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MKS Type 252D
Exhaust Valve Controller

Preliminary manual for the

MKS Type 252D Unit

This is a preliminary manual and MKS Instruments makes no claims as to its accuracy or correctness. Due to continuing research and development activities, the information contained within this manual, including product specifications, is subject to change without notice. Please observe all safety precautions and use appropriate procedures when handling and operating the Type 252D Unit.

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.

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Safety Procedures and Precautions

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.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person capable of rendering first aid and resuscitation, is present.

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 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 the power cord and connector specified for your product.
Use only a cord in good condition.

USE THE PROPER POWER SOURCE

This product is intended to operate from a power source that does not apply more than 250 Volts RMS between the supply conductors, or between either of the supply conductors and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

USE THE PROPER FUSE

Use only a fuse of the correct type, voltage rating, and current rating, as specified for your product.

KEEP AWAY FROM LIVE CIRCUITS

Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

DO NOT OPERATE IN EXPLOSIVE ATMOSPHERES

To avoid explosion, do not operate this product in an explosive atmosphere unless it has been specifically certified for such operation.

KEEP AWAY FROM VALVE OPENING

Keep fingers, other body parts, and other materials away from the valve opening when the valve is in operation.

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.

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Chapter One: General Information

Introduction

The MKS Type 252D Exhaust Valve Controller controls a stepper motor powered exhaust valve (MKS Type 253) to maintain a constant pressure in a vacuum system by varying the pumping speed. The 252 controller can provide a ±15 VDC output and will accept pressure inputs from a variety of transducers. The front panel controls allow selection of the input range, control loop tuning, and automatic and manual valve control. An error meter is provided to assist you in tuning the control loop. External signals can be used to command the external set point and open or close the valve.

Typically, a pressure control system consists of three basic parts:

- The pressure sensor
- The controller and control valve
- The system whose pressure is to be controlled

The pressure sensor will usually be an MKS Baratron® Capacitance Manometer whose output is 0 to 10 VDC. Provision for other inputs (0 to 1 VDC or 0 to 100 mV) has been built into the controller so that other transducers may be used. The pressure (vacuum) system consists of a chamber and a pumping system. Typically, users want to control the mass flow of gas entering the system while the system pressure is maintained by the 252 controller and 253 control valve (refer to Figure 1, page 13).

The 252 controller's new 15-pin Type "D" connector allows you to connect the unit to a Type 253B throttle valve. If you install the 252 controller into an existing system that uses the old (hex) connector cables, an adapter cable is required (refer to *Valve Connector*, page 15, for more information).

The 252 controller takes the DC pressure transducer signal, compares it to the set point, and positions the valve so that it will drive the actual pressure to the set pressure. The 252 controller contains the three modes of control action found in most current industrial controllers: proportional, derivative, and integral. Briefly, these functions are as follows:

1. **Proportional** gives a valve action (position) that is instantaneously a linear function of the error signal. For example:

   Signal to valve = K_1 x Error (K_1 is adjustable by the gain pot)

2. **Derivative** action provides a signal to the valve that is proportional to the rate of change of the error signal. For example:

   Signal to valve = $K_2 \times \frac{d(\text{Error})}{dt}$ (K_2 is adjustable by the phase pot)

   A simple description of this mode of control is that it provides an anticipation element, or the valve reaches its proper steady state position sooner than without derivative. This is apparent when setting up the system; the derivative, or phase lead control tailors the under or overshoot. In other words, it cancels out the build-up of lags already built into the system.

3. **Integral** action provides an additional valve signal which is proportional to the length of time that an error signal exists. For example:

   Signal to valve = $\int d(\text{Error}) / dt$.

   In other words, as time passes, the valve position changes which reduces the signal error to zero.

How This Manual is Organized

This manual is designed to provide instructions on how to set up, install, and operate a Type 252 unit.

Before installing your Type 252 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, 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 how to troubleshoot a problem should the 252 unit malfunction.

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

Appendix B: Model Code Explanation, describes the instrument's model code and how to order the unit.

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 252 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 252 Unit

MKS has carefully packed the Type 252 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 252 Unit
- Type 252 Instruction Manual (this book)
- Power Cable

Note 

1. Metal, braided, shielded cables are required to meet CE Mark certification.
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 252 controller to a Type 627 transducer, use part number CB258-1-10; for a metal, braided, shielded cable use part number CB258S-1-10.

Optional Equipment

- Rack Mounting Kit:
  RM-6
- Electrical Connector Accessory Kit:
  252D-K1
- Input Cables:

CB250-7-6	Connects the 252 unit to a Type 270/690 system
CB254-2-10	Connects the 252 unit to Type 122, 124, 223, 622, and 623 transducers
CB254-1-10	Connects the 252 unit to Type 121 and 122 transducers
CB254-4-10	Connects the 252 unit to a Type 220 transducer
CB258-1-10	Connects the 252 unit to Type 127, 258, 358, 558, 624, 626, and 627 transducers
CB128-2-10	Connects the 252 unit to Type 128, 625, and 628 transducers
CB254-17-6	Connects the 252 unit to Type PDR-C-1C/2C, PDR-D-1, and PDR-5B power supply/readouts
CB120-3-10	Connects the 252 unit to a Type 120 transducer with a separate input power connector

- Valve Cable:

CB252-16-10	Connects the 252D unit to a 253B valve

- Valve Adapter Cable:

CB252-17-1	Replaces a 252A-C unit with a 252D unit

Setup

System Design

The standard one inch 253 valve has a maximum conductance of 150 liters/sec. and a minimum controllable conductance of about 0.15 liters/sec. Within this range of about 1000 to 1, the 252 controller can provide excellent control if the other system parameters allow. Plumbing should be as short in length and as large in diameter as possible. Connections can be made directly with the KF-40 flanges. A wide variety of 253 valves are available from ¾" to 12". There are three different flange types. For mounting instructions, refer to the 253 manual.

Tubing between the pressure transducer and the chamber should be less than 6 inches long and no less than ¼" in diameter. Fittings should be checked to make sure they do not have small drilled passages and antichambers off the main vacuum chamber should be kept to a minimum as they might cause stability problems.

