



120551-P1
Rev A, 2/97
Instruction Manual

MKS Type 244E Pressure/Flow Controller MKS Type 245 Control Valve



WARRANTY

Type 244E and 245 Equipment

MKS Instruments, Inc. (**MKS**) warrants that the equipment described above (the "equipment") manufactured by **MKS** shall be free from defects in materials and workmanship for a period of one year from date of shipment and will for a period of two years from the date of shipment, correctly perform all date-related operations, including without limitation accepting data entry, sequencing, sorting, comparing, and reporting, regardless of the date the operation is performed or the date involved in the operation, provided that, if the equipment exchanges data or is otherwise used with equipment, software, or other products of others, such products of others themselves correctly perform all date-related operations and store and transmit dates and date-related data in a format compatible with **MKS** equipment. THIS WARRANTY IS **MKS'** SOLE WARRANTY CONCERNING DATE-RELATED OPERATIONS.

For the period commencing with the date of shipment of this equipment and ending one year later in the case of defects in materials and workmanship, but two years later in the case of failure to comply with the date-related operations warranty, **MKS** will, at its option, either repair or replace any part which is defective in materials or workmanship or with respect to the date-related operations warranty without charge to the purchaser. The foregoing shall constitute the exclusive and sole remedy of the purchaser for any breach by **MKS** of this warranty.

The purchaser, before returning any equipment covered by this warranty, which is asserted to be defective by the purchaser, shall make specific written arrangements with respect to the responsibility for shipping the equipment and handling any other incidental charges with the **MKS** sales representative or distributor from which the equipment was purchased or, in the case of a direct purchase from **MKS**, with the **MKS** home office in Andover, Massachusetts, USA.

This warranty does not apply to any equipment which has not been installed and used in accordance with the specifications recommended by **MKS** for the proper and normal use of the equipment. **MKS** shall not be liable under any circumstances for indirect, special, consequential, or incidental damages in connection with, or arising out of, the sale, performance, or use of the equipment covered by this warranty.

MKS recommends that all **MKS** pressure and flow products be calibrated periodically (typically every 6 to 12 months) to ensure accurate readings. When a product is returned to **MKS** for this periodic re-calibration it is considered normal preventative maintenance not covered by any warranty.

THIS WARRANTY IS IN LIEU OF ALL OTHER RELEVANT WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING THE IMPLIED WARRANTY OF MERCHANTABILITY AND THE IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, AND ANY WARRANTY AGAINST INFRINGEMENT OF ANY PATENT.

**MKS Type 244E
Pressure/Flow Controller
MKS Type 245
Control Valve**

Copyright © 1997 by MKS Instruments, Inc.

All rights reserved. No part of this work may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying and recording, or by any information storage or retrieval system, except as may be expressly permitted in writing by MKS Instruments, Inc.

Baratron® is a registered trademark of MKS Instruments, Inc., Andover, MA

Table of Contents

Safety Information.....	1
Symbols Used in This Instruction Manual.....	1
Symbols Found on the Unit	2
Safety Procedures and Precautions	3
Chapter One: General Information.....	7
Introduction	7
How This Manual is Organized.....	9
Customer Support.....	9
Chapter Two: Installation	11
How To Unpack the Type 244 Unit	11
Unpacking Checklist	11
Interface Cables	12
System Interface Cables	12
Generic Shielded Cable Description	13
Product Location and Requirements.....	15
Operating Environmental Requirements	15
Safety Conditions	15
Setup	16
System Design	16
Mounting Instructions	18
Vacuum Connections	22
Gas Source.....	23
Electrical Information	24
Fuses.....	24
Grounding	24
Valve Connector.....	25
Input Connector.....	26
Interface Connector	27

Chapter Three: Overview	29
General Information	29
Power Supply	29
Stepping Drive Motor.....	30
Front Panel Controls	31
Rear Panel Controls.....	33
Labels	34
Serial Number Label.....	34
Chapter Four: Operation	35
How To Setup the Controller.....	35
How To Tune-Up the Controller.....	36
How To Use the Normal/Reverse Switch.....	37
How To Use External Control	37
How To Use the Valve Position Option.....	38
Interconnections.....	39
How To Use the Multiple Set Point Option	40
Control	40
Selection.....	40
Interconnections.....	41
How To Use the Process Limit Option	42
Interconnections.....	43
How To Adjust the Valve.....	44
Chapter Five: Maintenance and Troubleshooting.....	47
General Information	47
Maintenance.....	47
How To Clean the Unit.....	47
How To Replace the Fuses.....	47
How To Perform the Controller Alignment Procedure.....	48
How To Bakeout the APC Valve	50
How To Adjust the Valve	53
Troubleshooting	54
Appendix A: Product Specifications.....	59

Appendix B: Model Code Explanation	61
Model Code	61
Index	63

List of Figures

Figure 1: Preferred Method To Connect a Shielded Cable.....	14
Figure 2: Alternate Method To Connect a Shielded Cable	14
Figure 3: Mounting Dimensions of the Servo Driven Valve Assembly	19
Figure 4: Standard Pressure Control Setup.....	20
Figure 5: Two Gas Ratio Control.....	21
Figure 6: Front Panel Controls	31
Figure 7: Rear Panel Controls.....	33
Figure 8: Serial Number Label	34
Figure 9: Process Limit Set Point Control	42
Figure 10: Low Pressure Throughput of a Typical APC Valve.....	45
Figure 11: High Pressure Throughput of a Typical APC Valve.....	45
Figure 12: Cross Section of an APC Valve	51

List of Tables

Table 1: Definition of Symbols Found on the Unit	2
Table 2: System Interface Cables.....	12
Table 3: Maximum Inlet Pressures	23
Table 4: Fuse Information	24
Table 5: Valve Connector Pinout.....	25
Table 6: Input Connector Pinout.....	26
Table 7: Interface Connector Pinout	27
Table 8: Stepping Drive Motor Four-Step Sequence	30
Table 9: Valve Position Option Pinout	39
Table 10: Multiple Set Point Option Pinout.....	41
Table 11: Process Limit Option Pinout	43
Table 12: Test Point Voltages.....	49
Table 13: Troubleshooting Chart	55

Safety Information

Symbols Used in This Instruction Manual

Definitions of WARNING, CAUTION, and NOTE messages used throughout the manual.

Warning



The **WARNING** sign denotes a hazard. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.

Caution



The **CAUTION** sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of all or part of the product.

Note



The **NOTE** sign denotes important information. It calls attention to a procedure, practice, condition, or the like, which is essential to highlight.

Symbols Found on the Unit

The following table describes symbols that may be found on the unit.

