support section of Chapter 1 for instructions on obtaining a RMA Number (Return Material Authorization Number) and details on the Health and Safety form that is required with every return.

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:

- 640 Series Pressure Controller
- 640 Series Instruction Manual (this manual)

Optional Equipment:

- Electrical Connector Accessories Kit - 640A-K1 (includes a mate to the I/O connector)
- Interface cables

Product Location and Requirements

- Ambient operating temperature range: 0° to 50° C (32° to 122° F)
- Power requirement: ±15 VDC ±5%, 200 mA maximum current
- Storage temperature range: -20° to 80° C (-4° to 176° F)
- Mount the 640 Series controller in an upright position if possible, although any mounting orientation is satisfactory. Refer to *Installing the Unit*, page 15, for more information.
- Install a separate positive shutoff valve if your system cannot tolerate some leakage across the control valve in the 640 controller. The control valve is not a positive shutoff valve so some leakage across the valve may occur.

Warning

Follow your corporate policy for 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.

- Install the 640 Series controller in a "flowing" system where gas is continually added and evacuated. Do ***not*** use the controller in a "dead-ended" system (a system which cannot remove excess pressure). The 640 Series controller is not designed to vent excess pressure to the atmosphere.
- Verify that your pressure system can withstand pressure equal to the full scale range of the transducer. Your pressure system may be exposed to the full scale pressure since the 640 controller will control over the entire full scale range of the transducer. As a precaution, you may choose to install a safety valve in your system to vent excess pressure.
- Take care not to expose the transducer to pressures above its full scale range. Pressures exceeding 45 psia or twice the full scale pressure (whichever is greater) may damage the transducer.

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

To order a metal braided shielded cable, add an "S" after the cable type designation. For example, to order an overall metal braided shielded cable to connect to a 246 unit, use part number RCB259S-5-10. Use part number RCB259-5 to order a non-shielded cable.

Interface Cables	
To Connect To . . .	**Use Cable . . .**
Type 246, 247, or 113 set point/display module	RCB259S-5-10/ RCB259-5-10
Type 647 or 167 set point/display module (includes open and close lines)	RCB147S-1-10/ RCB147-1-10

Table 2: 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 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.

The I/O Connector

The Type 640 Series controller has one 15-pin, male Type "D" connector that provides the pressure output, set point input, and trip point output signals.

I/O Connector Pinout	
Pin #	**Assignment**
1	Valve Test Point
2	Pressure Signal Output
3	Valve Close
4	Valve Open
5	Power Common
6	-15 V
7	+15 V
8	Set Point In
9	No Connection
10	Optional Input
11	Signal Common
12	Signal Common
13	Trip Point A Out
14	Trip Point B Out
15	Chassis Ground

Table 3: I/O Connector Pinout

Note The "No Connection" pin assignment refers to a pin with no internal connection.

Pressure Signal Output (Pin 2)

The 640 Series controller allows you to access the pressure signal from the transducer, correct it in some way, and re-introduce it into pin 10 of the 640 Series controller to be used as the input signal in closed-loop control. This function is useful if you need to correct for a zero offset.

Pin 2 accesses the pressure signal as it travels from the transducer to the control circuitry. Pin 10, re-introduces the signal into the 640 Series controller.

Set Point Input (Pin 8)

The set point input signal can be a 0 to 5 Volt (factory setting) or 0 to 10 Volt signal. The range of the set point input signal must *match* the range of the pressure output signal. The 640 controller is initially configured for a 0 to 5 Volt pressure output signal. Therefore, the set point input signal must be 0 to 5 Volts, where 5 Volts represents 100% of full scale. To change the range of the pressure output signal to 0 to 10 Volts, you must reposition jumpers on the Transducer board. Refer to *How To Change the Pressure Output Signal Range*, page 48, for instructions on changing the pressure output range.

Note For downstream control applications, the 640 controller must have sufficient pressure on its inlet side to achieve the set point.

Optional Input (Pin 10)

Use pin 10 to re-introduce another signal, such as a zero corrected pressure signal, into the control circuitry of the 640 Series controller. The corrected signal introduced on pin 10 overrides the pressure transducer signal (pin 2), and is sent to the control loop circuitry.

The Trip Point Pins (Pins 13 and 14)

The 640 Series controller offers two alarm trip points; Trip Point A and Trip Point B. Each trip point has an LED and adjustment pot on the top cover. The trip points are NPN open collector transistors.

The trip points can be set from 1 to 100% of full scale by adjusting the appropriate trip point pot located on the top of the unit. The trip point setting is a 0 to 5 VDC signal available on the side of the unit.

Use the appropriate trip point output signal to control a relay or another piece of equipment, such as a valve, or as a digital input to a computer. The trip point signal is pulled to ground when the trip point is on. The voltage value of the pin is 5 Volts when the respective trip point is off.

Refer to *Trip Points*, page 39, for a complete description of the trip points..

Gas Pressure and Control

Pressure Limits

The control valve, enclosed in the 640 Series controller, is rated for a maximum inlet pressure of 150 psig for orifice sizes A through 4; 30 psig for orifice sizes 5 and 6. For more information refer to *Applications with a Large Differential Pressure,* page 40.

The control valve is *not* a positive shutoff valve. Some leakage across the valve may occur. Refer to *Appendix A: Product Specifications,* page 51, for the leak integrity specifications. If necessary, install a separate positive shutoff valve in your system.

Caution

Take care not to expose the transducer to pressures above its full scale range. Pressures exceeding 45 psia or twice the full scale pressure (whichever is greater) may damage the transducer.

Installing the Unit

The 640 Series Pressure Controller can be mounted to provide either upstream or downstream pressure control. Your application determines how to mount the unit into the pressure system. Connect the port labeled "Controlled Pressure Port" to the system whose pressure you need to control.

Note

MKS defines "upstream" and "downstream" control by the location of the controlled volume *relative to* the 640 Series Pressure Controller.

Downstream Pressure Control

Downstream pressure control occurs when the 640 Series controller is positioned *before* the controlled pressure volume in the gas flow path, so that the controlled volume is *downstream* of the 640 Series controller. The gas flow enters the 640 Series controller on the valve side, opposite the "Controlled Pressure Port." Figure 1, page 16 shows the gas flow for downstream control.

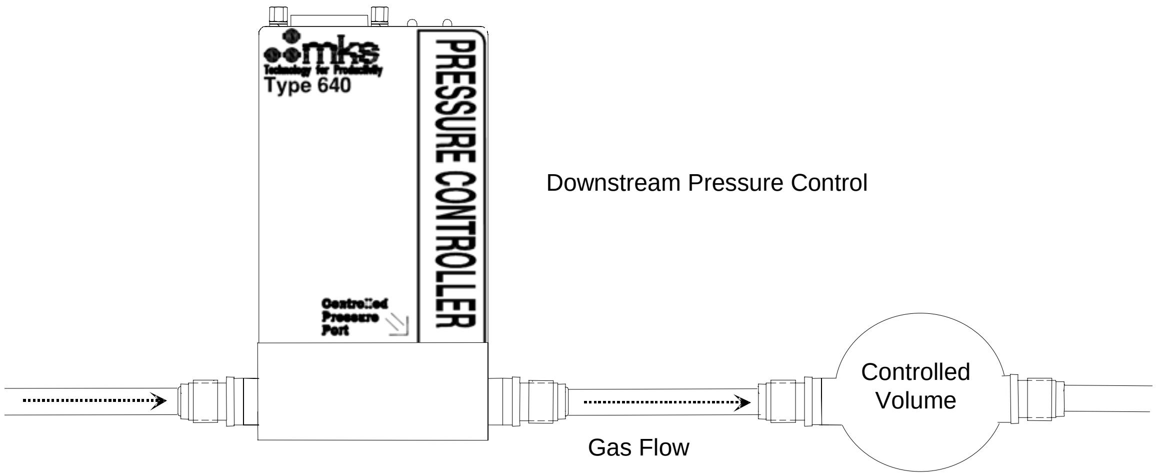

Figure 1: Downstream Pressure Control

The 640 Series controllers are shipped from the factory configured for downstream pressure control. Refer to Table 8, page 29, for the initial configuration of the unit.

Upstream Pressure Control

Upstream pressure control occurs when the 640 Series controller is positioned *after* the controlled pressure volume in the gas flow path, so that the controlled volume is *upstream* of the 640 Series controller. The gas from the pressure system enters the controller on the transducer side, labeled "Controlled Pressure Port." Figure 2 shows the gas flow for upstream control.

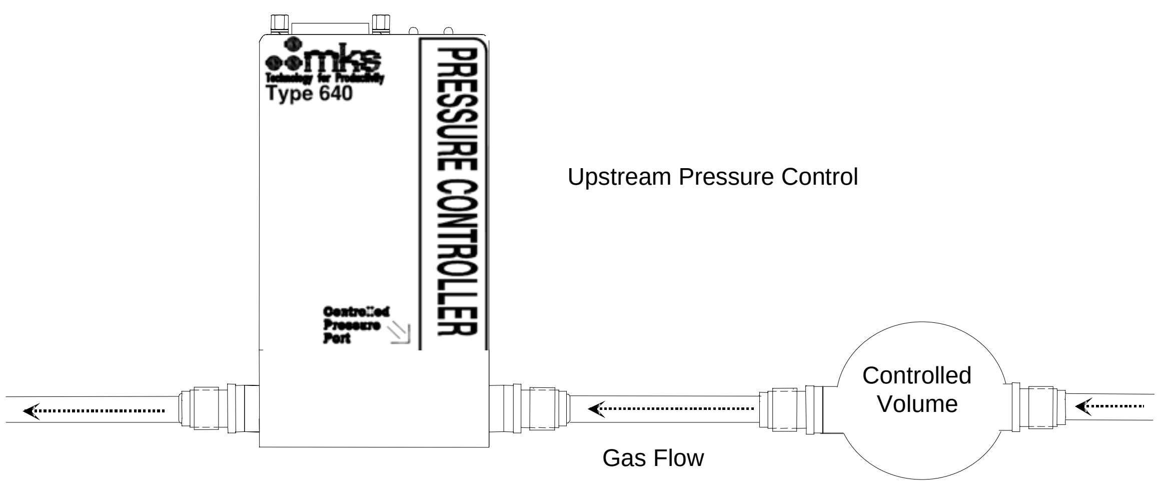

Figure 2: Upstream Pressure Control

The 640 Series controllers are shipped from the factory configured for downstream pressure control. To configure the pressure controller for upstream control, you must change switch settings inside the unit. Refer to *How To Select Upstream Control*, page 49, for instructions.

Dimensions

Note All dimensions are listed in inches with millimeters referenced in parentheses.

Side Port Version

Front and Back Views

The front of the unit has a “Controlled Pressure Port” label to indicate the transducer port. The opposite port houses the control valve. The gas flow can enter the unit through either port, depending upon whether you need upstream or downstream pressure control.

The back of the unit has the serial number tag and the pinout for the 15-pin Type “D” connector.