If a 270/690 type system is used for pressure measurement, make sure the 270 indicator switch is in the NORMAL position.

An important consideration is a condition that is peculiar to diffusion pumps called *choking*. If too much gas is introduced at too high a pressure, the pumping speed becomes erratic and changes radically. This behavior is easily recognized by lack of stability and pneumatic noise, sometimes making control impossible. Reducing the flow to the pump is the only solution. Another consideration involves removing delays in the system response that make stabilization difficult or impossible.

Note 

Diffusion pumps should never be operated at inlet pressures above which the "top jet" will experience a pressure in excess of 5×10^{-4} Torr.

Power and Fuse Requirements

The power requirements for the 252 controller are:

90 to 132 VAC @ 50-60 Hz
or
198 to 264 VAC @ 50-60 Hz

40 Watts @ 90 VAC 60 Hz minimum
70 Watts @ 132 VAC 50 Hz maximum

The line fuses protect the internal circuitry; both sides of the line are fused. The fuse values are:

100/120 VAC:	0.80 A Slo Blo / 250 V
220/240 VAC:	0.40 A Slo Blo / 250 V

Mounting Instructions

Controller

The 252 can be mounted on any instrument panel or placed on a bench. The mounting position is not critical and it will operate properly in any position. While the unit is designed and tested to be operated with no air circulation, it will run much cooler if the air slots are clear to allow convection air circulation. No special precautions are needed to protect the unit from ordinary mechanical shock and vibration. A rack mounting kit (RM-6) is available from MKS for single or dual unit rack mounting.

Valve

The 253 valve should be connected using pipe or hose as large in diameter and as short in length as possible. Refer to the 253 manual for mounting instructions.

Transducer

The pressure transducer should be mounted so that it is firmly supported, while at the same time, isolated from any vibration.

Any pressure transducer which delivers at least 0.1 Volt full scale, can be used as the feedback element for total pressure control.

Interconnections

Figures 1 and 2, page 13, show typical piping and cable interconnection diagrams. Figure 1 shows the usual setup for standard pressure control. Figure 2 shows a system where the 253 valve is connected in parallel with the isolation valve and a 270/690 pressure measurement system is used.

Connect the valve and transducer to the chamber using short connections with minimum restrictions. Six inches of ¼" tubing should be maximum. Never reduce the tubing size below that of the transducer. If the chamber is repeatedly opened to the atmosphere, the transducer should be protected by an isolation valve.

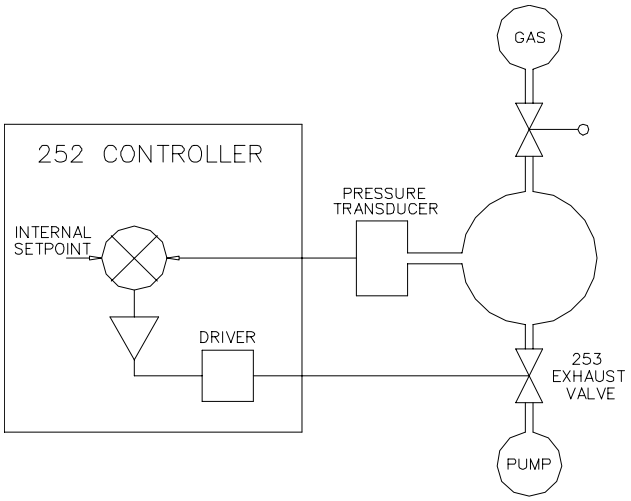

Figure 1: Standard Pressure Control Setup

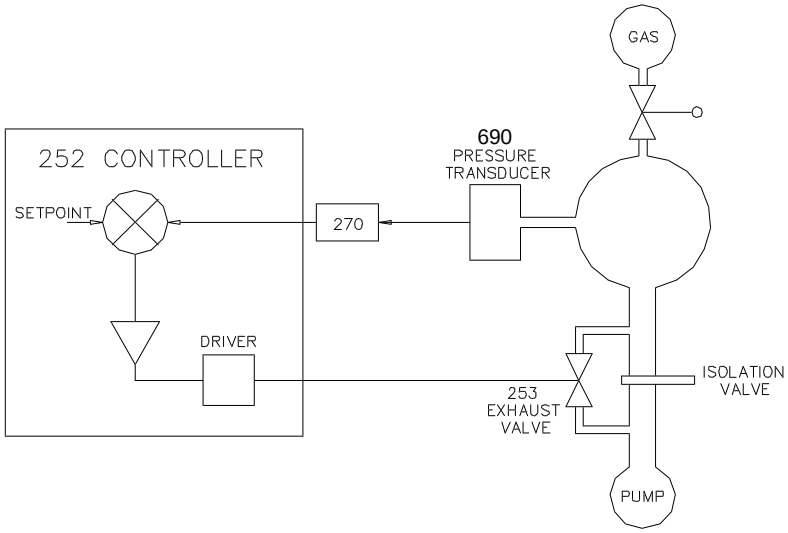

Figure 2: 253 Valve Connected in Parallel with an Isolation Valve

Cables

Note

1. Metal, braided, shielded cables are required to meet CE Mark certification.
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 252 controller to a Type 627 transducer, use part number CB258-1-10; for a metal, braided, shielded cable use part number CB258S-1-10.

Note

The "No Connection" and "Reserved" pin assignments are defined as follows:

1. The "No Connection" pin assignment refers to a pin with no internal connection.
2. The "Reserved" pin assignment refers to a pin with an internal connection which may be assigned a function in the future.

Valve Connector

The 15-pin Type "D" connector allows you to connect the 252 controller to a Type 253 throttle valve. If you are installing the 252 controller into an existing system that uses the old (hex) connector cables, an adapter cable is required.