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

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of intended use of the instrument and may impair the protection provided by the equipment. MKS Instruments, Inc. assumes no liability for the customer's failure to comply with these requirements.

Warning



The moving parts in the valve create a risk of personal injury until the valve is securely incorporated into a system. To avoid injury keep all objects away from any valve opening.

1. Do not insert object into openings where contact with moving parts is possible.
2. Isolate the equipment from any electrical or pneumatic power supply before handling the valve.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an MKS Calibration and Service Center for service and repair to ensure that all safety features are maintained.

SERVICE BY QUALIFIED PERSONNEL ONLY

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel only.

GROUNDING THE PRODUCT

This product is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting it to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

DANGER ARISING FROM LOSS OF GROUND

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electrical shock.

GROUND AND USE PROPER ELECTRICAL FITTINGS

Dangerous voltages are contained within this instrument. All electrical fittings and cables must be of the type specified, and in good condition. All electrical fittings must be properly connected and grounded.

USE THE PROPER POWER CORD

Use only a power cord that is in good condition and which meets the input power requirements specified in the manual.

Use only a detachable cord set with conductors that have a cross-sectional area equal to or greater than 0.75 mm². The power cable should be approved by a qualified agency such as VDE, Semko, or SEV.

USE THE PROPER POWER SOURCE

This product is intended to operate from a power source that does not apply more voltage between the supply conductors, or between either of the supply conductors and ground, than that specified in the manual.

USE THE PROPER FUSE

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

DO NOT OPERATE IN EXPLOSIVE ATMOSPHERES

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

HIGH VOLTAGE DANGER

High voltage is present in the cable and the sensor when the controller is turned on.

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 wetted materials in this product, including any sealing materials.

PURGE THE INSTRUMENT

After installing the unit, or before its removal from a system, be sure to 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 to protect personnel.

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

Before proceeding to instrument setup, carefully check all plumbing connections to the instrument to ensure leak-tight installation.

OPERATE AT SAFE INLET PRESSURES

This unit should never be operated 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, a suitable burst disc should be installed in the vacuum system to prevent system explosion should the system pressure rise.

KEEP THE UNIT FREE OF CONTAMINANTS

Do not allow contaminants of any kind to enter the unit before or during use. Contamination such as dust, dirt, lint, glass chips, and metal chips may permanently damage the unit.

KEEP AWAY FROM VALVE OPENING

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

This page intentionally left blank.

Chapter One: General Information

Introduction

The MKS Type 244D Pressure/Flow Controller controls the MKS Type 245 Control Valve to maintain a constant pressure or flow in a vacuum system by varying the valve's conductance. The 244 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, 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.

The 245 valve consists of an all metal Granville-Phillips 216 Type Valve which is bakeable to 450° C with the Servo Driver removed. The 245 valve is unique in that a stepper motor is used as the motion element instead of the usual 60 Hz servo motor. The Series 216 Servo Driven Valve Assembly is a precision instrument. *Successful use is dependent on strict adherence to the procedures specified in this manual.*

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 will consist 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 244 controller and 245 control valve.

The controller's new 15-pin Type "D" connector allows you to connect the unit to a Type 245 valve. If you install the 244 controller into an existing system that uses the old (hex) connector cables, an adapter cable is required (refer to *Optional Equipment*, page 11, for more information).

The 244 controller takes the DC pressure transducer signal, compares it to the set point, and positions the valve so that it drives the actual pressure to the set pressure. The 244 controller contains the three modes of control action found in most 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:

$$\text{Signal to valve} = K_1 \times \text{Error} \quad (K_1 \text{ is adjustable by the gain pot})$$

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

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

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:

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

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 244 unit.

Before installing your Type 244 unit in a system and/or operating it, carefully read and familiarize yourself with all precautionary notes in the *Safety Messages and Procedures* section at the front of this manual. In addition, observe and obey all WARNING and CAUTION notes provided throughout the manual.

Chapter One, *General Information*, (this chapter) introduces the product and describes the organization of the manual.

Chapter Two, *Installation*, explains the environmental requirements and describes how to mount the instrument in your system.

Chapter Three, *Overview*, gives a brief description of the instrument and its functionality.

Chapter Four, *Operation*, describes how to use the instrument and explains all the functions and features.

Chapter Five, *Maintenance and Troubleshooting*, describes basic maintenance procedures and how to troubleshoot a problem should the 244 unit malfunction.

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

Appendix B, *Model Code Explanation*, describes the instrument's ordering code.

Customer Support

Standard maintenance and repair services are available at all of our regional MKS Calibration and Service Centers, listed on the back cover. In addition, MKS accepts the instruments of other manufacturers for recalibration using the Primary and Transfer Standard calibration equipment located at all of our regional service centers. Should any difficulties arise in the use of your Type 244 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.

This page intentionally left blank.

Chapter Two: Installation

How To Unpack the Type 244 Unit

MKS has carefully packed the Type 244 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 244 Unit
- Type 244 Instruction Manual (this book)
- Power Cable

Optional Equipment

- Rack Mounting Kit:
RM-6
- Electrical Connector Accessory Kit:
244E-K1 (includes an I/O connector for the rear panel of the unit, a cover for the I/O connector, and a screw lock assembly for the I/O connector cover)
- System Interface Cables (refer to Table 2, page 12)

Interface Cables

As of January 1, 1996, most products shipped to the European Community must comply with the EMC Directive 89/336/EEC, which covers radio frequency emissions and immunity tests. In addition, as of January 1, 1997, some products shipped to the European Community must also comply with the Product Safety Directive 92/59/EEC and Low-Voltage Directive 73/23/EEC, which cover general safety practices for design and workmanship. MKS products that meet these requirements are identified by application of the CE Mark.

To ensure compliance with EMC Directive 89/336/EEC, an overall metal braided shielded cable, properly grounded at both ends, is required during use. No additional installation requirements are necessary to ensure compliance with Directives 92/59/EEC and 73/23/EEC.

Note



1. Overall metal braided shielded cables, properly grounded at both ends, are required to meet CE Mark specifications.
2. To order metal braided shielded cables, add an “S” after the cable type designation. For example, to order a standard cable to connect the 244 unit to a Type 627 transducer, use part number CB258-1-10; for a metal braided shielded cable use part number CB258S-1-10.

System Interface Cables

The system interface cables include cables to connect the 244 controller to a transducer or to the 245 valve, as well as the adapter cable necessary to replace a 244A-C unit with a 244E unit.