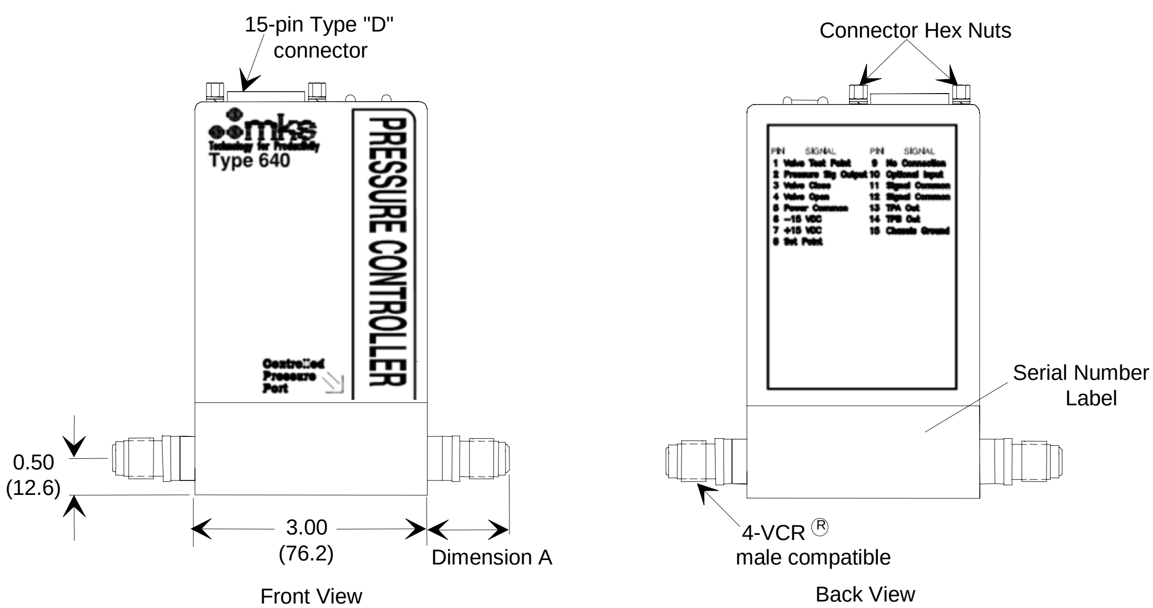

Figure 3: Front and Back Views of the Side Port 640 Series Controller

Fitting Dimension	
Fitting Type	**Dimension A**
Cajon® 4-VCR® Male	0.94 (23.8)
8-VCR Male	1.17 (29.7)
¼” Swagelok®	1.06 (26.9)

Table 4: Fitting Dimension

Side View

Pressure controllers have trip point test jacks located on the left, or valve, side of the unit. The test jacks enable you to measure the voltage value of each trip point while adjusting it via pots on the top of the unit. The trip point setting is adjustable from 0 to 5 Volts.

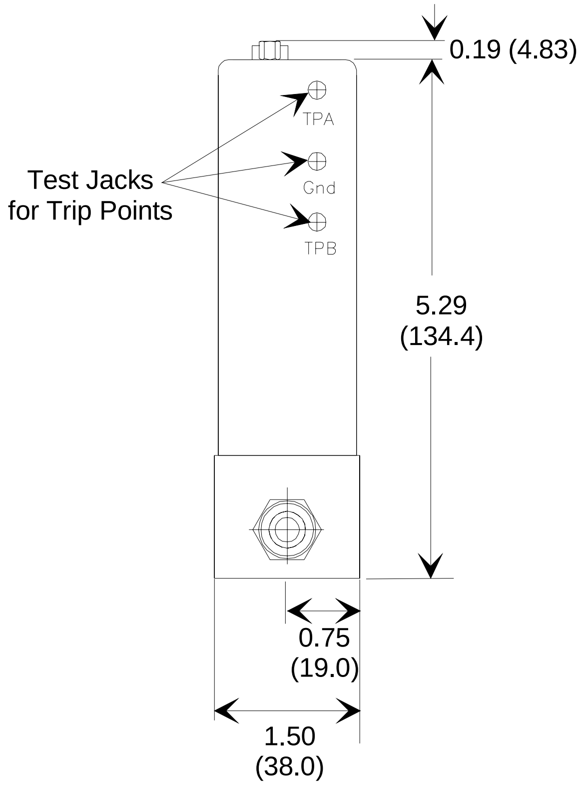

Figure 4: Side View of the 640 Series Controller
(Side opposite pressure controlled port)

Down Port Version

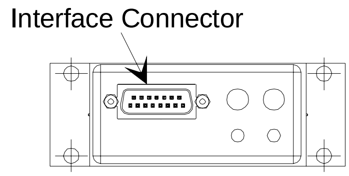

Figure 5: Top View of the Down Port Type 640 Controller

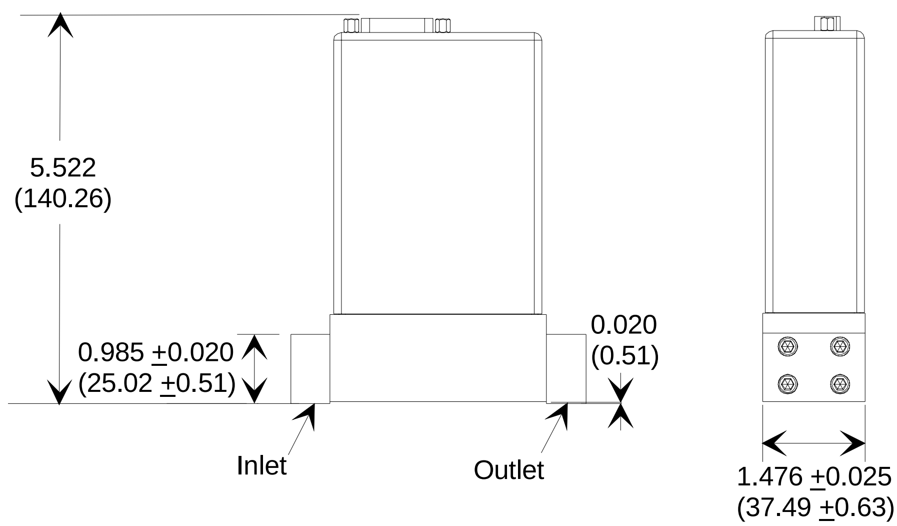

Figure 6: Front and Side View of the Down Port Type 640

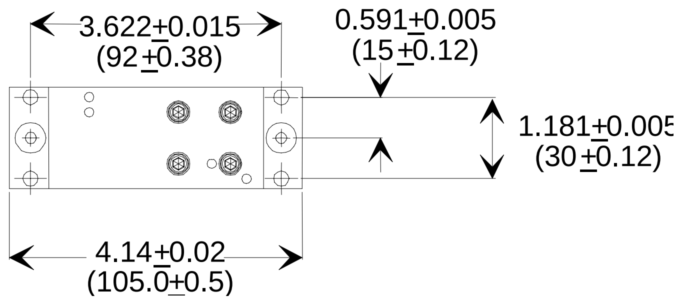

Figure 7: Bottom View of the Down Port 640

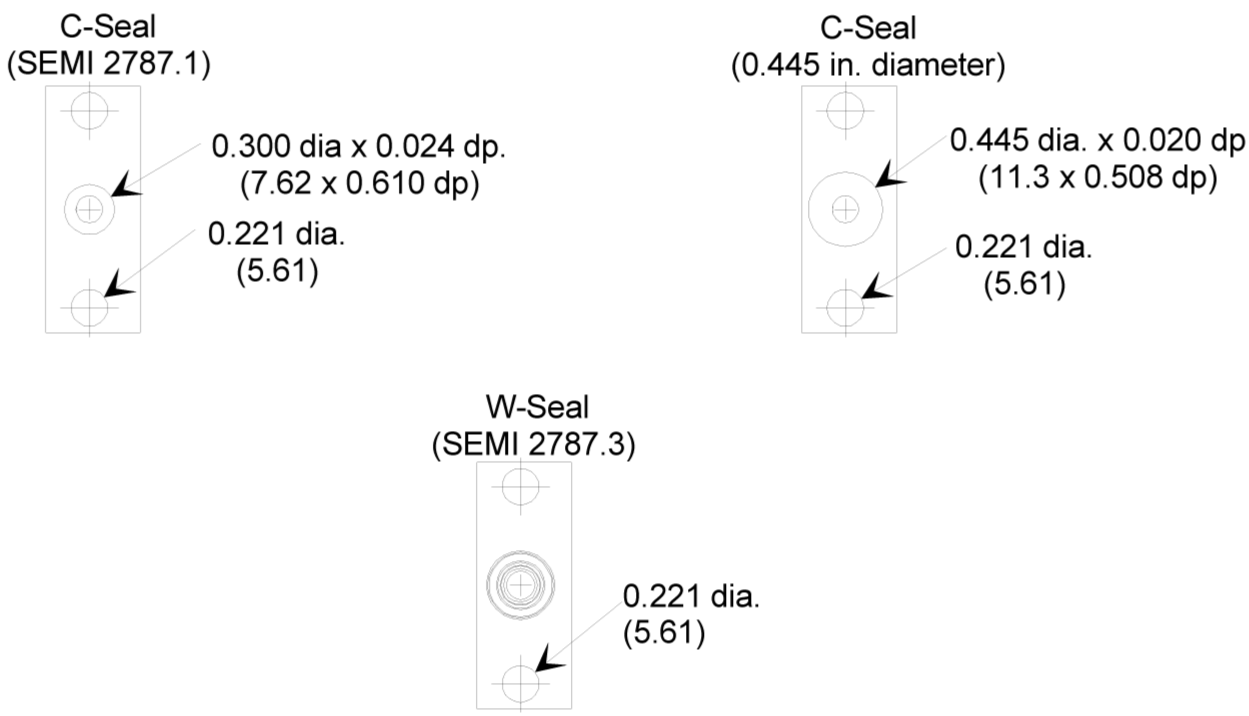

Figure 8: Bottom View of the Down Port Seals

Side Port Controller Mounting Instructions

Fittings

The 640 Series pressure controller is available with the following fittings:

- Cajon 4-VCR male compatible
- Cajon 8-VCR male compatible
- ¼" Swagelok compatible

Mounting Hardware

The Side Port 640 Series controller has four threaded mounting holes on the bottom or base of the unit. Use #8-32 hardware to mount the unit. Figure 9 shows the location and dimension of the mounting holes.

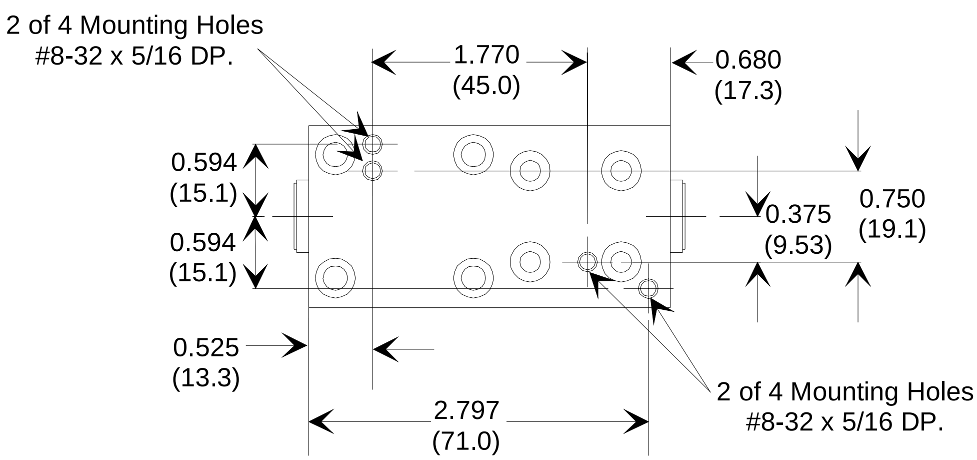

Figure 9: Bottom View of the Side Port 640 Series Controller

Down Port Controller Mounting Instructions

Refer to SEMI specification 2787.x for specific information on each fitting, as shown in Table 5.

SEMI Specifications for Down Port Fitting Options		
Fitting	**Model Code Designation**	**SEMI Specification**
C-Seal	C	2787.1
C-Seal (0.445 inch diameter)	D	—
W-Seal*	H	2787.3
** Consult factory for availability* *— No SEMI Specification applies*		

Table 5: SEMI Specifications for Down Port Fitting Options

Caution

1. **Handle the 640 Down Port Controller with extreme care. Be especially careful when placing the 640 Down Port Controller upright on a surface. Any scratches, dings, or dents on the bottom surface of the controller will cause improper sealing and may create a leak.**

2. **Do not remove the four (4) screws on the end of the controller. The internal seals are designed for one use only. The fitting surface may not remain flat if the screws are loosened.**

How To Connect the C-Seal Fittings

Note This section covers the mounting instructions for both the SEMI 2787.1 compliant and 0.445 inch diameter C-seals.