Use the following cable(s) to make the connection:

- CB252-16-10: This *interface* cable connects the 252D controller to a Type 253B valve
- CB252-17-1: This *adapter* cable allows you to replace a Type 252A-C controller with the Type 252D controller

Valve Connector Pinout	
Pin	**Assignment**
1	No Connection
2	No Connection
3	Limit switch common
4	Open limit switch
5	Close limit switch
6	No Connection
7	No Connection
8	Winding A
9	Winding A'
10	Winding A Common
11	No Connection
12	No Connection
13	Winding B
14	Winding B'
15	Winding B Common

Table 1: Valve Connector Pinout

Input Connector

This 14-pin Amphenol connector allows you to connect the 252 controller to a transducer. It provides ±15V power and accepts the input pressure signal from the transducer.

Input Connector Pinout	
Pin	**Assignment**
1	+ Pressure Input
2	Reserved
3	Reserved
4	Reserved
5	Reserved
6	Reserved
7	Reserved
8	(-) Input (Connect to Analog Ground - Pin 12 - at Input Source)
9	Reserved
10	Reserved
11	+15 VDC Output
12	Power Supply Ground (Analog Ground)
13	-15V Output
14	Chassis

Table 2: Input Connector Pinout

Interface Connector

This 14-pin Amphenol connector provides access to the miscellaneous outputs, ±15V power, and external inputs to the 252 controller.

Interface Connector Pinout	
Pin	**Assignment**
1	(+) Ext. Set Point
2	Reserved
3	Digital Ground (Common for Open, Close and Set Point selection)
4	Open (Connect to Pin 3 to open valve)
5	Close (Connect to Pin 3 to Close valve)
6	Reserved (Set Point 1 with Set Point option)
7	Reserved (Set Point 2 with Set Point option)
8	(-) Ext. Set Point (Connect to analog ground (Pin 12) at input source)
9	Reserved (Set Point 3 with Set Point option)
10	Reserved (Set Point 4 with Set Point option)
11	+15V Output
12	Power Supply Ground (Analog Ground)
13	-15V Output
14	Chassis

Table 3: Interface Connector Pinout

Note

Since there are a limited number of spare pins on the Interface connector, the exact pinout depends on which options are installed.

1. Refer to Table 5, page 30, for the Valve Position Option pinout.
2. Refer to Table 6, page 32, for the Multiple Set Point Option pinout.
3. Refer to Table 7, page 34, for the Process Limit Option pinout.

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Chapter Three: Overview

General Information

The Type 252 controller and 253 valve comprise a high performance exhaust control system. With the use of a suitable pressure transducer, pressure can be repeatedly held to less than 0.1% of full scale.

The purpose of a controller is to compare the required pressure level (set point) with the actual pressure level (feedback input) and make appropriate corrections in the pump speed (via adjustments on the valve) until the actual pressure equals the required pressure.

Figure 1, page 13, shows a simple pressure control loop consisting of a pressure transducer, controller, control valve, chamber, and pump. The pressure transducer converts pressure to an electrical signal which is compared in the controller to the set point (in most cases a precision pot whose voltage output is changed by rotating the dial).

Any error between the actual (feedback) and required (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, subsequently reducing the pressure.

An additional requirement of the controller is to provide a stabilizing or tuning control. This control (PHASE LEAD) allows you to compensate for the different delays, or lags, that occur in various systems.

Stepping Motor Drive

The direction of the stepping motor is determined by whichever pair of drivers change state, as shown in Table 4.

Four-Step Sequence						
	Step	A	A1	B	B1	
CW	1	ON	OFF	ON	OFF	CCW
↓	2	ON	OFF	OFF	ON	↑
	3	OFF	ON	OFF	ON	
	4	OFF	ON	ON	OFF	
	1	ON	OFF	ON	OFF	
For CW rotation follow steps 1, 2, 3, 4, etc. *For CCW rotation follow steps 4, 3, 2, 1 etc.*						

Table 4: Four-Step Sequence

Power Supply

The power supply consists of one transformer, one unregulated supply, two regulators (+ and - 15V) and a floating +5V supply for external inputs. The +5V is referenced to digital ground and all other supplies are referenced to analog ground. There is a 110 ohm resistor and two diodes to keep the analog ground within 6 Volts of the chassis ground.

The same arrangement is also used between analog ground and digital ground. The digital ground can be as much as 12 Volts from chassis ground.

The unregulated +24 Volt supply is capable of supplying one Amp to the motor and the +15 Volt regulator. The + and - 15 Volt regulators can easily handle 0.25 Amps each. The ±15 Volt supply current is small, so most of this is available to supply a pressure transducer for the feedback signal.

Front Panel Controls

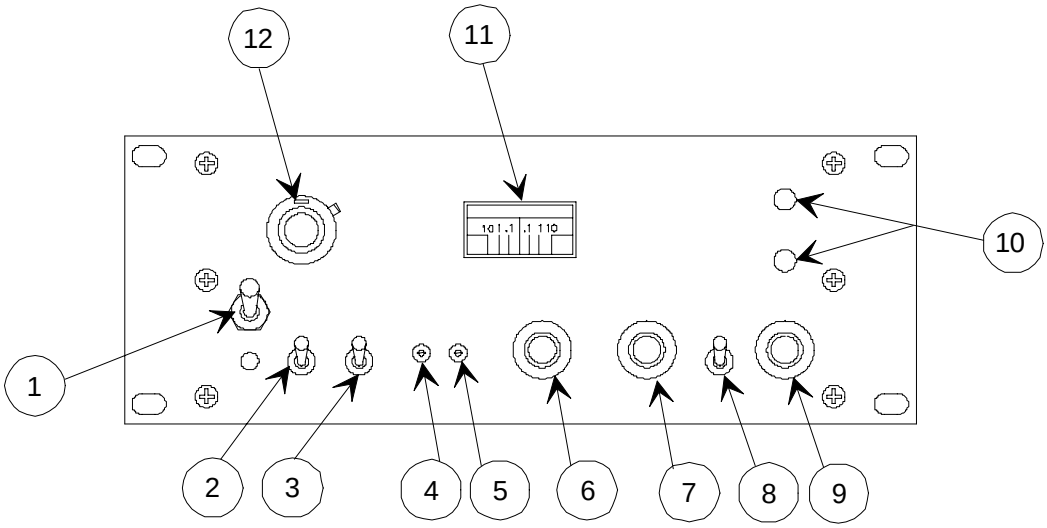

Figure 3: Front Panel Controls

1. **ON/POWER** - Controls the AC power to the 252 controller. The LED indicator below it indicates when the power is on, that is, the plug is in and the fuse is alive.