System Interface Cables		
To Connect the 244 Unit To...	Use the MKS Cable...	
	Standard	Shielded
270, 690 system	CB250-7-3	CB250S-7-3
122, 124, 223, 622, and 623 transducers	CB254-2-10	CB254S-2-10
121 and 221 transducers	CB254-1-10	CB254S-1-10
220 transducer	CB254-10-10	CB254S-10-10
127, 624, 626, and 627 transducers and 258, 358, 558, 1258, and 2258 mass flow meters	CB258-1-10	CB258S-1-10
128, 625, and 628 transducers	CB128-2-10	CB128S-2-10
PDR-C-1C/2C, PDR-D-1, and PDR-5B power supply/readouts	CB254-17-6	CB254S-17-6
120 transducer with a separate input power connector	CB120-3-10	CB120S-3-10

Table 2: System Interface Cables
(Continued on next page)

System Interface Cables (<i>Continued</i>)		
To Connect the 244 Unit To...	Use the MKS Cable...	
	Standard	Shielded
245 valve	CB252-19-10	CB252S-19-10
Allows replacement of a 244A-C unit with a 244E unit (refer to <i>Valve Connector</i> , page 25)	CB252-17-1	CB252S-17-1

Table 2: System 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. Refer to Figures 1 and 2, page 14. (A ¼ inch piece of #22 wire may be undesirably long since it has approximately 5 nH of inductance, equivalent to 31 ohms at 1000 MHz). After picking up the braid's ground, keep wires and braid flat against the case. With very few exceptions, grounded metal covers are not required over terminal strips. If one is required, it will be stated in the Declaration of Conformity or in the instruction manual.
5. In selecting the appropriate type and wire size for cables, consider:
 - A. The voltage ratings;
 - B. The cumulative I^2R heating of all the conductors (keep them safely cool);
 - C. The IR drop of the conductors, so that adequate power or signal voltage gets to the device;
 - D. The capacitance and inductance of cables which are handling fast signals, (such as data lines or stepper motor drive cables); and
 - E. That some cables may need internal shielding from specific wires to others; please see the instruction manual for details regarding this matter.

Example 1: Preferred Method To Connect Cable
(shown on a transducer)

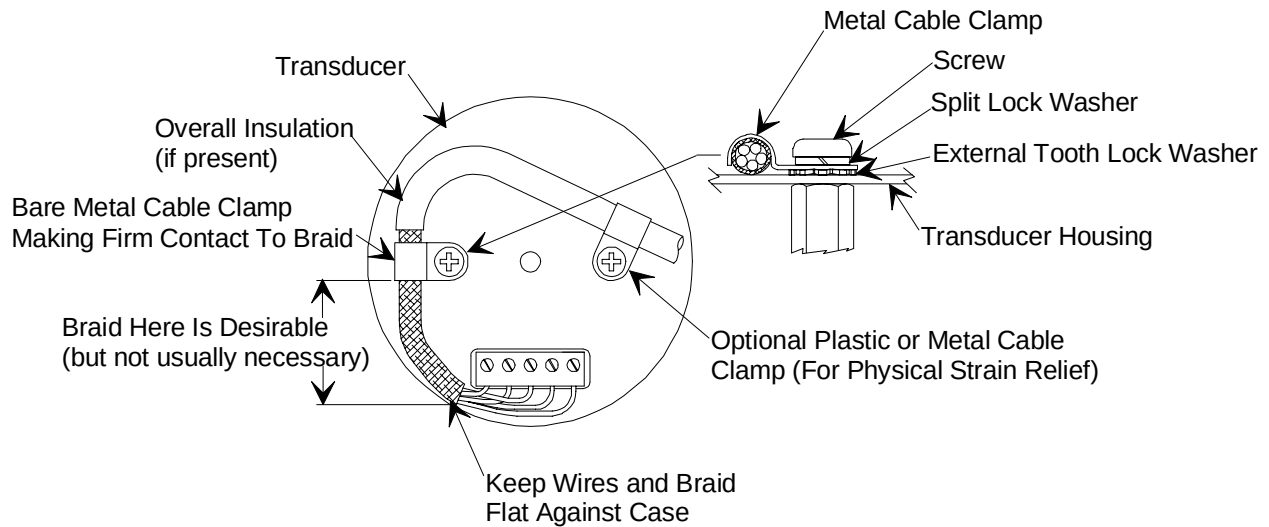


Figure 1: Preferred Method To Connect a Shielded Cable

Example 2: Alternate Method To Connect Cable
(shown on a transducer)

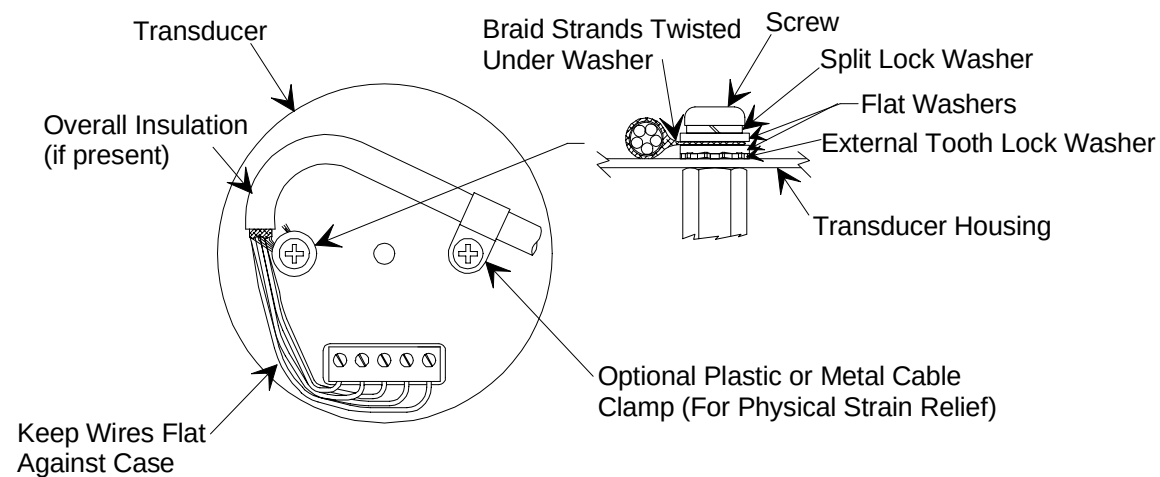


Figure 2: Alternate Method To Connect a Shielded Cable
(Use When Cable Clamp is Not Available)

Product Location and Requirements

The Type 244 unit meets the following criteria:

- POLLUTION DEGREE 2 in accordance with IEC 664
- Transient overvoltages according to INSTALLATION CATEGORY II

Operating Environmental Requirements

- Ambient Operating Temperature: 0° to 40° C (32° to 104° F)
- Main supply voltage fluctuations must not exceed $\pm 10\%$ of the nominal voltage
- Ventilation requirements include sufficient air circulation
- Connect the power cord into a grounded outlet
- Power: 100 to 120 VAC nominal @ 50/60 Hz
220 to 240 VAC nominal @ 50/60 Hz
37 VA @ 90 VAC 60 Hz Minimum
67 VA @ 132 VAC 50 Hz Minimum

Safety Conditions

The 244 unit poses no safety risk under the following environmental conditions.