1. Select the retainer and screws appropriate for the type of C-seal.

   There are two types of seal assemblies available:

   - Alpha-C™ is a nickel clad Inconel® 718 C-seal in a stainless retainer
   - Beta-C™ is an all 316L VIM/VAR stainless steel C-seal in a stainless steel retainer

SEMI 2787.1 C-Seal Retainer (EG&G Part Numbers)	
Type of C-Seal	**Part Number**
Alpha-C™	201015
Beta-C™	201027
The SEMI 2787.1 retainer is 0.004” thick. The gland depth is 0.024” in both the substrate and the controller	

Table 6: SEMI 2787.1 C-Seal Retainer (EG&G Part Numbers)

0.445 Inch Diameter C-Seal Retainer (EG&G Part Numbers)		
Type of C-Seal	**Substrate Gland Depth**	**Part Number**
Alpha-C™	0.020	201002
	0.030	201050
Beta-C™	0.020	201031
	0.030	201043
The retainer is 0.009” thick for the 0.020 gland depth *The retainer is 0.004” thick for the 0.030 gland depth*		

Table 7: 0.445 Inch Diameter C-Seal Retainer

2. Remove the protective packaging from the controller.

3. Hold the C-seal gasket by the retainer and remove the protective packaging.

4. Clean the sealing surfaces of the MFC and substrate using a clean room swab dampened with a solvent such as isopropyl alcohol. Wipe the surfaces in a circular pattern with light pressure. Blow clean the surfaces with filtered nitrogen.

Note Clean all re-used sealing surfaces prior to resealing. The C-seals are not reusable and should be discarded after use.

5. Use filtered nitrogen to blow clean the controller and C-seal.

6. Invert the controller and place the C-seal in the retainer, onto the controller bottom surface.

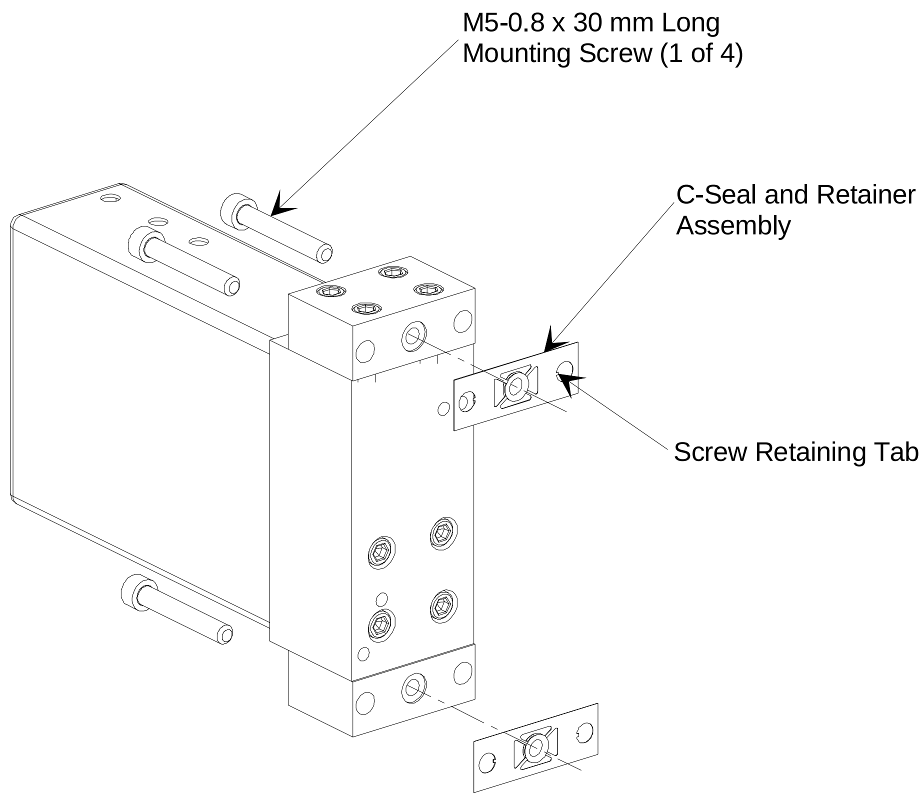

Figure 10: Exploded View of the C-Seal Components

7. Align the C-seal in the counter bore and the two screw holes in the retainer, with the screw holes in the controller.

8. Insert the mounting screws through the controller and thread them through the retainer so that the locking tabs in the retainer hold the screws and seal in place.

   The controller has been designed for M5 x 30 mm socket head cap screws. You may use 10-32 UNF x 1.25 long socket head cap screws instead of the metric screws, however the retainer will fit somewhat differently.

9. Place the controller and seal assembly onto the substrate; make sure to align the seals and screws properly.

10. Finger-tighten the screws evenly. Ensure that the controller is level or parallel to the substrate.

11. Use a hex driver to tighten the mounting screws with increments of approximately $^{1}/_{8}$ turn each. ***Do not*** make a "criss-cross" pattern; instead, close the fitting to substrate gap about halfway on one fitting then on the other. Finish the seal on the first fitting followed by the second.

Caution **Tighten the screws so that the seal is evenly tightened and the controller is not twisted. Incorrectly tightening the screws may damage the seal.**

12. Apply the final seating torque appropriate to the fastener used.

Caution **The fastener material, plating, lubrication, and size define the torque limitations that should be applied to the screw. Refer to the screw manufacturer's literature for the proper torque levels.**

13. Inspect the assembly to ensure that the controller is uniformly bottomed against the substrate and the retainer is tightly clamped.

How To Connect the W-Seal (SEMI 2878.3) Fittings

Note The gaskets used in the W-seal are also referred to as IGS (Integrated Gas Systems) gaskets. Replacement gaskets (part number UGF-6.35G) are available from Fujikin of America, Inc.

1. Remove the protective packaging from the controller.

   Fujikin has a gasket setting tool (part number IGS-Gasket-tool) available to facilitate the assembly process.

2. Hold the W-seal gasket by the retainer and remove the protective packaging.

3. Use filtered nitrogen to blow clean the controller and W-seal gasket.

Caution **Be careful not to damage the gasket. A damaged gasket will not seal properly.**

4. Install the gasket and retainer into the controller.

   The retainer will hold the gasket in place.

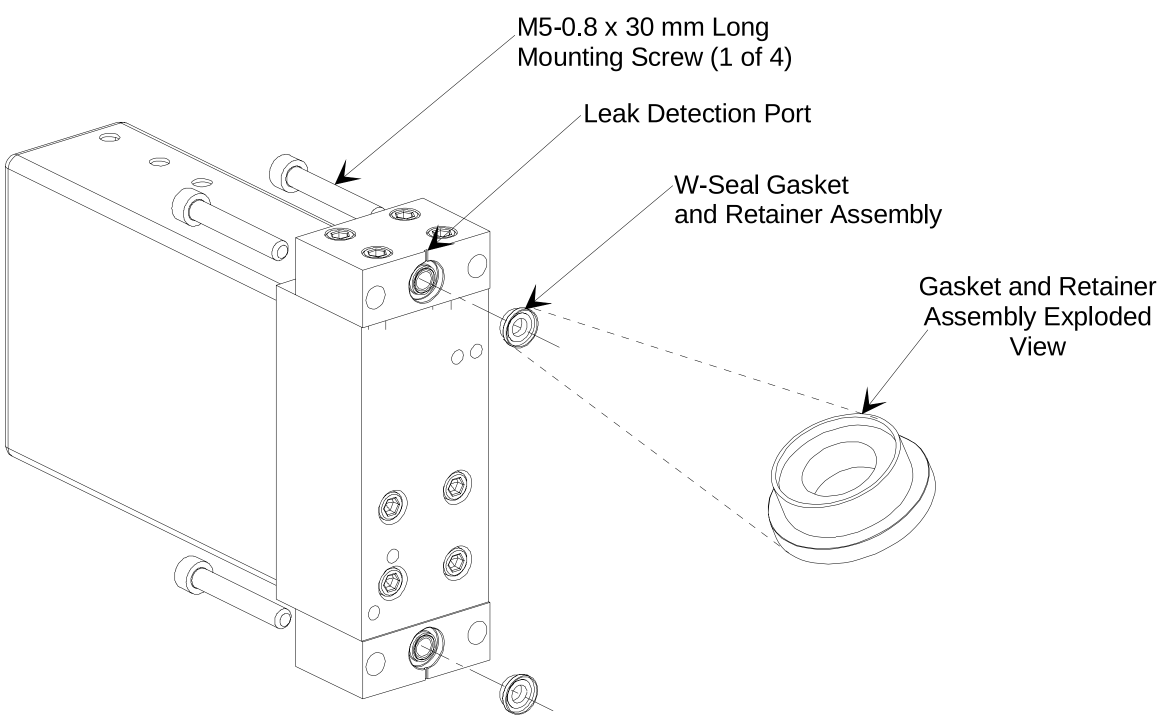

Figure 11: Exploded View of the W-Seal Components

5. Align the controller with the substrate and set the controller in place.

6. Finger-tighten the four (4) M5 x 30 mm long socket head cap screws evenly. Ensure that the controller is level or parallel to the substrate.

7. Use a hex driver to tighten the mounting screws with increments of approximately $^{1}/_{8}$ turn each. ***Do not*** make a “criss-cross” pattern; instead close the fitting to substrate gap about halfway on one fitting then on the other. Finish the seal on the first fitting followed by the second.

8. Refer to the screw manufacturer’s documentation for the final torque instructions.

Caution

The fastener material, plating, lubrication, and size define the torque limitations that should be applied to the screw. Refer to the screw manufacturer’s literature for the proper torque levels.

9. Leak check the controller using the leak port, located at the interface between the controller and the substrate.

   Refer to Figure 11, page 26, for the location of the leak detection port.

Initial Configuration

The 640 Series Pressure Controller is shipped from the factory with the configuration listed in Table 8.

Initial Configuration		
Feature	**Setting**	**Options**
Pressure Control	Downstream	Upstream
Set Point Input*	0 to 5 V	0 to 10 V
Pressure Output	0 to 5 V	0 to 10 V
Trip Point A Setting Action	 100% F.S. Trip high (TH)	 1 to 100% F.S. Trip low (TL)
Trip Point B Setting Action	 1% F.S. Trip low (TL)	 1 to 100% F.S. Trip high (TH)
P Term	Position 0	8 settings (0 through 7) on a 10 position dial (8 repeats setting 0; and 9 repeats setting 1)
I Term	Position 0	10 settings, 0 through 9
** Input must match the pressure output signal range*		

Table 8: Initial Configuration

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Chapter Three: Overview

General Information

Figure 11 shows the top view of the 640 Series Pressure Controller. The user adjustable controls for zero, span, the P term, the I term, and the trip points are located on the top of the controller. The trip point settings can be measured through two test jacks, located on the side of unit, as shown in Figure 4, page 18.

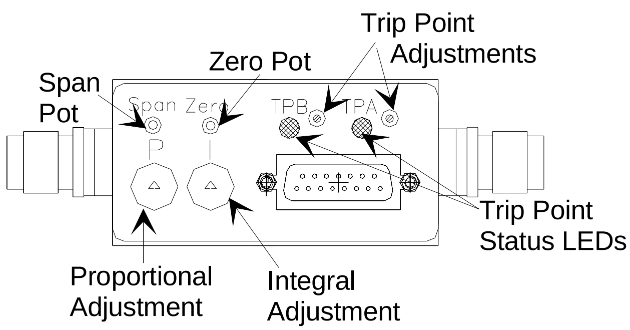

Figure 12: Top View of the 640 Series Controller

Pressure Control Range

The 640 Series controller can control pressure over a range of 2% to 100% of full scale. This means that a 640 controller with a 1000 Torr transducer can control pressure from 20 to 1000 Torr, and a unit with a 100 Torr transducer can control pressure from 2 to 100 Torr.