2. **INT/EXT** - Selects either the internal (front panel) set point control or an external set point voltage.

3. **10V/1V/0.1V** - Selects the full scale range of the input voltage. As shipped, the 252 controller is calibrated for ±0.25% on the 10V range. The 1V and 0.1V ranges are calibrated for ±2% as shipped, but can be adjusted closer with the span pot (refer to SPAN below).

4. **Z (ZER0)** - Allows for offsetting any initial zero errors in the transducer. With zero pressure (or flow) on the transducer and the set point at zero, adjust the zero pot for zero error on the error meter.

5. **SPAN** - Allows precise adjustment of the full scale input voltage. Any range can be accurately calibrated for any voltage within its range by applying an accurate full scale voltage, turning the set point to full scale, and adjusting the SPAN control for zero error. For example, with a 5.00 Volt input, put the SPAN select on 10V and adjust the SPAN for zero error on the error meter.

6. **PHASE LEAD** - The PHASE LEAD control allows you to compensate for the major lag in the control system. In pressure systems, this lag is generally caused by the restrictions in the pump line and the capacity of the pressure vessel. Typical settings are 1 to 5 seconds. A setting that is too low will cause overshoot; too high will cause a slow response.

7. **GAIN** - The GAIN setting determines the overall gain of the controller and should be as high as possible without making the system unstable. The higher the gain, the smaller the dead band. If some overshoot is tolerable, better control (less dead band) can be achieved. Typical settings are 100%.

8. **OPEN/CLOSE SWITCH** - The OPEN/CLOSE switch allows you to manually control the valve without worrying about set point settings, process variables, etc. The valve will move in the direction indicated.

9. **VALVE MODE SWITCH** - The VALVE MODE SWITCH selects the method of valve control. In CLOSE, the valve is driven to the fully closed position. In MANUAL, the valve is controlled by the OPEN/CLOSE switch. In S.S. (Soft Start), the valve is slowly driven towards OPEN until the pressure is near the desired set point, at which time, the controller automatically switches to AUTO. In the AUTO position, the controller drives the valve to maintain the set point pressure. In EXT, the controller operates as if in AUTO but will accept external OPEN and CLOSE commands. External OPEN or CLOSE commands will not affect the 252 controller unless the mode switch is in the EXT position.

10. **OPEN/CLOSE LIGHTS** - The OPEN/CLOSE LIGHTS indicate when the valve is fully open or fully closed. These lights are not used if the Valve Position Meter is installed.

11. **ERROR METER** - Meter indication of the difference between the set point and the actual pressure, or flow. The ERROR METER is useful when tuning the PHASE or GAIN controls because it shows overshoot and oscillation around the proper control level.

12. **SET POINT** - The SET POINT control is your input to the 252 controller. The dial represents the fraction of the full scale pressure range. The SET POINT is set to the desired pressure and the controller maintains that pressure while in the AUTO or EXT mode. For example, if the transducer's full scale pressure is 1 Torr and the SET POINT is set for 0.432 (4/32 indicated on the dial), then the 252 controller will maintain a pressure of 432 microns.

    When operating with external set point input (0 to 5V), the front panel SET POINT control should be fully clockwise (CW).

Rear Panel Controls

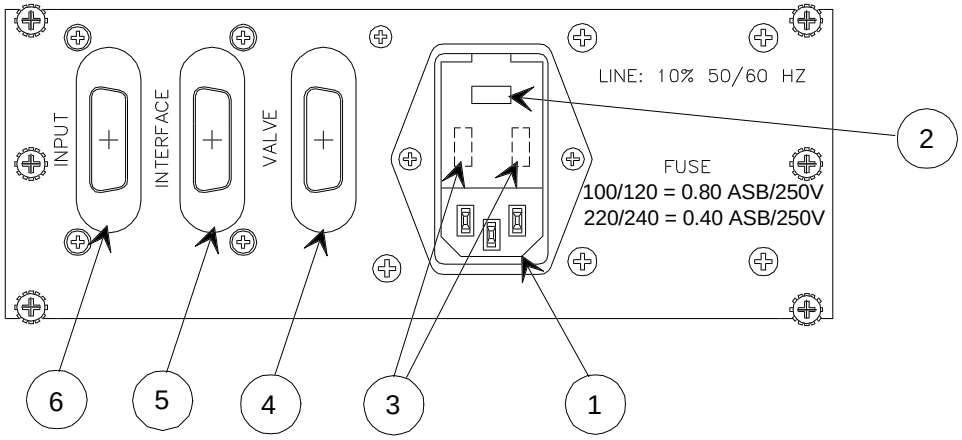

Figure 4: Rear Panel Controls

1. **LINE CORD** - Provides 115 or 230 VAC to the 252 controller.

2. **VOLTAGE SELECTOR -** Should be set to the proper input voltage before the line cord is plugged in and the power turned ON.

3. **FUSE -** Line fuse to protect internal circuitry. Both sides of the line are fused.

Caution **Disconnect the line cord from the AC power outlet before replacing the fuse.**

4. **VALVE** - The 253 valve connects to the 252 controller through a 15-pin Type "D" connector. Use cable CB252-16-10 to connect the valve and controller.

Note If you are installing the 252D controller into an existing system that uses the old (hex) connector cables, an adapter cable is required. Use adapter cable CB252-17-1 to replace a Type 252A-C controller with the Type 252D controller. Refer to Table 1, page 15, for the Valve connector pinout.

5. **INTERFACE** - This 14-pin Amphenol connector provides access to the miscellaneous outputs, ±15V power, and external inputs to the controller. Refer to Table 3, page 17, for the Interface connector pinout.