- Altitude: up to 2000 m
- Maximum relative humidity: 80% for temperatures up to 31° C, decreasing linearly to 50% at 40° C

Setup

System Design

There are several considerations that must be dealt with before startup.

Valve Selection

The correct valve must be selected to allow a reasonable fast time response.

For example:

Assume a system whose pumping speed is 500 liters/sec and whose volume is 100 liters. This means that the pump down time constant (T.C.) will be 0.2 seconds. To control at 100 μ or 0.1 Torr, with an up time constant equal to the down time constant (in the practical case, this will rarely happen), the quantity of gas that the pump is able to draw out at this pressure is 500 liters/sec x 100 μ , or 50000 μ L/sec; this converts to 1100 sccm.

If the 100 sccm valve is chosen, it would never get up to 100 μ because the pump is slightly faster than the valve (at 100 μ). The valve goes wide open and the pressure drops to the point where the valve throughput equals that of the pump (somewhat less than 100 μ pressure). Two things can be done to make the system work.

The first and proper course of action (which maintains the system's natural fast response) is to select a bigger valve (5000 sccm) which, provides more gas than the pump can extract. If overshoot occurs, the down T.C. will be a combination of the pump and chamber T.C., modified by the controller's T.C. as control point is approached. Basically, if a large valve is selected, the speed of up control will be a function of the controller's speed (incoming flow) and the down control will be a function of the pump's speed.

The second course of action is to reduce the pumping speed. However, this approach (usually realized by partially closing a valve) slows down the entire system.

Pressure Range

The range of pressure over which the system will work must be selected.

It is recommended that this be limited to 1000 to 1, although pressures five decades apart have been controlled with a single valve.

Lags

Lags must be removed.

If lags (delays) are built into a system, stabilization will be difficult or impossible. Lag may be introduced pneumatically in two areas: the tubing to the sensor and the tubing to the valve. **Both tubing runs must be less than 3 inches long and no less than ¼ inch in diameter.** Make sure the fittings do not introduce extra lags (internal small drilled passages). Other lags such as antichambers off the main vacuum chamber may also cause problems and must be kept to a minimum.

If a Type 170-6 unit is being used for pressure measurement, the most likely cause of lag is allowing the indicator switch to be placed in the NORMAL position, (T.C. of 380 ms). This switch must be in the FAST position (38 ms).

Choking

Another 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.

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.

Mounting Instructions

Controller

The 244 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 operate 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.

Transducers

Any pressure transducer which delivers at least 0.1 Volt full scale, can be used as the feedback element for total pressure control. The pressure transducer should be mounted so that it is firmly supported, while at the same time, isolated from any vibration.

Valve

The metal-to-metal seal in the Automatic Pressure Control (APC) valve is particularly susceptible to damage by corrosive materials, excessive temperatures, and contamination by foreign particles. It is easily damaged through improper use or careless bakeout procedures. Use every precaution to prevent contamination from entering the APC valve.

Note

Keep the red plastic caps on the APC valve ports until the valve is ready to be connected to the system.

The servo driven valve assembly (refer to Figure 3, page 19) is shipped with the mounting plate attached. It may be mounted to operate in any position, but horizontal mounting is recommended. If it is necessary to remove the mounting plate from the servo driven valve assembly so that it can be mounted to a rigid support, follow the instructions below:

1. Remove the two Allen head screws which attach the mounting bracket to the APC valve body.
2. Carefully slide the mounting bracket off the guide pins on the motor mounting plate.
3. Attach the mounting bracket to a rigid support.
4. Carefully slide the mounting bracket back onto the guide pins on the motor mounting plate.
5. Replace the two Allen head screws to secure the valve body to the mounting bracket.

Figure 3: Mounting Dimensions of the Servo Driven Valve Assembly

Interconnections

Figure 4 and Figure 5, page 21, show typical piping and cable interconnection diagrams.

Figure 4 shows the usual setup for standard pressure control. If a mass flow meter is used for feedback to the 244 controller then flow can be controlled instead of pressure.

Figure 5, page 21, shows a two gas ratio control system where the pressure in the chamber and the *ratio* of two gases are controlled. This arrangement is made practical by the EXTERNAL SET POINT input available on the 244 controller.

All connections to the chamber (both to the pressure transducer and from the valve) should be as large a diameter and as short as practical. Six inches of ¼" tubing should be maximum. Never reduce the tubing size below that of the valve and transducer. If the chamber is repeatedly opened to the atmosphere, the transducer should be protected by an isolation valve.

Figure 4: Standard Pressure Control Setup

Figure 5: Two Gas Ratio Control

Vacuum Connections

Two types of connections are available for the APC valve body.

Flange Connections

This procedure is applicable to the 2¾" O.D. CuSeal flange and the 1⁵/₁₆" O.D. Mini-CuSeal flange.

1. Insert a new, clean OFHC copper gasket between each pair of mating flanges, using care not to mar the gasket surfaces.
2. Insert and gradually and uniformly tighten the flange bolts until the mating surfaces are in contact.

It is important that the mating surfaces be in intimate contact for good mechanical strength. All flanges supplied are Type 304 Stainless Steel and only Type 18-8 Stainless Steel bolts and nuts should be used to connect these flanges.

Welding Connections

The welding connections are ¼" O.D. x 0.035" wall Type 304 Stainless Steel which welds readily to any other 300 series Stainless Steel except the free machining grades. An inert atmosphere inside the tubulation must be used in all welding operations to prevent the formation of an oxide scale which might enter the APC valve and cause a malfunction. Heliarc welding using an argon atmosphere inside the tubulation has been found to be entirely satisfactory.

Gas Source

In some cases where control is to be extended below 10^{-8} Torr, the inlet pressure will need to be reduced to below one atmosphere for optimum results.

For gas inlet pressures below one atmosphere, either valve port may be connected to the system and the other port to the gas source. To obtain the minimum volume and surface area in the system, connect the center port (port B) to the system. The maximum permissible inlet pressures for the APC valve depend upon the type of tubulation supplied to it. Table 3 lists the maximum inlet pressures for the different types of vacuum connections.