A Typical Control System

The 640 Series Pressure Controllers are used in a wide variety of control systems, most of which share several characteristics. Typically, a control system consists of four basic parts:

- Pressure transducer
- Control electronics
- Control valve
- Pressure system (whose pressure is being controlled)

The 640 Series Pressure Controller provides the first three components.

- The pressure transducer is an MKS Baratron capacitance manometer.
- The 640 Series unit contains the electronics necessary for pressure control.
- The control valve included in the 640 controller is a proportional control valve.
- The pressure system can be any process requiring pressure control.

How The 640 Series Pressure Controller Works

The 640 Series controller compares the pressure reading to the set point, and positions the valve to maintain, or achieve, the set point pressure. The controller functions as a PI (Proportional-Integral) controller. Both the Proportional (P) term, and the Integral (I) term have adjustable dials on the top of the 640 Series controller.

Example

Assume that your 640 Series controller is positioned for downstream control. The controlled pressure volume is positioned *before* the 640 Series controller so the controller will regulate the amount of gas entering the pressure system.

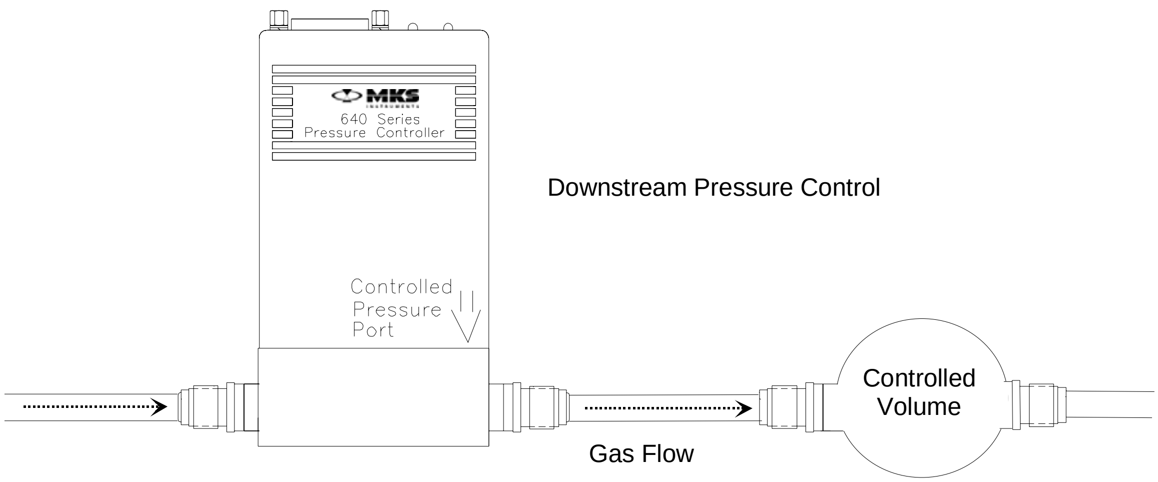

Figure 13: Sample Pressure Control System

When the actual pressure reading is *less than* the set point value, the 640 Series controller opens the valve to increase the amount of gas entering the system. As the valve opens, gas enters the pressure system, so the pressure rises to meet the set point value.

When the actual pressure reading is *greater than* the set point value, the 640 Series controller closes the valve to decrease the amount of gas entering the system. As the valve closes, less gas enters the pressure system, so the pressure drops to meet the set point value.

Tuning the 640 Series Pressure Controller

Tuning optimizes the way the 640 Series unit controls your system. The Proportional (P) and Integral (I) terms adjust the response of the 640 Series controller. The controller responds to changes in either the pressure of the system or the value of the set point.

Proportional Term

The Proportional (P), or gain, term is used as a constant to create a valve drive signal that is proportional to the error signal. The error signal is multiplied by the proportional control setting, thus creating a proportional valve drive signal. The higher the proportional control, the greater the change in valve drive signal. Typically, a higher proportional control setting yields a faster response. However, too high a proportional control setting will cause the pressure to oscillate around the set point. Too low a proportional control setting will result in a slow response from the controller. Figure 11 shows the effects of the Proportional term.

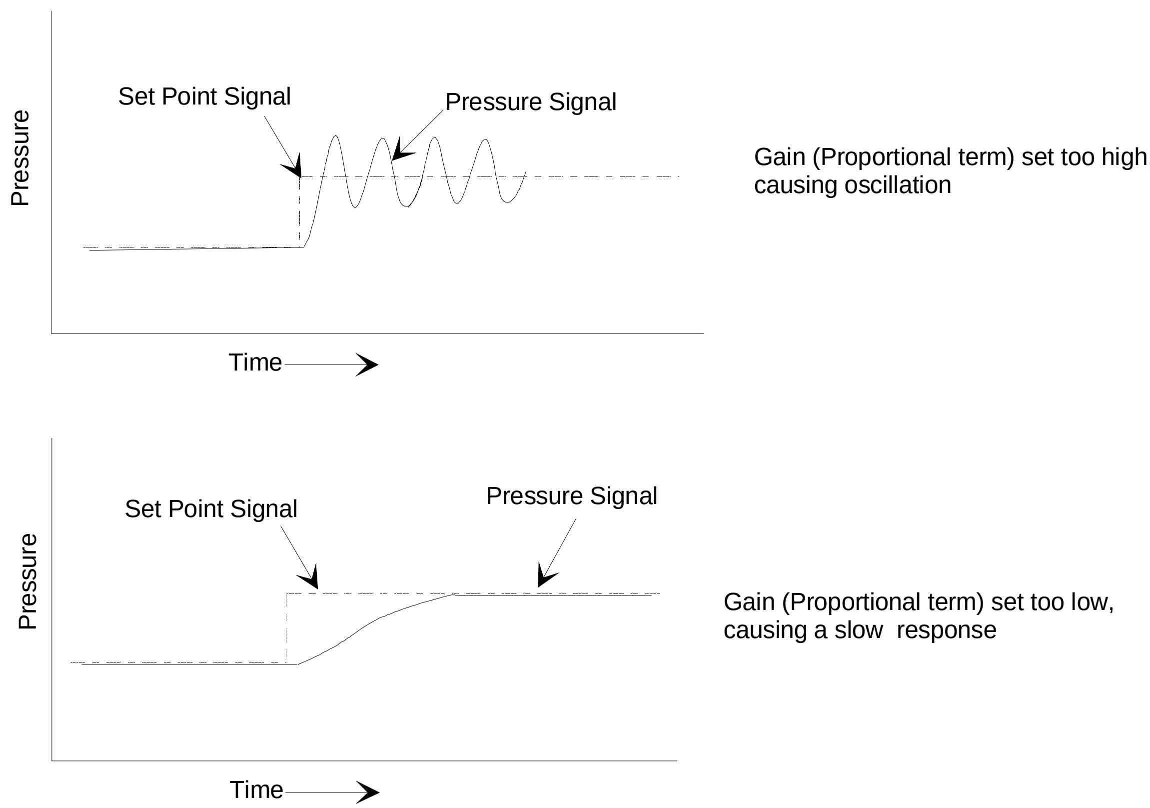

Figure 14: Effects of the Proportional Control

Adjusting the Proportional Control

The Proportional (P) term adjustment is located on the top of the 640 Series unit, as shown in Figure 11, page 31. The control is a 10-position dial, though it uses only 8 values. The last positions, 8 and 9, repeat the values of positions 0 and 1. The initial setting is 0. As you increase the setting number, the value of the term increases by a factor of approximately 2.8.

Integral Term

The action of the Integral (I) term creates a valve drive signal that is proportional to the magnitude and sign of the area under the error signal curve (error signal with respect to time). Therefore, as time passes, the integral term acts to position the valve to reduce the error signal to zero. An increase in the integration time increases the period of time over which the error signal is generated, and the system response gets slower. Figure 11 shows the effects of the Integral term.

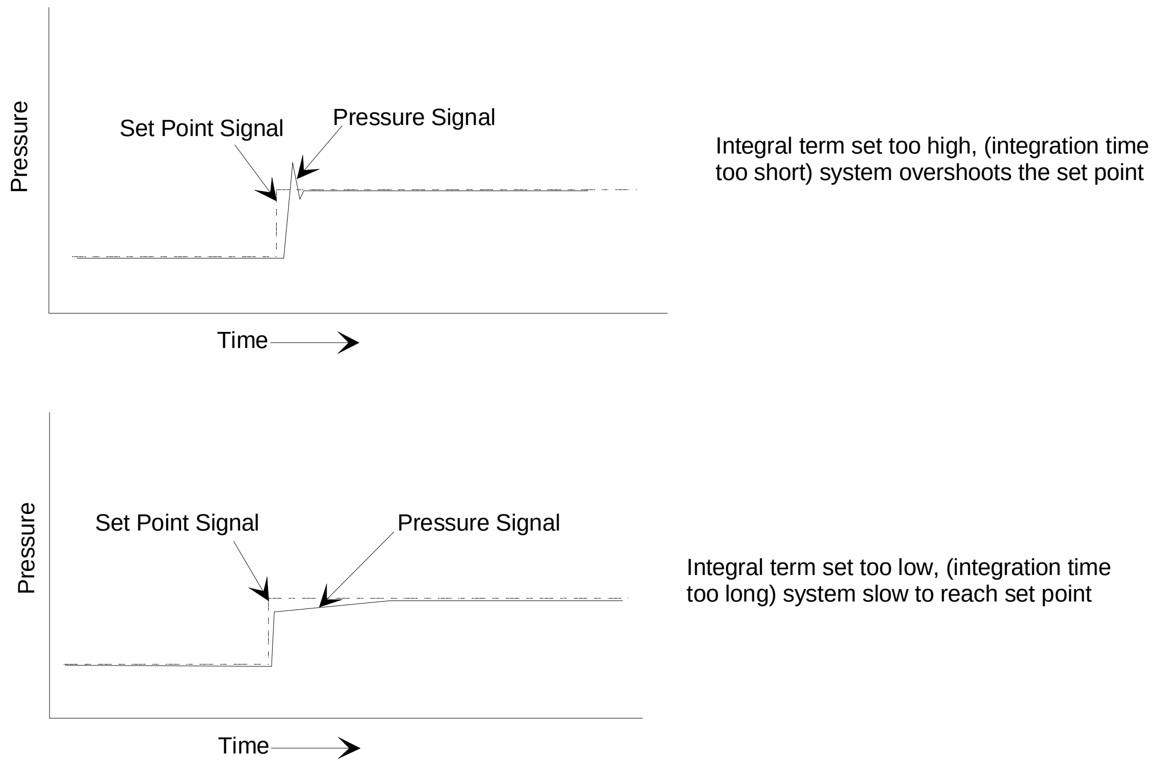

Figure 15: Effects of the Integral Control

Adjusting the Integral Control

The Integral (I) term adjustment is located on the top of the 640 Series unit, as shown in Figure 11, page 31. The control is a 10-position dial where the 0 setting has the *longest* integration time; the 9 position setting has the *shortest* integration time. The initial setting is 0.

Note To *shorten* the integration time, *increase* the I term setting.

Tuning the 640 Controller

Tuning the 640 controller involves adjusting the Proportional and Integral terms to optimize the response of the controller *in your system*. Since every system is different, the optimum settings for the P term and I term will vary. Also, the response of the system to increasing and decreasing pressures may vary. Tune the system to provide the best response in the direction of pressure change that you anticipate.

The following graphs show the response of the 640 controller to changes in the set point. The set point changed from 4 Torr (2 Volts) to 6 Torr (3 Volts), and back again. The pressure response was tracked using a digital storage oscilloscope.

Note

The following three graphs were generated on a system consisting of a 640 controller positioned for downstream control, with a 10 Torr transducer, 1000 sccm flow of nitrogen gas, 30 psia inlet pressure, and 1 liter system volume. Tuning with nitrogen may not offer maximum performance if another gas is used for processing.