6. **INPUT** - This 14-pin Amphenol connector provides ±15V power and accepts the input pressure signal. Refer to Table 2, page 16, for the Input connector pinout.

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Chapter Four: Operation

How To Setup the Controller

Before plugging in the AC line cord, turn the power switch OFF and perform the following steps:

1. Ensure that the voltage selector on the rear panel is in the proper position and that the fuse has the proper rating.

   The power and fuse ratings are listed in *Appendix A: Product Specifications*, page 43.

2. Place the INT/EXT and RANGE switches in the proper positions and turn the SET POINT control to zero.

3. Plug in the power cord and turn on the POWER.

   The power LED should light.

4. Allow the system to warm up for at least 15 minutes.

5. Ensure the chamber pressure is less than the resolution of the transducer, and zero the controller by setting the SET POINT at zero (fully CCW) and adjusting the ZERO control for zero error on the meter.

Note

1. Temperature-controlled transducers, such as the 270/690 and 127 or 128, need approximately four hours to completely stabilize.
2. If a 270 signal conditioner is used, the 270 Sensor Zero control can be used for zeroing; the RESPONSE switch should be in the NORMAL position.

6. Turn ON the gas source.

How To Tune-Up the Controller

Turning the Valve Mode Switch (VMS) to S.S. (Soft Start), AUTO, or EXT puts the 252 controller into the Automatic control mode. The exhaust valve will be driven to maintain pressure at the set point value.

The pressure in the chamber may be manually adjusted with the OPEN/CLOSE switch before switching to AUTO; or, the controller can handle the transition from fully closed (or opened) to Automatic without operator assistance.

When making the transition from a situation where the valve is fully closed and the chamber is at atmospheric pressure, to automatic with the chamber at control pressure (near vacuum), a *Soft Start* feature is provided. Soft Start allows the valve to open at a slow and predictable rate until the control pressure is reached; at which point the controller electronics switches to automatic. Note that the front panel switch is not moved, simply the electronics.

To tune the control response in the AUTO mode, set the initial PHASE setting to 1.5 seconds and the initial GAIN setting to 100%. Check the settings by making a small change in the set point control and observing the error meter. Optimum response is for the error to reduce to zero, but with little or no overshoot.

If the pressure oscillates (error swings from positive to negative and back again), the GAIN is too high. If the pressure overshoots, but settles to the proper value, more PHASE LEAD is required. If the pressure settles to a steady value, which is other than the set point (greater than 0.25% error), more GAIN is needed.

When making final adjustments, move the controls less than 10° to prevent overcontrolling. Various pressures will require different GAIN and PHASE LEAD settings, although pressures of up to two decades apart may be controlled using the same settings.

Note that the maximum rate of rise in pressure is determined by the following formula (with the exhaust valve fully closed):

$$Pr = \frac{F}{V}$$

where: Pr is pressure rate of rise in Torr/sec.
F is flow in Torr-liters/sec.
V is volume in liters

Consequently, in systems with small input flows and relatively large volumes, the pressure will rise slowly even when the 253 control valve is fully closed. If the controller cannot be adjusted for good control, the problem may be caused by improper pneumatic connections (refer to *System Design*, page 11).

How To Use the Normal/Reverse Switch

Most applications will require that when the pressure is greater than the set point, the valve should be driven OPEN to return the pressure to the proper value. This is "normal" operation and assumes that the output of the pressure transducer *increases* positively for increasing pressure.

Inside the 252 controller, at approximately the center of the P.C. board, is a slide switch which can be used to obtain "reverse" action from the controller. This switch should be in the REVERSE position if the pressure transducer (or process variable) *decreases* for increasing pressure.

How To Use External Control

The 252/253 exhaust control system can be externally controlled with two inputs on the Interface connector. Refer to Table 3, page 17, for the Interface connector pinout.

Note 

The Valve Mode switch on the front panel (refer to Figure 3, page 21) ***must*** be in the EXT position for the 252 controller to accept external inputs.

Shorting the OPEN input (Pin 4) to digital ground (Pin 3) will cause the valve to drive toward open and it will continue opening as long as Pins 3 and 4 are connected, or until it reaches the fully open position.

Shorting the CLOSE input (Pin 5) to digital ground (Pin 3) will cause the valve to drive toward CLOSE and it will continue closing as long as Pins 3 and 5 are connected, or until it reaches the fully closed position.

Shorting both Pins 4 and 5 to digital ground (Pin 3) will cause the valve to HALT and ignore any automatic commands.

If neither Pins 4 or 5 are connected to Pin 3, the 252 controller will provide automatic control of pressure to the selected set point.

Soft Starting can be achieved from external control by allowing the valve to run about 0.1 seconds in automatic and then shorting Pins 4 and 5 to Pin 3 to HALT the valve for 0.9 seconds. This should be repeated for about 10 cycles or until the pressure approaches the set point. Pins 4 and 5 can then be left open for normal automatic control.

How To Use Set Point Control

The set point voltage may be taken from the front panel control(s) or an external voltage. The standard 252 controller has a single front panel set point control.

When the INT/EXT switch (refer to Figure 3, page 21) is in the INT position, the 252 controller will control to a pressure equal to the percentage of the front panel set point times the pressure transducer range.

For example, if a 10 Torr transducer is used and the set point is at 38%, the 252 controller will control at (10 Torr x 38%) = 3.8 Torr. If the INPUT range switch (refer to Figure 3, page 21) is set to 1V (instead of 10V), the apparent pressure range is 1 Torr, and the control pressure would be (1 Torr x 38%) = 0.38 Torr.

If the INT/EXT switch is set to the EXT set point position, the 252 controller will control to a pressure equal to the external set point voltage times the front panel set point control. Normal external set point voltage is 0 to 5 Volts with the front panel pot at 100%. This gives set points from 0 to 100% of the apparent transducer range. If 0 to 10 Volts is required for the external set point voltage, set the front panel control at 50%.

Note that the external set point input has a differential input and the signal source common should also be connected to Power Common of the 252 controller (pin 12 on the Interface connector) at the signal source end.