Maximum Inlet Pressures		
Connection Type	Port A	Port B
Type 304	Stainless Steel	
Tubulation (for welding)	25 psig	2000 psig
CuSeal Flanges	25 psig	200 psig

Table 3: Maximum Inlet Pressures

When operating from a pressurized gas source a suitable burst disc should be installed in the vacuum system to prevent system explosion should system pressure rise.

Moist gases such as undried air or gases containing oil or other contaminants are difficult to control at low flow rates. Liquid films form quickly on the sealing surface, producing a liquid seal which has only on or off properties and may result in violent pressure oscillations.

When moist gases are being controlled, a possible solution to the problem is to place a gas drying unit in line between the gas source and the APC valve. (Van Waters & Rogers, Inc. Drierite drying unit #26668 has proven satisfactory.) An oil trap placed between the gas source and the APC valve will aid in keeping oil out of the APC valve when controlling gases containing oil.

Electrical Information

Fuses

The line fuses protect the internal circuitry; both sides of the line are fused. The fuse values are listed in Table 4.

Fuse Information	
Voltage	Fuse Type
115 VAC	0.80 A (T) / 250 V / 5 x 20 mm
230 VAC	0.40 A (T) / 250 V / 5 x 20 mm

Table 4: Fuse Information

Caution



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

Grounding

For protective earthing, plug the power cord into a properly grounded outlet.

Valve Connector

The 15-pin Type “D” connector allows you to connect the 244 controller to a Type 245 valve, using cable CB252-19-10. If you are installing the 244 controller into an existing system that uses the old (hex) connector cables, an adapter cable is required. Use adapter cable CB252-17-1 or CB252S-17-1 to replace a Type 244A-C with the Type 244E unit.

Note



Overall metal braided shielded cables, properly grounded at both ends, are required to meet CE Mark specifications.

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 5: Valve Connector Pinout

Note



The “No Connection” pin assignment refers to a pin with no internal connection.

Input Connector

This 14-pin Amphenol connector allows you to connect the 244 controller to a transducer. It provides $\pm 15\text{V}$ power and accepts the input pressure signal from the transducer.

Input Connector Pinout	
Pin	Assignment
1	($\pm$) 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	$\pm 15\text{V}$ Output
12	Power Supply Ground (Analog Ground)
13	-15V Output
14	Chassis

Table 6: Input Connector Pinout

Note



The “Reserved” pin assignment refers to a pin with an internal connection which may be assigned a function in the future.

Interface Connector

This 14-pin Amphenol connector provides access to the miscellaneous outputs, ± 15 V power, and external inputs to the 244 controller.

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

- Refer to Table 9, page 39, for the Valve Position Option pinout
- Refer to Table 10, page 41, for the Multiple Set Point Option pinout
- Refer to Table 11, page 43, for the Process Limit Relay Option pinout

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 7: Interface Connector Pinout

Note



The “Reserved” pin assignment refers to a pin with an internal connection which may be assigned a function in the future.

This page intentionally left blank.

Chapter Three: Overview

General Information

The Type 244 controller and 245 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 4, page 20, 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 required signal (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 the operator to compensate for the different delays, or lags, that occur in various systems.

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 supply 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.

Stepping Drive Motor

The 245 valve is unique in that a stepper motor is used as the motion element instead of the usual 60 Hz servo motor. The direction of the stepping motor is determined by whichever pair of drivers change state, as shown in Table 8.

Stepping Drive Motor Four-Step Sequence						
CW ↓	Step	A	A1	B	B1	CCW ↑
	1	ON	OFF	ON	OFF	
	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 8: Stepping Drive Motor Four-Step Sequence

Front Panel Controls

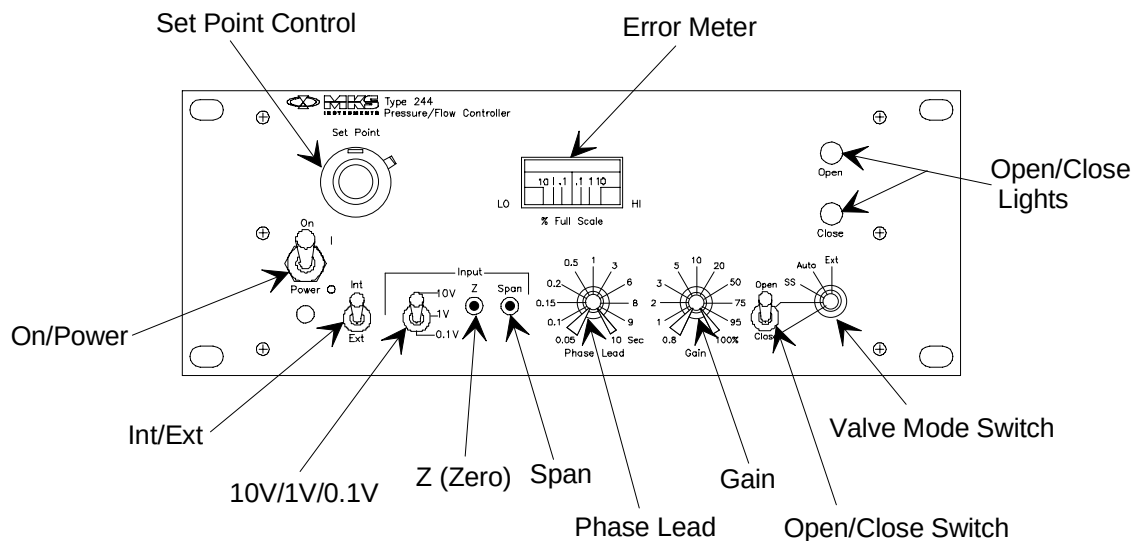


Figure 6: Front Panel Controls

ON/POWER - Controls the AC power to the 244 controller. The LED indicator below it indicates when the power is on, that is, the plug is in and the fuse is alive.

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

10V/1V/0.1V - Selects the full scale range of the input voltage. As shipped, the 244 controller is calibrated for $\pm 0.25\%$ on the 10V range. The 1V and 0.1V ranges are calibrated for $\pm 2\%$ as shipped, but can be adjusted closer with the span pot (refer to SPAN below).

Z (ZERO) - 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.

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.

PHASE LEAD - The PHASE LEAD control allows the operator 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.

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%.

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

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 EXTERNAL, the controller operates as if in AUTO but will accept external OPEN and CLOSE commands. External OPEN or CLOSE commands will not affect the 244 controller unless the mode switch is in the EXTERNAL position.

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.

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.