The same P and I term values may not create the same effect in your system.

Controller Response with the Initial Values

The initial values (P = 0; I = 0) yield:

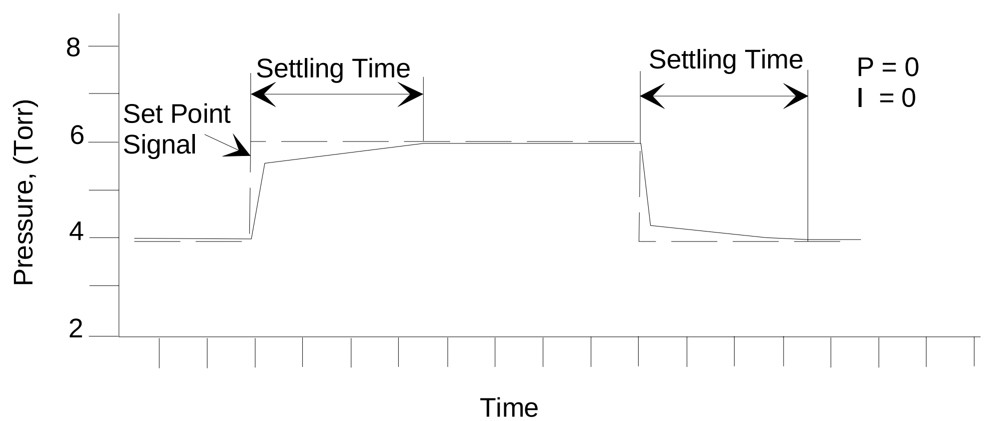

Figure 16: Controller Response with Initial P Term and I Term Values

The controller response is slow to reach the set point, however, there is no pressure overshoot and no oscillation. Increase the P term to create a faster response.

Controller Response with Increased P Term

Increasing the P term to 1 while holding the I term at 0 yields:

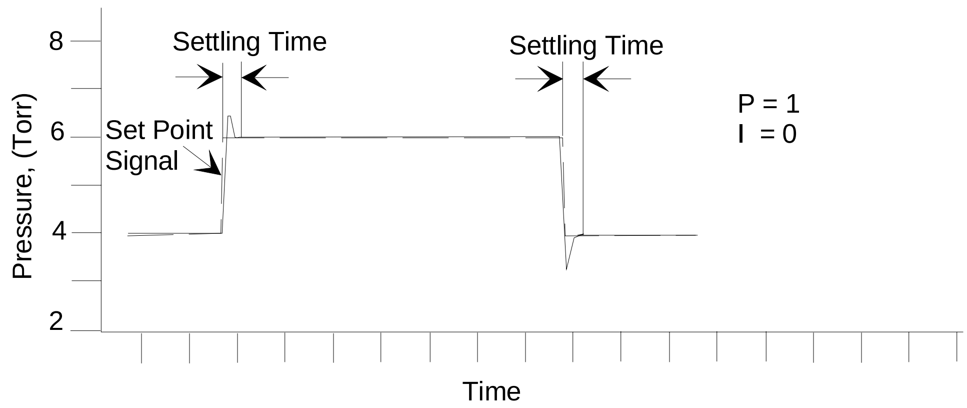

Figure 17: Controller Response with Increased P Term

The controller responds much faster, however some overshoot occurs.

Controller Response with Increased I Term

Reducing the P term to 0 and increasing the I term to 5 yields:

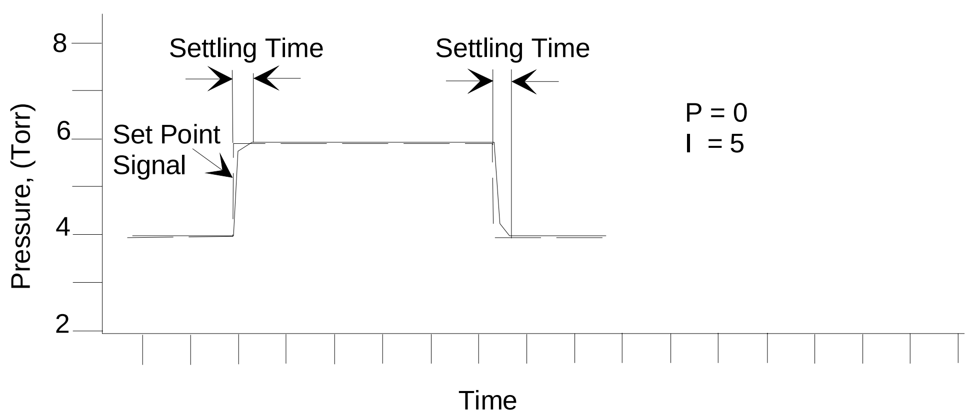

Figure18: Controller Response with Increased I Term

The response of the controller is quick, yet no overshoot occurs. This combination of P term and I term yields the best control for our example system.

Priority of Commands

The 640 Series controller has an established hierarchy that it uses to determine which commands take precedence. The commands and operating modes are listed according to the order of priority (from highest to lowest):

- Valve Close Command
- Valve Open Command
- Set Point Recognition Operating Mode
- Closed-Loop Control Operating Mode

$\overline{\text{Valve Close}}$ and $\overline{\text{Valve Open}}$ Commands: The valve override commands immediately move the valve to the appropriate position, either closed or open. These valve commands take precedence over any other operation. The overline ($\overline{\quad\quad}$) indicates that the valve commands are active when their respective pins are pulled low. For example, if the valve is currently operating under pressure control to maintain a desired pressure, and the Valve Open pin (pin 4) is pulled low, the valve will move to the fully open position. The Valve Close command has the highest priority. Therefore, if both the Valve Open and Valve Close commands are issued, the valve will move to the fully closed position.

Set Point Recognition Operating Mode: The 640 Series controller can control pressure over the range from 2% to 100% of full scale. If the set point signal is *less than* 1% of full scale, the set point recognition becomes effective. The 640 Series controller positions its valve in the fully closed position for downstream control, or the fully open position for upstream control. Increase the set point signal to a value *greater than* 1% of full scale to resume pressure control.

Closed-Loop Control Operating Mode: When the 640 Series controller operates in closed-loop control mode, it compares the pressure signal from its transducer (pin 2) or any signal on the Optional Input pin (pin 10) to the set point. The 640 Series controller positions its valve to achieve or maintain the set point pressure (or other variable if the Optional Input is used) in the system. Closed-loop control mode has the lowest priority. The 640 Series controller defaults to closed-loop control in the absence of any higher priority commands..

Refer to *The I/O Connector*, page 13, for more information on the Optional Input function.

Trip Points

The 640 Series controller provides two trip points (Trip Point A and Trip Point B). Each trip point operates independently and controls an open collector output that can be connected to an external relay. Each trip point has an adjustment pot, a status LED, and a test jack. Refer to Figure 11, page 31, for the location of the trip point adjustment pots and LEDs. The test jacks are located on the side of the unit, as shown in Figure 4, page 18. Refer to *How To Adjust the Trip Point Values,* page 44, for instructions on changing the trip point values.

Action of the Trip Points

The trip points can be turned on when the pressure is above or below the trip point value, depending upon the location of jumpers on the Transducer board. The initial configuration is:

- Trip Point A is set to trip high; it is on when the pressure is *above* the trip point (it is off when the pressure is below the trip point value)
- Trip Point B is set to trip low; it is on when the pressure is *below* the trip point (it is off when the pressure is above the trip point value)

When on, the trip point is connected, through the collector of an NPN transistor, to power ground. Refer to *Trip Point Specifications,* page 52, for the ratings. You can use the units' trip point output (available on pins 13 and 14 of the I/O connector) for further process control.

To change the action of a trip point, refer to *How To Select the Trip Point Action,* page 45.

Applications with a Large Differential Pressure

Applications with a large differential pressure between the inlet and outlet, or a large inlet pressure, may require special precautions:

- *If the inlet pressure is more than two times the transducer full scale pressure or 45 psia, whichever is greater*

  You must ensure that the valve will never be fully opened to the transducer. Pressures in excess of 45 psia or two times the transducer full scale (whichever is greater) may damage the transducer.

- *The inlet pressure on the valve is 150 psig (orifice sizes A through 4) or 30 psig (orifice sizes 5 and 6)*

  This is the maximum inlet pressure rating of the valve. The force of high inlet pressure on the valve may inhibit valve movement. A normally closed valve may be unable to open.

Labels

The 640 Series controller carries a serial number label which identifies the serial number, model number, and pressure range. It also displays the CE Mark which indicates compliance with European directives. The serial number label is located on the back of the unit.

Figure 19: Serial Number Label

Chapter Four: Operation

How To Check the Zero

Check the transducer zero before operating the unit initially 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.

Note The port labeled "Controlled Pressure Port" serves as the transducer inlet port. Figure 3, page 17, shows the labels on the unit.

How To Zero a Type 640 (Absolute) Unit

To zero a 640 controller (with an absolute transducer inside) 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 unit in the *same orientation* as it will be positioned when installed in your system.

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 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 a proper zeroing pressure). In this case, mount the unit on the leak detector *in the same plane of orientation as it will be during actual use*.

To properly zero a 640 controller (that contains an absolute transducer):

1. Install the 640 controller in a system and connect a power supply/readout.

   The pressure signal is available on pin 2 of the I/O connector. Use either pin 11 or 12 as the ground. Refer to Table 3, page 13, for the pinout of the I/O connector.

2. Pump the system down to a pressure below the resolution of the transducer within the 640 controller. Table 9 lists the recommended pressure levels.

Highest Pressure for Zero Adjustment of an Absolute Transducer	
Full Scale Range	**Pressure**
10 Torr	< 5 x 10^{-4} Torr
100 Torr	< 5 x 10^{-3} Torr
1000 Torr	< 5 x 10^{-2} Torr
60 psia	< 2 x 10^{-3} psia
100 psia	< 5 x 10^{-3} psia

Table 9: Highest Suggested Pressure for Zero Adjustment of an Absolute Transducer

3. Using a small screwdriver, adjust the ZERO pot until the readout displays zero (0000).

   Refer to Figure 11, page 31, for the location of the ZERO pot.

How To Zero a Type 641 (Gage) Unit

Follow the instructions below to zero a 641 controller (that contains a gage pressure transducer).

1. Install the 641 controller in a system with a power supply/readout.

   The pressure signal is available on pin 2 of the I/O connector. Use either pin 11 or 12 as the ground. Refer to Table 3, page 13, for the pinout of the I/O connector.

2. Open the process port to local atmospheric pressure.

Note The "reference" port of the transducer is always open to the local atmospheric conditions. The zero is set only when the "Controlled Pressure Port" is also open to local atmospheric pressure.

3. Using a small screwdriver, adjust the ZERO pot until the readout displays zero (0000).

   Refer to Figure 11, page 31, for the location of the ZERO pot.

How To Adjust the Span

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, contact an MKS Service Center for calibration.

How To Tune the 640 Series Controller

You may need to tune the 640 Series controller to optimize how it controls your system. Tuning consists of varying the P (Proportional) and I (Integral) parameters to achieve the fastest, smoothest response to changes in the set point value. Ideally, the 640 controller should respond to a new set point value by rapidly changing the pressure in the system to match the set point with little under or overshoot. Refer to *How The 640 Series Pressure Controller Works*, page 33, for a complete description of the effects of the P and I terms.

The P term and the I term are initially set to position 0. The controls are located on the top of the unit, as shown in Figure 11, page 31. Each control has a 10-position dial. The P term has only 8 values; positions 8 and 9 repeat the values of positions 0 and 1.

1. Send your set point signal. If you are using multiple set points send the most critical set point.
2. Change the set point in the direction that you expect the system to deviate in, and observe the controller response.

   A properly tuned controller will reach the new set point rapidly, without overshoot.