If the Multiple Set Point Option (MSO) is used (refer to *How To Use the Multiple Set Point Option*, page 31), only the internal, front panel controls can be used for set point input. The controls are set to different pressure settings and then selected with either the front panel switch or remotely.

To remotely select set points, the front panel set point selector *must be set to REMOTE*. Connect the appropriate Interface connector pin to digital ground to select a set point control; the LED above that control will light.

Do not select more than one set point at a time! Refer to Table 3, page 17, for the Interface connector pinout.

Advisory

When interfacing with external computers, we strongly advise that the external commands (CLOSE, OPEN, and HALT) be used when the valve is required to be in a specific condition (closed, opened, etc.).

While it is possible to drive the valve to one extreme or the other (OPEN or CLOSE) by use of the external set point input, the valve *may not stay* in that condition. For example, if an external set point of zero is used to drive the valve full open, then all works well until the pressure *approaches zero.* As the controller *anticipates* the pressure approaching zero, it may have enough drive signal to partially close the valve. The rate of change of pressure will at least be reduced and may be stopped altogether. This is a particular problem when high gain, large phase lead, or lower input ranges (1V or 0.1 V) are used.

How To Use the Valve Position Option

The Valve Position Option (VPO) provides a front panel meter readout of the valve position (0 to 100%) and an analog (0 to 10 Volts) signal on the rear panel. These outputs provide you and the controller with an up-to-date readout of the valve position. Using this information, you can determine the "normal" operating range of the valve and later, if the pump becomes contaminated or if something deteriorates, the pumping speed and the valve will open to compensate for it. The change in valve position can be read on the meter, or output voltage.

When the power is first turned on, the meter and output voltage will go to the position indicated by the limit switches; 0 for Close and 100 for Open.

Note 

If the valve is not against one of the limit switches, then the meter and output voltage will go higher than full scale and remain there until either one of the limit switches is contacted. The meter and voltage will then track the valve position.

The VPO operates by counting the pulses used to drive the stepper motor. The counter output is converted, by resistors, to an analog current. This current is buffered to drive the meter and is amplified to drive the output. The output is adjusted for +10 Volts output but can be adjusted for +5 Volts output with R16 on the main P.C. board. Note that the Zero control (R13) affects both the meter zero and the output zero.

Interconnections

Since there are a limited number of spare pins on the Interface connector, the exact pinout will depend on which options are installed. Some examples are listed in Table 5, page 30.

Valve Position Option Pinout				
Interface Connector Pin	**A Standard Unit with VPO**	**B Multiple Set Point Option (MSO) and VPO**	**C MSO, VPO, and Process Limit Option (PLO)**	**D VPO and PLO**
1	(+) Ext. Set Point	VPO (+10 V)	VPO (+10 V)	(+) Ext. Set Point
2	Reserved	----------	PLO Logic Output	----------
3	Digital Ground	Digital Ground	Digital Ground	Digital Ground
4	Open	Open	Open	Open
5	Close	Close	Close	Close
6	Reserved	Set Point 1	Set Point 1	PLO N.O. Relay
7	Analog Ground	Set Point 2	Set Point 2	PLO N.C. Relay
8	(-) Ext. Set Point	(-) Ext. Set Point	(-) Ext. Set Point	(-) Ext. Set Point
9	Reserved	Set Point 3	Set Point 3	PLO Relay Common
10	VPO (+10 V)	Set Point 4	Set Point 4	VPO (+10 V)
11	+15VDC Supply	+15VDC Supply	+15VDC Supply	+15VDC Supply
12	Power Ground	Power Ground	Power Ground	Power Ground
13	-15VDC Supply	-15VDC Supply	-15VDC Supply	-15VDC Supply
14	Chassis Ground	Chassis Ground	Chassis Ground	Chassis Ground

Table 5: Valve Position Option Pinout

How To Use the Multiple Set Point Option

The Multiple Set Point Option (MSO) provides up to four front panel set point pots which can be selected either from the front panel, or remotely. When selected, each set point pot provides a precision reference for the controller which maintains the control pressure (or flow) at the preset level.

The set point pots are preset with up to four levels which can be selected by using the front panel selector switch. In the REMOTE position, fully open and fully close can be selected, the valve can be held at its present location, and an external programmer can select any of the preset levels by activating a digital control line.

Settings

The MSO set point pots are 10-turn precision units with calibrated dials. Each pot covers the full range of the feedback transducer (0 to 100%). The controllers are calibrated for a precise 10 Volt full scale and should not need adjustment if a 10 Volt transducer is used. If other full scale voltage transducers are used, refer to the SPAN adjustment procedure in *Front Panel Controls*, item 5, page 21.

The set point controls are your input to the controller. The dial represents the fraction of full scale range. For example, if the transducer's full scale pressure is 10 Torr, and a set point is set for 0.342 (3/42 indicated on the dial), then when the set point is selected, the controller will maintain a pressure of 3.42 Torr in either S.S., AUTO, or EXT (with no overriding commands).

Each set point pot should be set to a pressure (or flow) required by the process. The pots can be adjusted at any time, whether they are ON or OFF.

Selection

When the front panel switch is selecting a particular set point, all remote select signals are ignored. In REMOTE, any and all remote signals will be selected and ***it is important that only one set point be selected at a time.***

As normally shipped, the remote set point select lines are wired for negative true; that is, a short-to-digital ground will select the appropriate set point. When the lines are not shorted to ground, they are pulled up to +5V with a 10K resistor.

If positive true logic is desired; that is, a positive signal (5V) will select the appropriate set point; then a jumper should be installed near R23 at the rear of the MSO P.C. board. ***Note that if positive true logic is used, all unused set point select lines must be held at digital ground.***

As each set point is selected, a light above the set point pot is illuminated.

Interconnections

The remote set point select lines are brought out on the Interface connector and are listed in Table 6. The *digital* ground should be connected to the circuit ground of the digital instrument that is selecting the set points. Refer to Table 3, page 17, for the complete Interface connector pinout.