SET POINT - The SET POINT control is the operator's input to the 244 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 AUTO or EXTERNAL. 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 244 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

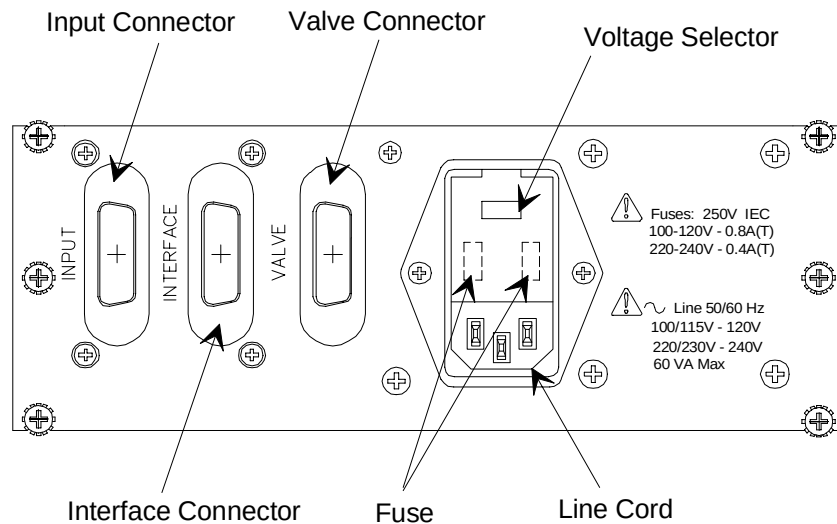


Figure 7: Rear Panel Controls

LINE CORD - Provides 115 or 230 VAC to the 244 controller. For protective earthing, plug the power cord into a properly grounded outlet.

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

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.

VALVE - The 245 valve connects to the 244 controller through a 15-pin Type "D" connector. Use cable CB252-19-10 to connect the valve and controller.

Note



If you are installing the 244E controller into an existing system that uses the old (hex) connector cables, an adapter cable is required. Use adapter cable CB252-17-1 or CB252S-17-1 to replace a Type 244A-C controller with the Type 244E controller. Refer to Table 5, page 25, for the Valve connector pinout.

INTERFACE - This connector provides access to the miscellaneous outputs, $\pm 15V$ power, and external inputs to the controller. Refer to Table 7, page 27, for the Interface connector pinout.

INPUT - This connector provides $\pm 15V$ power and accepts the input pressure signal. Refer to Table 6, page 26, for the Input connector pinout.

Labels

Serial Number Label

The Serial Number label, located on the side of the instrument, lists the serial number and the product model number of the unit.

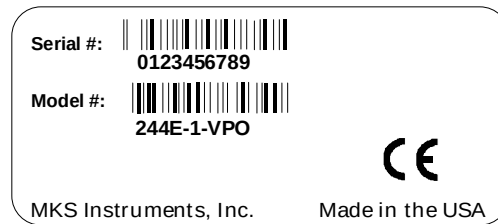


Figure 8: Serial Number Label

The instrument is identified as “244E - X - YYY”, where:

244E = Type number

X = Number of set point controls

YYY = Options

Refer to *Appendix B: Model Code Explanation*, page 61, for more information.

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 fuse rating are listed in *Appendix A: Product Specifications*, page 59.

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, 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 690/270 and 127 or 128, need about 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 244 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. This feature allows the valve to open at a slow and predictable rate until the control pressure is reached; at this 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 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 245 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 *Interconnections*, page 20).

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 244 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 either:

- The pressure transducer (or process variable) *decreases* for increasing pressure
- The valve drive signal increases when the pressure is greater than the set point (such as exhaust control)

How To Use External Control

The 244/245 exhaust control system can be externally controlled with two inputs on the Interface connector. Refer to Table 7, page 27, for the Interface connector pinout.

Note



The Valve Mode switch on the front panel (refer to Figure 6, page 31) **must** be in the EXTERNAL position for the 244 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 244 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 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 9.

Valve Position Option Pinout				
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	+15 VDC Supply	+15 VDC Supply	+15 VDC Supply	+15 VDC Supply
12	Power Ground	Power Ground	Power Ground	Power Ground
13	-15 VDC Supply	-15 VDC Supply	-15 VDC Supply	-15 VDC Supply
14	Chassis Ground	Chassis Ground	Chassis Ground	Chassis Ground

Table 9: 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 are selectable 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.

Control

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).

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*, page 31.

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 will be 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 10. The *digital* ground should be connected to the circuit ground of the digital instrument that is selecting the set points. Refer to Table 7, page 27, for the complete Interface connector pinout.

Multiple Set Point Option Pinout	
I/O Connector Pin	Assignment
3	Digital Ground
6	Set point 1
7	Set point 2
9	Set point 3
10	Set point 4

Table 10: 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 $\pm 0.5\%$ to $\pm 100\%$. An LED indication is provided on the board to assist in the set-up.

The PLO board compares the absolute value of the error signal to the process limit setting, and 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).

Control

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 9.

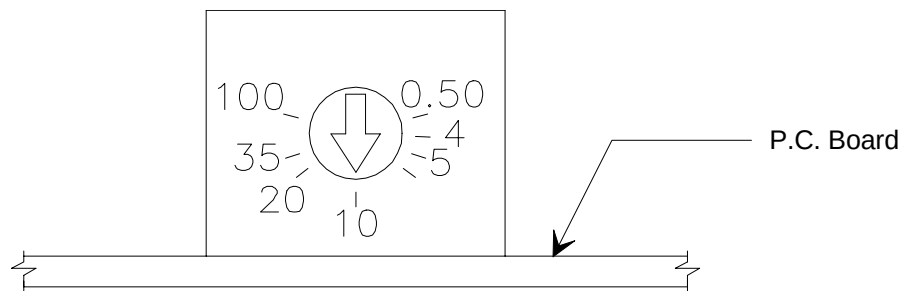


Figure 9: Process Limit Set Point Control

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 ($\pm 0.05\%$) 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 in Table 11.

Process Limit Option Pinout			
I/O 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		Set Point 4	
11		+15 VDC Supply	
12		Power Ground	
13		-15 VDC Supply	
14		Chassis Ground	

Table 11: 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 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 Adjust the Valve

Please note the following important precautions:

- Please read all of the instructions before operating the valve
- **Do not** allow contaminants of any kind to enter the APC (Automatic Pressure Control) valve before or during use
Contamination such as dust, dirt, lint, glass chips, and metal chips will permanently damage the sealing surfaces
- **Do not** remove the plastic port covers until the APC valve is mounted and ready to be connected to the vacuum system
- **Do not** bake the APC valve with the servo driver attached
- **Do not** let the ambient temperature drop more than 10° C when the servo driver is used only to seal the APC valve.

The servo driver and APC valve are designed to be operated at ambient temperatures not to exceed 50° C. It is not necessary to control the temperature of this unit during automatic operation as any change of leak rate due to temperature changes will automatically be compensated.