   - If the controller is too slow to reach the set point, increase the P term.
   - If the pressure fluctuates around the set point, decrease the P term.
   - If the pressure overshoots the set point and then settles to the correct pressure, increase the I term.
3. Repeat step 1 until the response of the controller is optimized.
4. Change the set point in the opposite direction, and observe the response.

   Although the response may vary slightly, it should be acceptable. If it is not acceptable, follow the guidelines in step 1 to tune the controller.

How To Adjust the Trip Point Values

Equipment required: a digital volt meter (DVM)

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.**

MOVE CAUTION TO 1ST PAGE CHAPTER 4, p.43

Each trip point has a test jack that allows you to measure the trip point setting. The test jacks are located on the side of the unit. Figure 4, page 18, shows the location of the test jacks and a ground connection. The trip point adjustment pots, located on the top of the unit, allow you to vary the trip point setting.

The range of the trip point setting is 0 to 5 Volts, corresponding to 0 to 100% of transducer full scale.

Note The trip point range is from 0 to 5 Volts, regardless of the range of the set point input and pressure output signals.

---

1. Insert the positive test probe into the test jack labeled “TP A” and the ground probe into the test jack labeled “Gnd.”

   Insert the probes sufficiently to obtain a good reading. There is no back plane in the test jacks to stop the probe.

2. Use a small screwdriver to adjust the trip point adjustment pot labeled “TP A”.

   Refer to Figure 11, page 31, for the location of the trip point adjustment pots. Turning the pot clockwise raises the trip point setting.

3. Repeat steps 1 and 2 to adjust TP B.

Refer to *How To Select the Trip Point Action,* page 45, to change the action of the trip points.

How To Select the Trip Point Action

The 640 Series controller is initially configured with TP A set to trip high (it is on when the pressure is *above* the trip point pressure) and TP B set to trip low (it is on when the pressure is *below* the trip point pressure). To change the action of the trip points you must remove the cover of the units and change jumpers on the Transducer board. Each trip point has a jumper block with the jumper positions labeled TL (trip low) and TH (trip high).

1. Stop the gas flow through the 640 Series controller.

2. Remove any leads or wires attached to the connector on the 640 Series controller.

3. Use a 3/16" hex wrench (or open-ended wrench) to remove the hex nuts on each side of the I/O connector. Remove the 4 Phillips head screws from the sides of the enclosure.

   Refer to Figure 1, page 13, for the location of the hex nuts on the I/O connector. Place the hex nuts and screws aside for safe keeping.

4. Position the controller with the front side facing you, and pull up on the enclosure to remove it.

   The board assembly will be visible, with the Transducer board facing you and the Control board behind it.

5. Locate the jumper blocks labeled "JP4" and "JP3" in the middle of the Transducer board.

   Refer to Figure for the location of the jumper blocks.

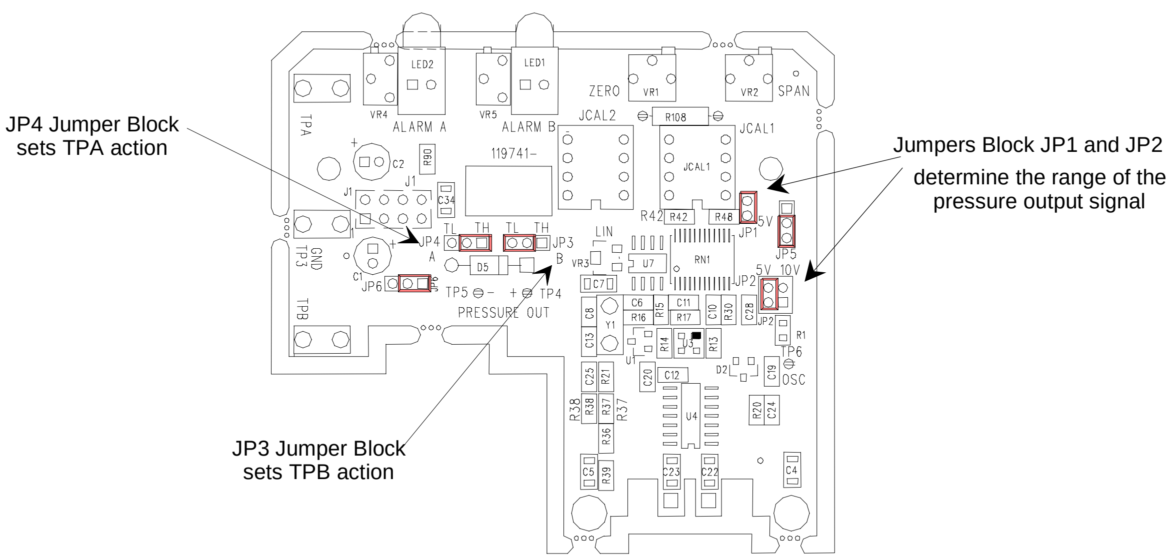

Figure 20: Jumper Positions on the Transducer Board

6. Position the jumper on jumper block "JP4" to select the action for TP A.

   Jumper block "JP3" controls TP B.

The board silkscreening defines the jumper positions. TH indicates that the trip point will be on when the pressure is above the trip point, and TL indicates that the trip point will be on when the pressure is below the trip point.

7. Slide the enclosure over the unit and press it in place.

8. Attach the hex nuts, removed in step 3, to the I/O connector. Install the Phillips heads screws in the sides of the enclosure.

9. Reconnect the leads and wires.

10.

How To Use Trip Points as Error Indicators

You can use the trip points to indicate when the error signal deviates from a given range. The error is defined as the difference between the actual pressure reading and the set point.

For example, assume you have a 100 Torr unit and your set point is 50 Torr. You want the trip points to illuminate when the error is more than ±5% of the set point value, which indicates that the pressure reading has deviated by more than ±2.5 Torr. This allows the pressure to vary from 47.5 to 52.5 Torr.

The 640 Series controller is initially configured with TP A on *above* the trip point and TP B on *below* the trip point. If you have not changed the action of either trip point, you may follow the steps below. If you have changed the action of the trip points, you need to reset them back to the initial configuration for this example. Refer to *How To Adjust the Trip Point Values,* page 44, for instructions.

1. Calculate the trip point voltage that corresponds to each trip point value:

   $$\frac{\text{Trip Point Pressure (Torr)}}{\text{Full Scale Pressure (Torr)}} \text{ x TP Adjustment Range (V)} = \text{Trip Point Voltage (V)}$$

   where the full scale pressure is 100 Torr and the TP adjustment range is 5 Volts.

   TP A: $\frac{52.5 \text{ Torr}}{100 \text{ Torr}} \times 5 \text{ V} = 2.625 \text{ Volts}$

   TP B: $\frac{47.5 \text{ Torr}}{100 \text{ Torr}} \times 5 \text{ V} = 2.375 \text{ Volts}$

2. Measure the value of TP A by inserting a positive test probe into the test jack labeled “TP A” and the ground probe into the test jack labeled “Gnd.”

   The ground connection and the test jacks are located on the side of the unit, as shown in Figure 4, page 18. A 0 to 5 V signal corresponds to a 0 to 100% full scale pressure.

3. Use a small screwdriver to adjust the pot for TP A, located on the top of the unit, to set TP A to 2.625 Volts.

   Refer to Figure 11, page 31, for the location of the trip point adjustments.

4. Measure the value of TP B by inserting a positive test probe into the test jack labeled “TP B” and the ground probe into the test jack labeled “Gnd.”

5. Use a small screwdriver to adjust the pot for TP B, to set TP B to 2.375 Volts.

   The trip points will be off when the pressure reading is between 47.5 and 52.5 Torr. Should the pressure deviate from this range the appropriate trip point will turn on and its LED will illuminate. Trip Point A will turn on when the pressure exceeds 52.5 Torr and Trip Point B will turn on when the pressure falls below 47.5 Torr.

How To Change the Pressure Output Signal Range

The pressure output signal can be a 0 to 5 Volt (initial setting) or 0 to 10 Volt signal. To change the range of the pressure output signal, and therefore, the set point input, you must remove the cover of the 640 pressure controller and reposition two jumpers on the Transducer board.

Note The range of the pressure output signal determines the range used for the set point input signal. The initial configuration is for a 0 to 5 Volt pressure output signal. Therefore, a set point input signal of 5 Volts is equal to 100% of full scale. If you change the range of the pressure output signal to 0 to 10 Volts, a 5 Volt set point signal would be 50% of full scale.

1. Stop the gas flow through the 640 pressure controller.
2. Remove the power supply and any other leads or wires attached to the connector on the 640 controller.
3. Use a $^{3}/_{16}$” hex wrench (or open-ended wrench) to remove the hex nuts on each side of the I/O connector. Remove the 4 Phillips head screws from the sides of the enclosure.

   Refer to Figure 3, page 17, for the location of the hex nuts on the I/O connector. Place the hex nuts and screws aside for safe keeping.
4. Position the controller with the front side facing you, and pull up on the enclosure to remove it.

   The MKS logo is displayed on the front of the unit. The board assembly will be visible, with the Transducer board facing you. The Control board is connected to the back of the Transducer board.
5. Locate the jumper block labeled “JP2” on the right-hand side of the Transducer board.
6. Refer to Figure , page 45, for the location of the “JP2” jumper block.
7. Position the jumper vertically, according to the silkscreening on the board.

   Position the jumper on the right-hand side for 0 to 10 Volt operation; the left-hand side for 0 to 5 Volt operation.
8. Locate the jumper block labeled “JP1”, above jumper block JP2.
9. Remove the jumper on JP1 for 10 Volt operation.

   For 5 Volt operation, the jumper must be in place.
10. Slide the enclosure cover over the unit.
11. Attach the hex nuts, removed in step 3, to the I/O connector. Install the Phillips heads screws in the sides of the enclosure..
12. Reconnect the leads and wires.

How To Select Upstream Control

The 640 Series controller is configured for downstream control when it leaves the factory. To use it in a upstream control application, you must remove the enclosure cover and reposition switch SW303 on the Control board.

1. Stop the gas flow through the 640 Series controller.

2. Remove I/O cables attached to the connector on the 640 Series controller.

   3. se a 3/16" hex wrench (or open-ended wrench) to remove the hex nuts on each side of the I/O connector. Remove the 4 Phillips head screws from the sides of the enclosure.

   Refer to Figure 3, page 17, for the location of the hex nuts on the I/O connector. Place the hex nuts and screws aside for safe keeping.

3. Position the controller with the back side facing you, and pull up on the enclosure to remove it.

   The back side of the unit lists the I/O connector pinout. The board assembly will be visible, with the back of the Control board facing you. The Transducer board is connected to the front of the Control board.

4. Locate the switch labeled "SW303" in the middle section of the Control board.

   Refer to Figure 2111 for the location of the switch.