Multiple Set Point Option Pinout	
Interface Connector Pin	**Assignment**
3	Digital Ground
6	Set Point 1
7	Set Point 2
9	Set Point 3
10	Set Point 4

Table 6: Multiple Set Point Option Pinout

How To Use the Process Limit Option

The Process Limit Option (PLO) provides a logic signal (+5V) and a relay closure when the controller error deviates from zero by more than the process limit. The process limit can be set by an internal control to any range from ±0.5 to ±100%. An LED indication is provided on the board to assist in the setup.

The PLO board compares the absolute value of the error signal to the process limit setting. If the error is less than the setting, the relay is energized, the LED is green, and the logic level is low (0 Volts). If the error signal is greater than the process limit setting, the relay is de-energized, the LED is red, and the logic level is high (+5 Volts). If power is lost, the relay will be de-energized, the LED will be off and the logic level will appear low.

Note For some customers, the logic output is reversed from that described above; *within* process control gives a high output (+5 Volts) and *out-of-control* gives a low output (0 Volts).

Controls

The process limit set point control is a single-turn pot which is non-linear to provide greater resolution at the lower percentage settings. The approximate settings are shown in Figure 5.

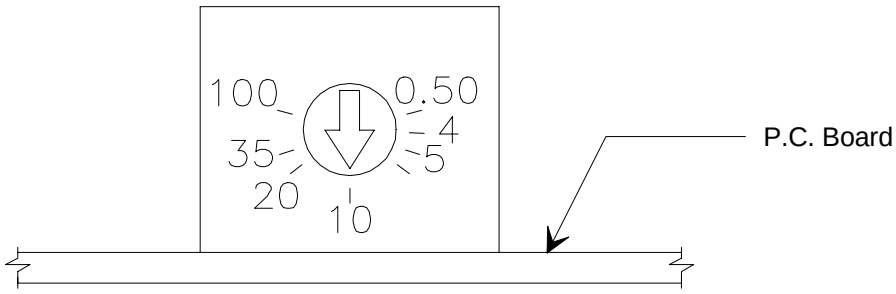

Figure 5: Process Limit Set Point Control

The PLO is usually shipped with the set points at 10%. However, the process limit set point should be set as required; 2 to 20% is typically used. Larger percentages will be required for noisy or fast changing systems.

To establish a precise process limit set point:

1. Input a stable signal (such as zero).

   The error meter should read zero (±0.05%) when the controller set point is also at zero.

2. Increase the set point to the deviation at which the PLO is required to trip.

3. Adjust the process limit set point until the LED is just tripping.

Interconnections

Since there are a limited number of spare pins on the Interface connector, the exact pinout will depend on which options are installed. Some examples are listed Table 7.

Process Limit Option Pinout			
Interface Connector Pin	**#1 Standard Unit with PLO**	**#2 Multiple Set Point Option (MSO) and PLO**	**#3 MSO, PLO, and Valve Position Option (VPO) where valve position voltage is brought out**
1	(+) Ext. Set Point		VPO (+10 V)
2		PLO Logic Output	
3		Digital Ground	
4		Open	
5		Close	
6	PLO N.O. Relay	Set Point 1	
7	PLO N.C. Relay	Set Point 2	
8	(-) Ext. Set Point		
9	PLO Relay Common	Set Point 3	
10	VPO (+10 V)	Set Point 4	
11	+15VDC Supply	+15VDC Supply	
12	Power Ground	Power Ground	
13	-15VDC Supply	-15VDC Supply	
14	Chassis Ground	Chassis Ground	

Table 7: Process Limit Option Pinout

Note

1. The N.O. relay contact is CLOSED when the error signal is less than the Process Limit Set Point (that is, everything is normal). Relay contacts are rated to switch 0.25 Amps, 28 Volts resistive, or 3 watts, whichever is less.
2. The logic input will source 1 mA (4700 ohms to +5 Volts) and will sink 10 mA to digital ground.
3. Digital ground (Pin 3) is the reference for the OPEN, CLOSE, and EXTERNAL set point inputs and is also reference for the PLO output.

How To Use the Reverse Limit Switch Option

The Reverse Limit Switch Option (RLSO) is incorporated in the 252 controller to provide for valves that have limit switches which are closed when the valve is in the center of it's operating range. The limit switches open when the valve reaches the appropriate end. The standard 252 controller is set up for limit switches that close when the valve reaches the appropriate end.

The RLSO simply inverts the logic signals from the limit switches. The RLSO P.C. board is installed inside the 252 controller where the valve cable plugs into the main P.C. board.

No external adjustments are needed. The standard VALVE connector on the rear panel is used with the same pin assignments as the standard unit (refer to Table 1, page 15, for the Valve connector pinout).

Note that if *no* cable or valve is connected to the unit, both the fully OPEN and CLOSE lights will be on and the 252 controller does *not* put out any drive pulses. For troubleshooting, either a valve will have to be connected, or the VALVE connector Pins 10 and 11 will have to be connected to Pin 12.

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Chapter Five: Maintenance and Troubleshooting

General Information

If the 252 instrument fails to operate properly upon receipt, check for shipping damage, 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.

Maintenance

Alignment Procedure

The following alignment procedure should be followed to verify the zero and full scale alignment of the 252 controller. Allow the controller to warm up for at least 30 minutes, with the 253 valve attached, before starting the alignment. Note that the P.C. board has a block of test pins (TPB-1, 2, 3, etc.) located in the front left-hand side of the board.