When the servo driven valve assembly is to be used only to seal the APC valve during long periods, it may be desirable to control the APC valve ambient temperature. If the automatic control has been turned off, a drop of more than 10° C may cause the APC valve to open slightly, permitting gas to leak into the system. If the APC valve has opened slightly due to an extreme decrease in temperature, it may be closed manually by turning the compensating screw (shown in Figure 12, page 51) clockwise, 1/10 turn at a time.

Maximum throughput is 100 Torr Liters/sec with atmospheric pressure on the inlet as shown in Figure 10, page 45. Larger throughputs are as shown in Figure 11, page 45; note that in this figure, exhaust is to atmosphere.

Figure 10: Low Pressure Throughput of a Typical APC Valve

Figure 11: High Pressure Throughput of a Typical APC Valve

This page intentionally left blank.

Chapter Five: Maintenance and Troubleshooting

General Information

If the 244 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

Periodically check for wear on the cables and inspect the enclosure for visible signs of damage.

How To Clean the Unit

Periodically wipe down the unit with a damp cloth.

How To Replace the Fuses

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

115 VAC 0.80 A (T) / 250 V / 5 x 20 mm

230 VAC 0.40 A (T) / 250 V / 5 x 20 mm

Caution



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

How To Perform the Controller Alignment Procedure

The controller alignment procedure verifies the zero and full scale alignment of the 244 controller. Allow the controller to warm up for at least 30 minutes, with the 245 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
- 245 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 245 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 ±15 or 230 ±15 Volts A.C.
5. Check the voltage at the test points listed in Table 12, page 49, and readjust the appropriate control if necessary.

Test Point Voltages			
Condition	Test Point	Voltage	Control
	(+) 15 V Supply Jumper	+ 15.00 $\pm$.05	R132
	(-) 15 V Supply Jumper	- 15.00 $\pm$.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 $\pm$.002	SPAN (R17)
Set point = 1000	TPB-7	5.000 $\pm$.002	Set point Adjust (R20)
TPB-8 = TPB 5.000	TPB-6	0.000	Diff. Amp. Cal (R36)

Table 12: Test Point Voltages

How To Bakeout the APC Valve

The 245 valve consists of a Granville-Phillips 216 Type Valve which is all metal and bakeable to 450° C with the Servo Driver removed. The Automatic Pressure Control (APC) valve may be baked at temperatures up to 450° C provided both parts are maintained at pressures below 1×10^{-4} Torr. Low pressures are necessary to minimize oxidation of the silver sealing material.

The metal-to-metal seal in the APC valve is particularly susceptible to damage by corrosive materials, excessive temperatures, and contamination by foreign particles. It is easily damaged through improper use or careless bakeout procedures. Use every precaution to prevent contamination from entering the APC valve.

The servo driver must be removed for any bakeout. During bakeout, the APC valve must be held in the open position by the bakeout clamp. Refer to Figure 12, page 51, for a cross sectional view of the APC valve.

Removing the Servo Driver

1. Close the valve between the gas source and the servo driven valve assembly.
Do not turn off the system pump as both parts must be maintained at pressures below 1×10^{-4} Torr.
2. Open the APC valve using the 244 controller.
3. Disconnect the servo cable from the servo driven valve assembly.
4. Remove the wedge screw.
Refer to Figure 4.
5. Remove the four socket head cap screws from the APC valve, releasing the servo driver from the APC valve.
6. Carefully slide the servo driver away from the APC valve in a straight line parallel with its principal axis.
Use care not to damage the APC valve.
7. Store the servo driver in a clean polyethylene bag as dust and abrasive material can damage the component parts.
8. Remove the bakeout clamp from the mounting bracket and attach it to the nosepiece of the APC valve.
9. Retract the nosepiece to the stop on the bakeout clamp.
10. Bakeout the APC valve at any temperatures up to 450° C.
Both parts must be maintained at pressures below 1×10^{-4} Torr. Low pressures are necessary to minimize oxidation of the silver sealing material.

Figure 12: Cross Section of an APC Valve

Replacing the Servo Driver

Equipment Needed:

- Lint free cloth
- Trichloroethylene

After the APC valve has cooled, replace the servo driver as follows:

1. Remove the bakeout clamp.

Warning



The servo driver must never be attached to the APC valve unless the servo driver is in the fully open position.

If the servo driver is still open from Step 2, page 50, by-pass Steps 2, 3, and 4 of this procedure, and proceed with Step 5. If not, continue, starting at Step 2.

2. Re-connect the servo cable between the controller and the servo driven valve assembly.
3. Turn on the power and place the function switch to the OPEN position.
The motor will run until the OPEN LED comes on.
4. Thoroughly clean the mating surfaces of the servo driver and the APC valve using a lint-free cloth and trichloroethylene.
5. Carefully slide the servo driver onto the APC valve, making certain the two guide pins have engaged the mounting plate.
6. Insert and tighten the four socket head cap screws, securing the APC valve to the servo driver.

Caution



Be certain not to turn the hex head compensating screw.

7. Tighten the wedge screw against the nosepiece.
8. Close the APC valve.

How To Adjust the Valve

Equipment Needed:

- Stopwatch

1. Connect in the sensor and then mount the sensor and the valve in a vacuum system.
2. Turn on all equipment, close the valve, pump the system down, and note the pressure reading.
3. Start the stopwatch and put the 244 rotary switch in the open position.

Monitor how long it takes until the system pressure starts to rise and close the valve. With a new valve this should take approximately 14 seconds. The objective is to get this time down to **3.5 to 5 seconds**.

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 13, page 55).

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 <i>Choking</i>, page 17). d. Readjust PHASE and/or GAIN controls. (refer to <i>How To Tune-Up the Controller</i>, page 36).
Error Meter shows steady error greater than $\pm 0.25\%$	a. Increase GAIN setting (refer to <i>How To Tune-Up the Controller</i>, page 36). 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 correct (usually NORMAL). d. Check if motor can be moved in Manual. See 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 244 controller.
Motor does not move in Manual or Auto	a. Valve jammed. b. Trouble in Digital or Motor drive sections of 244 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 13: Troubleshooting Chart
(Continued on next page)