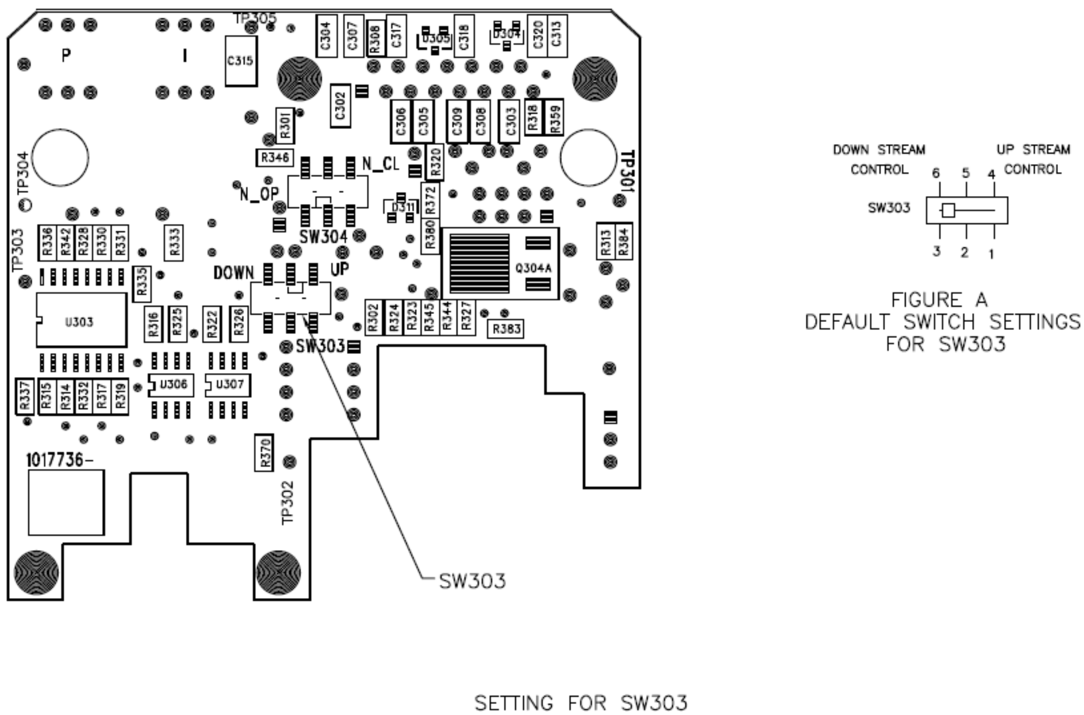

Figure 21: Switch Setting on the Control Board

5. Slide switch SW303 to the right for upstream control.

   Figure 11, page 50, shows the switch configured to operate with a normally closed valve.

6. Slide the enclosure over the unit and press it in place.

7. Attach the hex nuts and screws removed in step 3 to the I/O connector and enclosure sides.

8. Reconnect the I/O cables.

Appendix A: Product Specifications

Performance Specifications

Accuracy[2]	±0.5% Reading
CE Compliance Electromagnetic Compatibility[3]	 EMC Directive 89/336/EEC
Control Range	2.0 to 100% F.S.
Control Repeatability	±0.1% F.S.
Proportional Term	8 positions (0 through 7; positions 8 and 9 repeat settings 0 and 1)
Integral Term	10 positions (0 through 9)
Leak Integrity Internal to external Through closed *metal* valve Through closed Kel-F valve Through closed *elastomer* valve	 $<10^{-9}$ scc/sec He $<$1% F.S. or 1 sccm (with 1 ATM ΔP N_2), whichever is greater $<$0.5% F.S. (with 1 ATM ΔP N_2) 1 x 10^{-4} scc/sec He
Maximum Operating Differential Pressure[4] Valve orifices sizes A through 4 Valve orifice sizes 5 and 6	 150 psid ≤ 30 psid
Temperature Coefficient Zero Span	 ±0.04% F.S./°C ±0.04% Reading/°C

Environmental Specifications

Operating Temperature Range	0° to 50° C (32° to 122° F)

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[2] Pressure output signal includes controller error, linearity, hysteresis, and repeatability.

[3] An overall metal braided shielded cable, properly grounded at both ends, is required during use.

[4] Consistent with the overpressure limit of the transducer within the 640 Series controller.

Storage Temperature Range	-20° to 80° C (-4° to 176° F)
Storage Humidity Range	0 to 95% Relative Humidity, non-condensing

Trip Point Specifications

Trip Points	Two open collector transistors, adjustable from 0 to 100% full scale
Rated Current	30 VDC/250 mA
State	On above or below trip point; jumper selectable
Hysteresis	3% full scale (factory set)
Status LEDs	Green when the transistor is on
Settings	0 to 5 Volts corresponds to 0 to 100 % full scale

Physical Specifications

Burst Pressure	≥1500 psig
Dimensions	1.5 in x 3.0 in (less fittings) x 5.55 in max. 3.81 cm x 7.62 cm (less fittings) x 14.1 cm max.
Fittings	Cajon 4-VCR male compatible, 8-VCR male compatible, ¼ inch Swagelok compatible, C-Seal (SEMI 2787.1), W-Seal (SEMI 2787.3)
Full Scale Pressure Ranges	10, 100, 1000 Torr, 60 psi, 100 psi
Rated Orifice Flow (N_2 flow at 15 psig to atmosphere)	50, 200, 1000, 5000, 10,000, 20,000, 50,000 sccm
Input Power	±15 VDC ±5%, 200 mA, maximum
Maximum Cable Length	100 ft.
Overpressure Limit	45 psia or 200% F.S., whichever is greater
Pressure Signal Output	0 to 5 VDC initial configuration (0 to 10 VDC jumper selectable)
Set Point Input	0 to 5 V or 0 to 10 V (matches the pressure signal output)
Transducer, Baratron	
Type 640	Absolute pressure capacitance manometer
Type 641	Gage pressure capacitance manometer
Valve Options	
Type	Normally closed
Seal Material	Kel-F, Kalrez, Chemraz, Viton, or all-metal
Weight	2.54 lbs. (1.15 kg)
Wetted Material	
Standard	316L, 316LVAR, Viton, Inconel®, Nickel
Optional	316 SS (all-metal), Kalrez, Kel-F, Chemraz

Due to continuing research and development activities, these product specifications are subject to change without notice.

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Appendix B: Valve Orifice Selection

General Information

The 640 controller is available in seven (7) valve orifice sizes. You should confirm that the valve orifice in your 640 controller is the correct size for your application before you install it into your system. The orifice is *not* adjustable and is only replaceable at the factory.

This selection guide is valid with either seal material (metal or elastomer).

Checking the Orifice Size

The orifice number is included in the model code number of your 640 controller, as shown in Figure 12. The nominal flow rate range for the orifice numbers are listed in Table 10. Refer to *Appendix D: Model Code Explanation*, page 65, for a complete description of the model code.

Model Code: 640BXXXYZQRST

where	XXX = Pressure Range
Y = Fitting Type
Z = Valve Type
Q = Body Seal Material
R = Valve Orifice Size (Flow Range)
S = Trip Points
T = Valve Plug Material

Figure 12: Model Code Explanation

Orifice Size	
Orifice Size (Model Code Entry)	**Nominal Range (sccm of N_2 with 1 ATM ΔP)**
A	50
1	200
2	1000
3	5000
4	10000
5	20000
6	50000

Table 10: Orifice Size

How To Verify the Orifice Selection

The correct orifice depends on three pieces of information: the upstream pressure, the downstream pressure, and the flow rate. These instructions assume that you are using nitrogen gas. If you are using a gas other than nitrogen, you must complete the additional step in *Using Different Gases*, page 58.

Note

The valves are not calibrated to match the valve orifice selection graph in Figure 13, page 57. The graph displays *typical* valve behavior.

1. Determine the pressure differential (delta P), by subtracting the outlet pressure from the inlet pressure.
2. Use the inlet pressure and the pressure differential to determine the valve orifice index number listed in Table 11.

   For example, if your inlet pressure is 30 psia and your outlet pressure is at atmosphere (15 psia), the pressure differential (delta P) is 15 psia. Therefore, your valve orifice index number would be 175.

Delta Pressure (psia)

Inlet Pressure (psia)	**>50**	**50**	**30**	**15**	**8**	**4**	**2**	**1**	**0.5**	**Inlet Pressure (Torr)**
100	585	585	480	355	265	190	135	95	65	**5170**
50	—	295	295	240	185	130	95	65	50	**2585**
30	—	—	175	175	140	100	75	50	40	**1551**
20	—	—	—	115	110	80	60	40	30	**1034**
15	—	—	—	90	90	70	50	35	25	**776**
10	—	—	—	—	60	55	40	30	20	**517**
5	—	—	—	—	—	30	25	20	15	**259**
2	—	—	—	—	—	—	10	10	9	**103**
1	—	—	—		—	—	—	6	6	**51.7**
	>5170	**5170**	**1551**	**776**	**414**	**207**	**103**	**51.7**	**25.9**	

Delta Pressure (Torr)

Table 11: Valve Orifice Index Number

3. Use the index number and your maximum flow rate, to determine the orifice size from Figure 13.

   Each line represents the *maximum* flow rate for the orifice. Choose the orifice number *above* your point on the graph to ensure that the orifice can deliver the required flow. Continuing with the example above, the index number is 175, and assuming a maximum required flow rate of 1000 sccm, the correct orifice would be number 2.

Note If the point on the graph falls *close to* the maximum flow rate for an orifice, you may choose to use the next largest orifice number. However, a larger orifice number provides a higher minimum flow rate as well. For example, in an elastomer sealed unit, orifice number 2 covers the range from 1 to 1000 sccm (N_2 at 1 atm ΔP), whereas orifice number 3 covers from 5 to 5000 sccm.

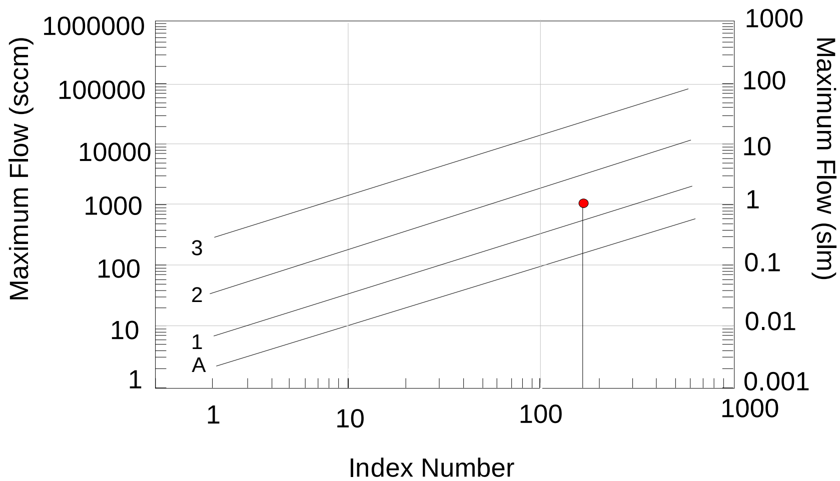


Figure 13: Flow Range Selection

4. Check the orifice size of your 640 controller (included in the model number).

Using Different Gases

The valve orifice selection data is based on nitrogen gas. If you will be using a gas other than nitrogen, you need to compensate for the density difference between nitrogen and your process gas before you can select the appropriate valve orifice.

1. To calculate an orifice sizing factor, use the equation:

$$\sqrt{\frac{N_2 \text{ Density}}{\text{Gas Density}}} = \text{ Orifice Sizing Factor}$$

   Appendix C: Gas Density Table, page 61, lists the standard density for common gases.

2. To calculate the valve orifice index number for the new gas:

(valve orifice index number for nitrogen) x (orifice sizing factor) = new valve index number

3. Proceed with step 3 of *How To Verify the Orifice Selection*, page 57, to determine the correct orifice size.

Example 1: Using Sulfur Hexafluoride (SF_6)

Following the example in *How To Verify the Orifice Selection*, page 56, using 100% sulfur hexafluoride (SF_6):

1. Calculate the orifice sizing factor, using the equation above.

   The standard density of SF_6 is 6.516, so the equation is:

$$\sqrt{\frac{1.250}{6.516}} = 0.44 \text{ Orifice Sizing Factor}$$

2. Calculate the valve index number, using the equation above.

(175) x (0.44) = 77 valve index number for SF_6

3. Use the index number and the maximum flow rate to determine the orifice number from Figure 13, page 57.

   Using the maximum flow rate of 1000 sccm (in our example) and an index number of 77, the correct orifice number would be 2. Since sulfur hexafluoride is heavier than nitrogen, the point on the graph is very near the top of the range for orifice number 2. Therefore, you may choose orifice number 3 if control in the lower end of the flow range is not critical.