Equipment Needed:

- 0 to 10 Volt source for input
- 253 valve for load
- 4½ place, 0 to 10 Volt meter

Connections

1. Connect the input source to the Input connector Pins 1 and 8 (Pin 8 should also be connected to Pin 12).

2. Connect the 253 valve to the VALVE connector.

3. Verify that the controls are in the following positions:

FRONT PANEL	
Set Point Pot	CCW (000)
Set Point Int/Ext	INT
Range	10V
Phase Lead	CCW
Gain	CW
Mode	Manual (pointing toward toggle switch)
Open/Close	Centered
INSIDE	
NORmal/REVerse	Normal (toward F.P.)
REAR PANEL	
115/230	As available

4. Verify that the A.C. supply is either 115 $\pm$15 or 230 $\pm$15 Volts A.C.

5. Check the voltage at the test points listed in Table 8, page 39, and readjust the appropriate control if necessary.

Test Point Voltages			
Condition	**Test Point**	**Voltage**	**Control**
	(+) 15 V Supply Jumper	+ 15.00 ±.05	R132
	(-) 15 V Supply Jumper	- 15.00 ±.05	R129
Input = 0.000V	TPB-8	0.000	Zero (R16)
Set point = 000	TPB-7	0.000	S.P. Zero (R32)
Input = 0 Set point = 0	TPB-6	0.000	D.A. Zero (R39)
Input = 0 Set point = 0	TPB-5	0.000	Meter Zero (R49)
Input = 0 Set point = 0	TPB-3	0.000	Lead Zero (R46)
Input = 0 Set point = 0	TPB-4	0.000	Gain Zero (R64)
Input = 10.000V	TPB-8	5.000 ±.002	SPAN (R17)
Set point = 1000	TPB-7	5.000 ±.002	Set point Adjust (R20)
TPB-8 = TPB 5.000	TPB-6	0.000	Diff. Amp. Cal (R36)

Table 8: Test Point Voltages

Troubleshooting

To locate the cause of trouble, follow steps 1, 2, and 3 in 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.

FRONT PANEL	
Power	ON (Power light should be on)
Set Point	Switch on INT Control at proper level
Input Select	As required (normally 10V)
Phase	As required (normally 1 to 5 sec.)
Gain	As required (normally 100%)
Mode	AUTO or EXT
INSIDE	
Nor/Rev	NORMAL
REAR PANEL	
115/230	As required by AC power supply

3. Determine the probable cause from the Troubleshooting Chart (refer to Table 9, page 41).

Troubleshooting Chart	
Symptom	**Checks and Probable Causes**
Error Meter shows oscillation or noise	a. Check that input flow is steady. b. Check that pressure transducer has a steady output (vibration isolation may be required). c. Check that diffusion pump is not choking. Refer to *System Design*, page 11. d. Readjust PHASE and/or GAIN controls. Refer to *How To Tune-Up the Controller*, page *26*.
Error Meter shows steady error greater than ±0.25%	a. Increase GAIN setting. Refer to *How To Tune-Up the Controller*, page *26*. b. If mode control is in EXT, remote controller may be overriding. Remove interface connector to verify. c. Check that Normal/Reverse switch (inside) is set correctly (usually NORMAL). d. Check if motor can be moved in Manual. Refer to Motor Symptoms, below.
Motor runs but valve flapper does not move	a. Set screws are loose in adapter between transmission and valve. b. Either arm or gear inside transmission box is loose. c. Stepping motor gear box gears loose or stripped.
Motor runs and valve flapper moves	a. Inability to control due to problems in Phase, Gain, or Digital sections of 252 controller.
Motor does not move in Manual or Auto	a. Valve jammed. b. Trouble in Digital or Motor drive sections of 252 controller.
Error meter shows error less than 0.25% but pressure is not correct	a. Check that Power is ON. b. Check that pressure transducer signal is proportional to pressure. c. Trouble in Input Amplifier or Set Point Amplifier.

Table 9: Troubleshooting Chart

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Appendix A: Product Specifications

CE Mark Compliance[1]	EMC Directive 89/336/EEC
External Input Commands	CLOSE and OPEN - TTL compatible (5V, 4.7K pull-up) Input activated by a LO signal (0 to +1 Volt) (activating both stops the valve)
External Set Point Signal	0 to 5 VDC analog (40K load impedence)
Fuses 100/120 VAC 220/240 VAC	 0.80 A Slo Blo / 250V 0.40 A Slo Blo / 250V
Input Signal	0 to 10 VDC, 0 to 1 VDC, or 0 to 0.1 VDC (switch selectable on front panel)
Operating Temperature	0° to 40° C (32° to 104° F)
Output Power	+ and - 15 ±0.6 VDC @ 250 mA maximum each
Power Requirements Input Power Line Voltage	 40 Watts @ 90 VAC 60 Hz minimum 70 Watts @ 132 VAC 50 Hz maximum 90 to 132 VAC @ 50-60 Hz or 198 to 264 VAC @ 50-60 Hz
Regulation	±0.25% of full scale maximum
Repeatability	±0.1% of full scale maximum
Valve Output	Built-in driver to power the 253 Control Valve (24 Volts at 1 Amp max.)

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

[1]When used with optional metal braided, shielded cables.

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Appendix B: Model Code Explanation

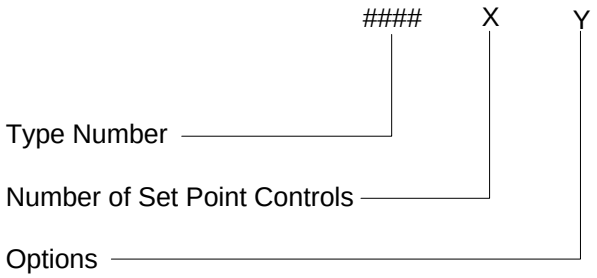
Model Code

The desired instrument options are identified in the model code when you order the unit.

The model code is identified as follows:

####-X-Y

where:



Type Number (####)

This designates the model number of the instrument.

The controller is identified as the Type 252D.

Number of Set Point Controls (X)

Three types of set point control (multiple set point option) are available, designated by a single number code.

		Ordering Code
Standard:	single set point control	1
Optional:	three set point controls	3
Optional:	four set point controls	4

Options (Y)

Two options are available, designated by a three letter code.

	Ordering Code
Valve Position Indicator	VPO
Process Limit Option	PLO

How To Order a Type 252 Unit

To order the Type 252 controller with one set point and no options, the product code is:

252D-1

To order the Type 252 controller with four set point control and the PLO option, the product code is:

250D-4-PLO

To order the Type 252 controller with four set point control, the valve position option, and the process limit option, the product code is:

250D-4-VPO-PLO

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