Troubleshooting Chart (Continued)	
Symptom	Checks and Probable Causes
APC valve fails to close tightly	a. Valve mounting screws not tightened. Open APC valve and tighten screws. b. The compensating screw is withdrawn (refer to Figure 12, page 51). Turn the compensating screw clockwise 1/10 turn and observe a decrease in the pressure of the vacuum system. If no change in pressure is observed continue checking as below. c. Using the manual switch, open the APC valve. Remove compensating screw and fill hole to bottom of thread with hydraulic oil. Fluid must have a minimum viscosity of 150 SSU at 100° F. Be sure all bubbles are dissipated. Remove the seal-off screw from the compensating screw. Replace compensating screw without seal-off screw and engage threads two full revolutions. Fill center recess in the compensating screw, if necessary to bring oil level to the top of the screw hole. Install seal-off screw and O-ring tight enough to seal hydraulic chamber. Hold hex head compensating screw with wrench while tightening seal-off screw. Using the manual switch, close the APC valve. Turn the compensating screw clockwise 1/10 turn at a time and observe a decrease in the pressure of the vacuum system. NOTE: When a metal-to-metal seal is suddenly closed while conducting gas, the real conductance may be zero but the apparent conductance may be appreciable for a few minutes due to gradual release of gas trapped in the seal. d. Set screw on drive gear loose (refer to Figure 12, page 51). Contact MKS Instruments. e. Sealing surfaces contaminated. Replace APC valve. Glass particles, lint, metal chips, and dust cannot usually be removed.

Table 13: Troubleshooting Chart
(Continued on next page)

Troubleshooting Chart (Continued)	
Symptom	Checks and Probable Causes
APC valve fails to open fully	a. Compensating screw in too far. Occasionally, when the servo driver is operated at too high an ambient temperature the hydraulic fluid expands so that the valve cannot be fully opened by the servo driver. Back the compensating screw out, 1/10 turn at a time, to relieve this condition. b. Hydraulic fluid has trapped air bubbles. Use remedy for “Insufficient hydraulic fluid” to replenish oil supply.
APC valve has only on or off properties. Does not give smooth continuous control.	a. A liquid film produced by allowing moist or vapor laden gases to flow through the APC valve has formed on the sealing surfaces. Perform a vacuum bakeout at 200° to 300° C for 2 to 3 hours (refer to <i>How To Bakeout the APC Valve</i>, page 50).
APC valve envelope develops leak after repeated bakeout	a. Brazed joints deteriorate with repeated temperature cycling. Replace APC valve. b. Mercury pumped system is improperly trapped. Replace APC valve and improve trapping of mercury.
APC valve envelope leaks after initial bakeout	a. Bakeout has opened a brazed joint. Mark location of leak but do not cover leak. Remove valve, carefully stopper tubulation, pack well and return to manufacturer for examination. Include statement of test and operating conditions. b. Mercury has amalgamated brazed joints. Replace APC valve and improve mercury trapping. Free replacement will not be made for amalgamated valves.
Kovar brazed joint leaks after glass blowing.	a. Repeated temperature cycling of Kovar to Monel brazed joints causes Kovar to crack. Replace APC valve. Never play flame over brazed joint.
Hydraulic fluid leaks around drive screw	a. O-ring damaged or compressed. Replace O-rings. Contact MKS Instruments for factory repair or purchase APC Hydraulic Driver Repair Kit from G-P, No. 0-01-213041.

Table 13: Troubleshooting Chart

This page intentionally left blank.

Appendix A: Product Specifications

CE Mark Compliance	
Electromagnetic Compatibility ¹	EMC Directive 89/336/EEC
Low-Voltage Requirements	Low-Voltage Directive 73/23/EEC
Installation Category	II, according to EN 61010-1
Pollution Degree	2, according to IEC 664
Product Safety and Liability	Product Safety Directive 92/59/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 will stop the valve)
External Set Point Signal	0 to 5 VDC analog (40K load impedance)
Fuse Rating	
115 VAC	0.80 A (T) / 250 V / 5 x 20 mm
230 VAC	0.40 A (T) / 250 V / 5 x 20 mm
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 Consumption	37 VA @ 90 VAC 60 Hz minimum 67 VA @ 132 VAC 50 Hz maximum
Power Requirement	
115 VAC Setting	100 to 120 VAC nominal @ 50/60 Hz
230 VAC Setting	220 to 240 VAC nominal @ 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 245 Control Valve (24 Volts at 1 Amp max.)

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

¹An overall metal braided shielded cable, properly grounded at both ends, is required during use.

This page intentionally left blank.

Appendix B: Model Code Explanation

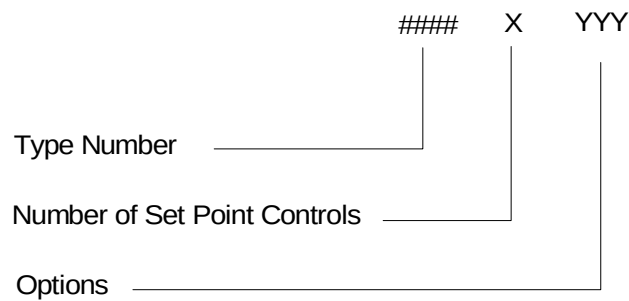
Model Code

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

The model code is identified as follows:

- X - YYY

where:



Type Number (####)

This designates the model number of the instrument. The controller is identified as the Type 244E.

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 (YYY)

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

Ordering Code

Valve Position Indicator	VPO
Process Limit Option	PLO

This page intentionally left blank.

Index

C

Cables, 12

CE Mark, 12, 25

input, 26

interface, 27

valve, 25

CE Mark, 12, 25

Connectors

input, 26

interface, 27

valve, 25

Controller

power supply, 29

Customer support, 9

G

Gas source, 23

I

Installation

optional equipment, 11

Installation Category, 15

L

Labels, 34

M

Maintenance

alignment procedure, 48

test point voltages, 49

valve adjustment, 53

valve bakeout, 50

Manual organization, 9

Model code, 61

Multiple set point option

control, 40

interconnections, 41

selection, 40

O

Operation

controller

normal/reverse switch, 37

setup, 35

tune-up, 36

external control, 37

multiple set point option, 40

process limit option, 42

valve position option, 38

P

Pollution Degree, 15

Power supply, 29

Pressure

maximum inlet, 23

Process limit option

control, 42

interconnections, 43

R

Returning the product, 9, 11

S

Serial number label, 34

Setup

- gas source, 23

- mounting instructions

 - controller, 18

 - transducers, 18

 - valve, 18, 50

- pressure range, 16

- system design

 - lags, 17

 - valve selection, 16

- vacuum connections, 22

Stepping drive motor, 30

T

Temperature, 15

Test point voltages, 49

Troubleshooting, 54

V

Vacuum connections

- flange connections, 22

- welding connections, 22

Valve

- adjustment, 44, 53

- bakeout, 50

- maximum throughput, 44

- servo driver, removing, 50

- stepping drive motor, 30

- temperature, 44

Valve position option

- interconnections, 39