Example 2: Using Helium (He)

Following the example in *How To Verify the Orifice Selection*, page 56, using 100% helium:

1. Calculate the orifice sizing factor, using the equation page 58.

   The standard density of He is 0.179, so the orifice sizing factor is:

$$\sqrt{\frac{1.250}{0.179}} = 2.64 \text{ Orifice Sizing Factor}$$

2. Calculate the valve index number, using the equation page 58.

(175) x (2.64) = 462 valve index number for He

3. Use the index number and the maximum flow rate to determine the orifice number from Figure 13, page 57.

   Using the maximum flow rate of 1000 sccm and an index number of 462, the correct orifice number would be 1. Since helium is lighter than nitrogen, a smaller orifice can deliver the same amount of flow. However, since the point on the graph is very near the top of the range for orifice number 1, you may choose orifice number 2 if control in the lower end of the flow range is not critical.

Example 3: Using 30% Hydrogen (H_2) and 70% Nitrogen (N_2)

Using a mixture of gases, such as 30% hydrogen and 70% nitrogen, may impact the orifice size. Following the example in *How To Verify the Orifice Selection*, page 56, with this gas mixture:

1. Calculate the orifice sizing factor, using the equation page 58.

   The standard density of H_2 is 0.0899 and N_2 is 1.250, so the orifice sizing factor is:

$$\sqrt{\frac{1.250}{(0.0899)(0.3) + (1.250)(0.7)}} = 1.18 \text{ Orifice Sizing Factor}$$

   Since the gas mixture is largely nitrogen, the orifice sizing factor is close to 1.

2. Calculate the valve index number, using the equation page 58.

   (175) x (1.18) = 207 valve index number for 30%H_2/70%N_2

3. Use the index number and the maximum flow rate to determine the orifice number from Figure 13, page 57.

   Using the maximum flow rate in our example of 1000 sccm and an index number of 207, the correct orifice number would be number 2.

Appendix C: Gas Density Table

GAS	SYMBOL	DENSITY g/l @ 0^{o}C
Air	- - -	1.293
Ammonia	NH_3	0.760
Argon	Ar	1.782
Arsine	AsH_3	3.478
Boron Trichloride	BCl_3	5.227
Bromine	Br_2	7.130
Carbon Dioxide	CO_2	1.964
Carbon Monoxide	CO	1.250
Carbon Tetrachloride	CCl_4	6.86
Carbon Tetraflouride (Freon - 14)	CF_4	3.926
Chlorine	Cl_2	3.163
Chlorodifluoromethane (Freon - 22)	$CHClF_2$	3.858
Chloropentafluoroethane (Freon - 115)	C_2ClF_5	6.892
Chlorotrifluoromethane (Freon - 13)	$CClF_3$	4.660
Cyanogen	C_2N_2	2.322
Deuterium	D_2	0.1799
Diborane	B_2H_6	1.235
Dibromodifluoromethane	CBr_2F_2	9.362
Dichlorodifluoromethane (Freon - 12)	CCl_2F_2	5.395
Dichlorofluoromethane (Freon - 21)	$CHCl_2F$	4.592
Dichloromethysilane	$(CH_3)_2SiCl_2$	5.758

(Table continued on next page)

GAS	SYMBOL	DENSITY g/l @ 0^{o}C
Dichlorosilane	SiH_2Cl_2	4.506
1,2-Dichlorotetrafluoroethane (Freon - 114)	$C_2Cl_2F_4$	7.626
1,1-Difluoroethylene (Freon - 1132A)	$C_2H_2F_2$	2.857
2,2-Dimethylpropane	C_5H_{12}	3.219
Ethane	C_2H_6	1.342
Fluorine	F_2	1.695
Fluoroform (Freon - 23)	CHF_3	3.127
Freon - 11	CCl_3F	6.129
Freon - 12	CCl_2F_2	5.395
Freon - 13	$CClF_3$	4.660
Freon - 13 B1	$CBrF_3$	6.644
Freon - 14	CF_4	3.926
Freon - 21	$CHCl_2F$	4.592
Freon - 22	$CHClF_2$	3.858
Freon - 23	CHF_3	3.127
Freon - 113	$C_2Cl_3F_3$	8.360
Freon - 114	$C_2Cl_2F_4$	7.626
Freon - 115	C_2ClF_5	6.892
Freon - 116	C_2F_6	6.157
Freon - C318	C_4F_8	8.397
Freon - 1132A	$C_2H_2F_2$	2.857
Helium	He	0.1786
Hexafluoroethane (Freon - 116)	C_2F_6	6.157
Hydrogen	H_2	0.0899
Hydrogen Bromide	HBr	3.610

(Table continued on next page)

GAS	SYMBOL	DENSITY g/l @ 0^{o}C
Hydrogen Chloride	HCl	1.627
Hydrogen Fluoride	HF	0.893
Isobutylene	C_4H_8	2.503
Krypton	Kr	3.739
Methane	CH_4	0.715
Methyl Fluoride	CH_3F	1.518
Molybdenum Hexafluoride	MoF_6	9.366
Neon	Ne	0.900
Nitric Oxide	NO	1.339
Nitrogen	N_2	1.250
Nitrogen Dioxide	NO_2	2.052
Nitrogen Trifluoride	NF_3	3.168
Nitrous Oxide	N_2O	1.964
Octafluorocyclobutane (Freon - C318)	C_4F_8	8.937
Oxygen	O_2	1.427
Pentane	C_5H_{12}	3.219
Perfluoropropane	C_3F_8	8.388
Phosgene	$COCl_2$	4.418
Phosphine	PH_3	1.517
Propane	C_3H_8	1.967
Propylene	C_3H_6	1.877
Silane	SiH_4	1.433
Silicon Tetrachloride	$SiCl_4$	7.580
Silicon Tetrafluoride	SiF_4	4.643
Sulfur Dioxide	SO_2	2.858

(Table continued on next page)

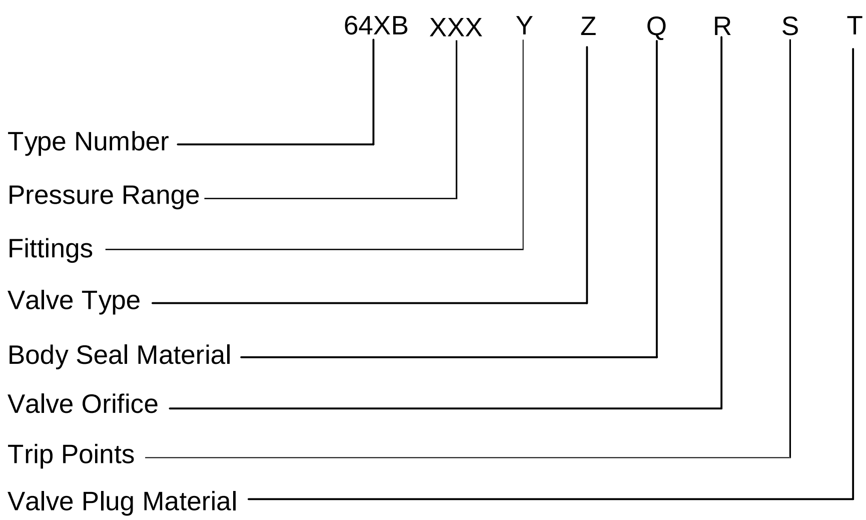
GAS	SYMBOL	DENSITY g/l @ 0^oC
Sulfur Hexafluoride	SF_6	6.516
Trichlorofluoromethane (Freon - 11)	CCl_3F	6.129
Trichlorosilane	$SiHCl_3$	6.043
1,1,2-Trichloro - 1,2,2-Trifluoroethane (Freon - 113)	CCl_2FCClF_2 or ($C_2Cl_3F_3$)	8.360
Tungsten Hexafluoride	WF_6	13.28
Xenon	Xe	5.858

NOTE: Standard Pressure is defined as 760 mmHg (14.7 psia) Standard Temperature is defined as 0^o C.

Appendix D: Model Code Explanation

Model Code Description

The model code number of your 640 Series Pressure Controller describes features of the unit, such as the pressure range, fittings, seal material, and orifice size (flow range).



Type Number (64XB)

The type number identifies your controller; either a 640B absolute pressure controller or 641B gage pressure controller.

Pressure Range (XXX)

The transducer enclosed in the 640 Series controller, is available in five standard full scale ranges. The full scale pressure is defined by a two number one letter designation.

Pressure Range Selection	
Full Scale Pressure	**Order Code**
10 Torr	11T
100 Torr	12T
1000 Torr	13T
60 psi	61P
100 psi	12P

Table 12: Pressure Range Selection

Fitting Number (Y)

The 640 Series controller has a range of fitting options, selected by a single letter code.

Fitting Type Selection	
Fitting Choice	**Order Code**
Cajon 4-VCR, male	W
Cajon 8-VCR, male	T
¼" Swagelok	S
Counter bore C-seal (SEMI 2787.1)	C
Fujikin W-seal* (SEMI 2787.3)	H
** Consult factory for availability*	

Table 13: Fitting Type Selection

Valve Type (Z)

The 640 Series controller has a normally closed valve, designated by a single number.

Valve Type	
Valve	**Order Code**
Normally Closed	1

Table 14: Valve Type

Body Seal Material (Q)

The control valve can use either one of a variety of elastomer seal materials, or an all-metal seal. Note: Valve Plug Material is specified later in the part number.

Seal Material Selection	
Seal Material	**Order Code**
Kalrez	K
Metal	M
Viton	V

Table 15: Seal Material Selection

Valve Orifice Size (R)

The 640 Series controller is available with one of seven (7) valve orifice sizes, defined by a single entry in the model code.

Valve Orifice Size Selection		
Valve Orifice Number	**Valve Orifice Size**	**Order Code**
A	50	A
1	200	1
2	1000	2
3	5000	3
4	10,000	4
5	20,000	5
6	50,000	6

Table 16: Valve Orifice Size Selection

Trip Point (S)

The 640 Series controller is built with trip points designated by a single number in the model code.

Trip Points
Order Code
2

Table 17: Trip Point Model Code Entry

Valve Plug Material (T)

A single letter defines the valve plug material.

Valve Plug Material	
Material	**Order Code**
Viton	V
Kalrez	D
Metal	M
Kel-F	F
Chemraz	C

Table 18: Valve Plug Material

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Index

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mks
Technology for Productivity

HEALTH AND SAFETY FORM

THIS FORM MUST BE COMPLETED AND RETURNED WITH EQUIPMENT OR SERVICE WILL NOT BE PERFORMED

RETURN MATERIAL AUTHORIZATION NUMBER (RMA#):	
RETURN TO STOCK NUMBER/RTS# (If applicable):	**Trade in number (if applicable):**

Section 1: (one instrument per form)	**MKS Part Number:**
	MKS Serial Number:

Section 2: Has this equipment been used? *(Please check appropriate boxes)*

☐	No – Still in MKS packaging
☐	No – Unit unpacked, but never installed in a system.
☐	Yes -- Used only with clean, dry inert gas (For Example: Air, N2, Ar, He).
☐	Yes -- Used with chemicals, non-inert gases, biological or radioactive agents.) Identify all materials:
☐	Yes -- Used in a Semiconductor Copper process. Equipment must be double bagged. Label outside bag and packing slip, Copper Part. Label final shipping container Copper Part and place a strip of ORANGE TAPE on the container.
	Has equipment been purged? ☐ No ☐ yes purged with what?
	Has equipment been flushed? ☐ No ☐ yes flushed with what?
	Has equipment been decontaminated? ☐ no ☐ yes, explain process:
	How many months in use?

Section 3: Detailed failure information or description or required service or reason for return.

Section 4: Company or Organization (mandatory information)

Company:		
Address:		
City:	**State:**	**Zip:**
Printed Name:	**Signature:**	
Date:	**Phone #:**	
Email:	**Fax #:**	
End User (if applicable):		

For MKS USE only:

MKS Subsidiary or Agent:
Contact Name:
Customer #:
Maximum Credit allowed (TBD after inspection)

ALL PRODUCTS MUST BE RETURNED IN SEALED BAGS

MKS will not accept delivery of equipment that has been chemically, radioactively or biologically contaminated, without written evidence of decontamination or laboratory analysis. Alternately, we will require evidence that the biological process is not harmful.

FRM13345 Rev.E